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Foreword

This Technical Specification (TS) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters are in Geneva.

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The DVB Project is an industry-led consortium of broadcasters, manufacturers, network operators, software developers, regulators and others from around the world committed to designing open, interoperable technical specifications for the global delivery of digital media and broadcast services. DVB specifications cover all aspects of digital television from transmission through interfacing, conditional access and interactivity for digital video, audio and data. The consortium came together in 1993.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Video delivery has become a dominant class of traffic on public networks. The wider market has embraced unicast streaming with the ability to adapt to network conditions as a means of delivering media on any type of access network. One of the reasons for its widespread adoption is the reuse of existing network technologies used to deliver other Internet services, in particular HTTP and Content Delivery Networks. Dynamic bit rate adaptation allows the streaming session to degrade gracefully as network conditions worsen, and to recover as they improve.

For consumption of the same linear media stream at the same time by a large audience, the number of simultaneous connections to the edge serving infrastructure carrying the same media payloads results in a high degree of redundancy which can be mitigated by the use of multicast packet replication at Layer 3. Unicast streaming is better suited to unsynchronised media consumption, or consumption of linear streams by smaller audiences.

By combining existing media encoding and packaging formats with the efficiency of point-to-multipoint distribution to the edge of IP-based access networks, it is possible to design a system for linear media distribution that is both efficient and scalable to very large audiences, while remaining technically compatible with the largest possible set of already-deployed end user equipment.

Point-to-multipoint topologies also offer opportunities for efficient pre-positioning of assets to devices at the edge of the network. This supports additional non-linear use cases and can help to alleviate peak demand on the access network at synchronization points in the linear schedule.

1 Scope

The present document specifies a reference functional architecture for an end-to-end system that delivers linear content over Internet Protocol (IP) networks in a scalable and standards-compliant manner. Scalability is achieved by means of IP multicast operating in parallel with and alongside conventional unicast delivery. The procedures and protocols used between the system functions are specified, along with data interchange formats, where appropriate.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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

[1] IETF RFC 7230: "Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing", June 2014.

[2] IETF RFC 7231: "Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content", June 2014.

[3] IETF RFC 7232: "Hypertext Transfer Protocol (HTTP/1.1): Conditional Requests", June 2014.

[4] IETF RFC 7233: "Hypertext Transfer Protocol (HTTP/1.1): Range Requests", June 2014.

[5] IETF RFC 7234: "Hypertext Transfer Protocol (HTTP/1.1): Caching", June 2014.

[6] IETF RFC 7235: "Hypertext Transfer Protocol (HTTP/1.1): Authentication", June 2014.

[7] IETF RFC 8446: "The Transport Layer Security (TLS) Protocol Version 1.3", August 2018.

[8] IETF RFC 1952: "GZIP file format specification version 4.3", May 1996.

[9] IEFF IETF RFC 4648: "The Base16, Base32, and Base64 Data Encodings", October 2006.

[10] ETSI TS 103 285: "Digital Video Broadcasting (DVB); MPEG-DASH Profile for Transport of ISO BMFF Based DVB Services over IP Based Networks", v1.3.1 February 2020.

[11] ISO 8601-1:2019: "Date and time — Representations for information interchange — Part 1: Basic rules", First edition, February 2019.

[12] ISO/IEC 15938-5:2003: "Information technology — Multimedia content description interface — Part 5: Multimedia description schemes", First edition, May 2003.

[13] IETF RFC 5952: "A Recommendation for IPv6 Address Text Representation", August 2010.

[14] IETF RFC 2046: "Multipurpose Internet Mail Extensions (MIME) Part Two: Media Types", November 1996.

[15] IETF RFC 3986: "Uniform Resource Identifier (URI): Generic Syntax", January 2005.

[16] IETF RFC 6585: "Additional HTTP Status Codes", April 2012.

[17] ETSI TS 126 346: "Universal Mobile Telecommunications System (UMTS); LTE; 5G; Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs (3GPP TS 26.346 Release 16)".

[18] ATSC A/331:2019: "ATSC Standard: Signaling, Delivery, Synchronization, and Error Protection", 20 June 2019.

[19] IETF RFC 5651: "Layered Coding Transport (LCT) Building Block", October 2009.

[20] IETF RFC 3230: "Instance Digests in HTTP", January 2002.

[21] IETF RFC 5775: "Asynchronous Layered Coding (ALC) Protocol Instantiation", April 2010.

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

[23] IETF RFC 3926: "FLUTE - File Delivery over Unidirectional Transport", October 2004.

[24] IETF RFC 5445: "Basic Forward Error Correction (FEC) Schemes", March 2009.

[25] IETF RFC 5053: "Raptor Forward Error Correction Scheme for Object Delivery", October 2007.

[26] IETF RFC 6330: "RaptorQ Forward Error Correction Scheme for Object Delivery", August 2011.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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

[i.1] IETF RFC 7540: "Hypertext Transfer Protocol Version 2 (HTTP/2)", May 2015.

[i.2] ISO/IEC 23009-1: "Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats".

[i.3] IETF RFC 4918: "HTTP Extensions for Web Distributed Authoring and Versioning (WebDAV)", June 2007.

[i.4] DASH Industry Forum: "DASH-IF Live Media Ingest Protocol" technical specification. https://dashif-documents.azurewebsites.net/Ingest/master/DASH-IF-Ingest.html.

[i.5] IETF RFC 8216: "HTTP Live Streaming", August 2017.

[i.6] ETSI TS 103 770: "Digital Video Broadcasting (DVB); Service Discovery and Programme Metadata for DVB-I".

[i.7] IETF RFC 6762: "Multicast DNS", February 2013.

[i.8] Fielding, Roy Thomas: "Chapter 5: Representational State Transfer (REST)". Architectural Styles and the Design of Network-based Software Architectures (Ph.D. dissertation). University of California, Irvine, 2000.

[i.9] Broadband Forum TR-069: "CPE WAN Management Protocol".

[i.10] Broadband Forum TR-369: "User Services Platform (USP)".

[i.11] ISO/IEC 23000-19: "Information technology — Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

content: any media object involved in a streaming session, including the presentation manifest and packaged media

NOTE: Each such object is uniquely identifiable by a Uniform Resource Identifier.

ingest object: media object offered at reference point $\mathbf{P_{in}'}$ or $\mathbf{O_{in}}$

NOTE: The *Multicast server* function maps each ingest object to one or more multicast transport objects.

linear service: set of service components that together make up an editorial linear user experience such as a television channel or radio station

media object: single externally addressable unit of packaged encoded media essence or related metadata to be conveyed via a multicast transport session or via a unicast transport session, e.g. a presentation manifest or DASH Segment identified by a URL

NOTE: Control plane documents, such as the multicast session configuration, are not media objects.

multicast media transport protocol: specification of the packet syntax to be used at reference point **M** between a *Multicast server* and a population of *Multicast gateway* and/or *Unicast repair* functions in a given deployed system

multicast session: time-bound transmission comprising all the multicast transport sessions required to deliver a linear service according to operational needs

NOTE: Not all service components need be delivered by multicast transport sessions at all times: some service components may be conveyed by unicast transport sessions alone. This is an operational decision.

multicast session configuration: set of multicast transport session parameters that completely describe all of the multicast transport sessions that comprise a single multicast session

multicast transport object: binary resource related to a media presentation that is conveyed in a multicast transport session and is uniquely identifiable in the multicast media transport protocol, e.g. a partial or complete media object

multicast transport session: time-bound stream of packets transmitted from a *Multicast server* to a *Multicast gateway* via reference point **M**, formatted according to a particular multicast media transport protocol, that conveys a multiplex of one or more service components and/or Forward Error Correction information

NOTE: A multicast transport session is uniquely identifiable by the combination of a source IP address, a destination multicast group IP address and a destination UDP port number, collectively referred to as the *<S, G, p>* triplet.

multicast transport session parameters: set of metadata defining the technical parameters required to deliver or receive a single multicast transport session

playback delivery object: media object provided in response to an HTTP Request at reference point **L**

presentation manifest: metadata providing information used in the playback of a linear service

NOTE: Examples include the Master Playlists (.m3u8) for an HLS streaming session [i.5], the ISML file for a Microsoft SmoothStreaming session, the Media Presentation Description (MPD) for a DVB DASH session [10] or the SDP file and MPEG-DASH MPD for a 3GPP MBMS session.

Presentation session: consumption of a linear service by a *Content playback* function making requests for a presentation manifest and playback delivery objects at reference point **L**

presentation timeline: schedule of media objects that need to be acquired by a *Content playback* function in order to sustain seamless playback of a particular linear service

NOTE 1: This may be governed by timing metadata in the media objects themselves, and an explicit timing model embedded in the presentation manifest, or it may be implied by media objects being listed in the presentation manifest as they become available for download.

NOTE 2: This term is consistent with the concept of Media presentation timeline in MPEG-DASH [i.2].

service component: sequence of media objects that is part of a linear service, e.g. a video stream or an audio stream

service description metadata: media object(s) used to describe the technical parameters of a single linear service

NOTE 1: The service description metadata for a particular linear service includes references (such as URLs) to one or more presentation manifests.

NOTE 2: The format of the service description metadata and the means of its acquisition both lie outside the scope of the present document.

system operator: business entity responsible for operating the functions specified in the present document

terminal device: consumer device that renders presentation sessions of linear services

3.2 Symbols

Void.

3.3 Abbreviations

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

ALC	Asynchronous Layered Coding
AL-FEC	Application Level FEC
API	Application Programmer's Interface
ATSC	Advanced Television Systems Committee
BBC	British Broadcasting Corporation
BMFF	Base Media File Format
CCI	Congestion Control Information (pertaining to LCT)
CDN	Content Delivery Network
CMAF	Common Media Application Format
CP	Content Provider
DASH	Dynamic Adaptive Streaming over HTTP
DNS	Domain Name System
DRM	Digital Rights Management
EPG	Electronic Programme Guide
ESI	Encoding Symbol Identifier (pertaining to AL-FEC)
FDT	File Delivery Table (pertaining to FLUTE)
FEC	Forward Error Correction
FEC	Forward Erasure Correction
FLUTE	File Delivery over Unidirectional Transport
FQDN	Fully-Qualified Domain Name (pertaining to DNS)
HLS	HTTP Live Streaming
HTTP	Hypertext Transfer Protocol
HTTPS	Secure Hypertext Transfer Protocol
IANA	Internet Assigned Numbers Authority
IP	Internet Protocol
ISO	International Organization for Standardization
LCT	Layered Coding Transport
MBMS	Multimedia Broadcast Multicast Services (pertaining to 3GPP)
MPD	Media Presentation Description (pertaining to MPEG-DASH)
MPEG	Moving Pictures Experts Group
PES	Packetized Elementary Stream (pertaining to MPEG-2 Transport Stream)

PID	Packet Identifier (pertaining to MPEG-2 Transport Stream)
PSI	Protocol-Specific Indication (pertaining to LCT)
ROUTE	Real-time Object delivery over Unidirectional Transport
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
SAST	Segment Availability Start Time
SDP	Session Description Protocol
STB	Set-Top Box
S-TSID	Service-based Transport Session Instance Description (pertaining to ROUTE)
TLS	Transport Layer Security
TOI	Transmission Object Identifier (pertaining to ALC/LCT)
TSI	Transmission Session Identifier (pertaining to ALC/LCT)
UDP	User Datagram Protocol
URI	Uniform Resource Identifier
URL	Uniform Resource Locator (pertaining to HTTP)
XML	eXtensible Markup Language

4 General

The present document specifies a reference functional architecture for an end-to-end system that delivers linear content over Internet Protocol (IP) networks in a scalable and standards-compliant manner. Scalability is achieved by means of IP multicast operating in parallel with and alongside conventional unicast delivery. The individual functions required for such a system are depicted in figure 5.2-1, and the interactions between them are shown as named reference points. The functional architecture is intended as an abstract reference: real implementations may, for example, combine multiple functions in a single deployable unit. The architecture is intended to be independent of any particular Internet Protocol address family.

Two mandatory multicast media transport protocols are specified in annex F and annex H:

- Every conformant realization of the *Multicast server* shall implement at least one of the mandatory multicast media transport protocols.
- Every conformant realization of the *Multicast gateway* shall implement at least one of the mandatory multicast media transport protocols.
- Every conformant realization of the *Unicast repair server* implementing reference point **M** shall implement at least one of the mandatory multicast media transport protocols.

In the following clauses, references to HTTP refer to the Hypertext Transfer Protocol message exchange semantics. Implementations shall, at minimum, conform to HTTP/1.1 protocol syntax as specified in IETF RFC 7230 [1] and may optionally implement subsequent protocol syntaxes, for example HTTP/2 [i.1].

Similarly, references to HTTPS refer to HTTP/1.1 over TLS 1.3 [7]. Implementations may optionally implement equivalent or better transport layer security protocols.

References to HTTP(S) mean "HTTP or HTTPS".

5 Reference architecture

5.1 Reference points

5.1.0 Introduction

The relationships between the logical functions in the reference architecture are identified by named reference points. In a practical deployment, each of these is realized by a concrete interface and conveys information between the relevant functions using a particular protocol. The reference points and the logical functions are illustrated by the reference architecture diagram in clause 5.2 and are summarized in figure 5.1.0-1 below.

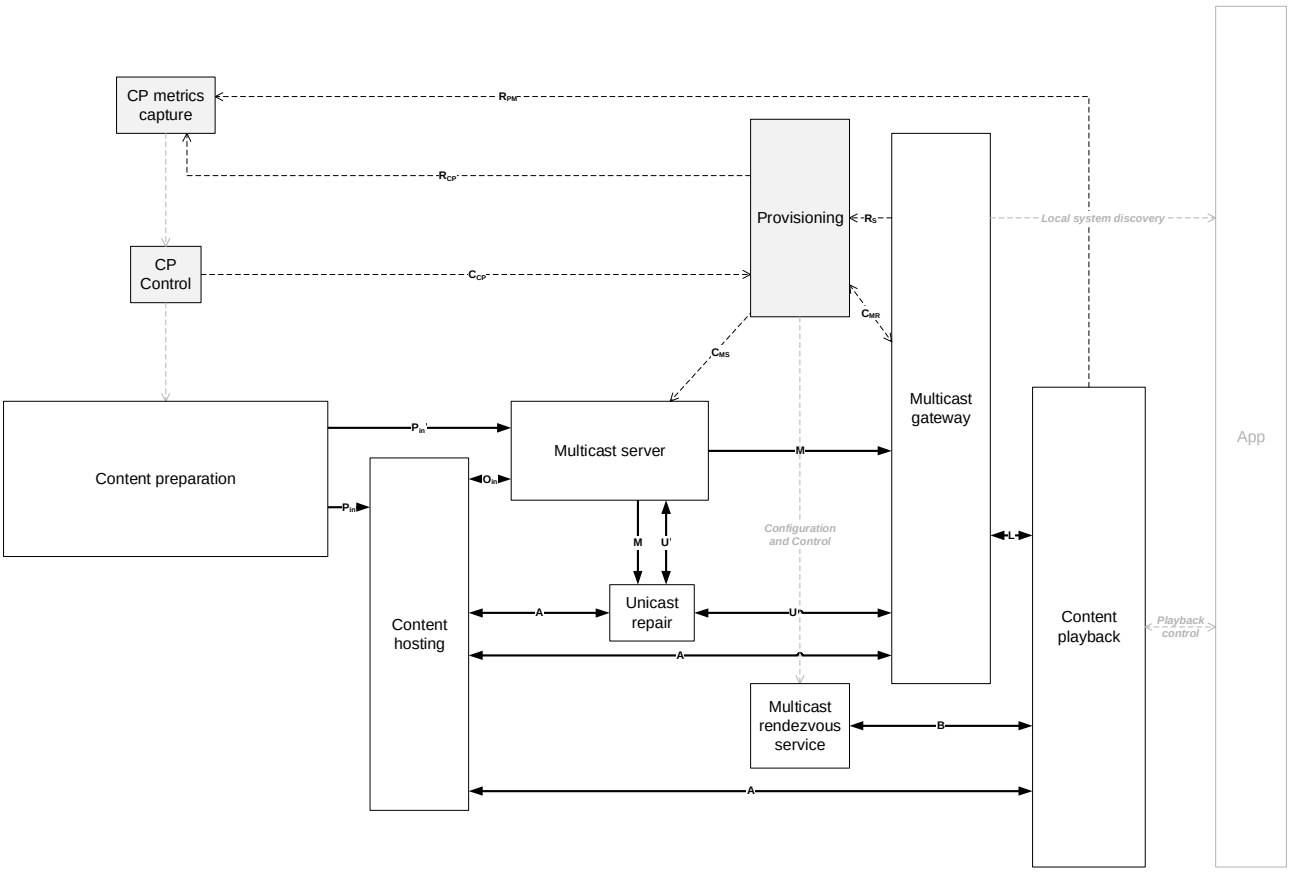


Figure 5.1.0-1: Simplified reference architecture

5.1.1 Data plane reference points

The reference points defined in this clause are used primarily to transport content:

L Unicast HTTP [1] to [6] or HTTPS [1] interaction between a *Content Playback* function and a *Multicast gateway*. This interface includes the fetching of all specified types of content.

NOTE: When a *Multicast gateway* and a *Content playback* function are co-located on a single end device, such as a set-top box (see clause 6.3), reference point **L** may be realized as a local API.

B Bootstrap unicast HTTP(S) interaction directly between a *Content playback* function and a *Multicast rendezvous service* function. Used to request the presentation manifest at the start of a linear playback session, as outlined in clause 5.3.9 and specified in clause 7.5.

A HTTP(S) acquisition from a *Content hosting* function of content not provided over reference point **M**. Used by a *Content playback* function to retrieve content out of scope for reference point **L**. Used in some deployments by a *Unicast repair service* function to retrieve content from a *Content hosting* function in order to effect content repair. Also used by a *Multicast gateway* for retrieving content directly from a *Content hosting* function via unicast when **U** is unable to perform content repair, as specified in clause 9.

M Multicast IP content transmission by a *Multicast server* function and reception by a *Multicast gateway* function and, in some deployments, reception by a *Unicast repair service* function.

U Unicast interaction between a *Unicast repair client* in a *Multicast gateway* and a *Unicast repair service*. This interface may be used to carry the payloads used for content repair functions in addition to the requests for such payloads.

U′ The unicast interaction between a *Unicast repair service* and a *Multicast server* as an alternative to fetching repair content over **A**. This interface may be used to carry the payloads used for content repair functions in addition to the requests for such payloads.

P_{in} Publication of content to a *Content hosting* function by a *Content packaging* subfunction. This could be implemented as a push interface, or content could be pulled on demand from a *Content packaging* function.

O_{in} Ingest of content by a *Multicast server* function from a *Content hosting* function. This is typically implemented as a pull interface.

P_{in}' Ingest of content by a *Multicast server* direct from a *Content packaging* function. This is typically implemented as a push interface.

5.1.2 Control plane reference points

The reference points defined in this clause are used for control signalling and operational reporting.

C_{MS} Control interface for configuration of a *Multicast server* function.

C_{MR} Control interface for configuration of a *Multicast gateway* function.

C_{CP} Control interface for configuration of a *Provisioning* function.

R_S Service reporting by a *Multicast gateway* function to a *Service reporting capture* function.

R_{CP} Service reporting by a *Service reporting capture* subfunction to a *Content Provider metrics reporting capture* function.

R_{PM} Reporting of playback metrics by a *Content playback* function to a *Content Provider metrics reporting capture* function.

5.2 Reference architecture diagram

A diagram of the reference architecture is shown on the next page (figure 5.2-1). Logical functions are depicted as named boxes and these may be nested in cases where a high-level function is composed of several subfunctions. Functions that lie within the scope of the present document are shown with black text. Those beyond the scope of the present document (but relevant to the functional architecture) are depicted with grey text. Functions lying primarily in the data plane are shown with unfilled boxes; control plane functions are shaded.

Data plane interactions are depicted using solid lines. Control plane interactions are depicted using dotted lines. Interactions that lie within the scope of the specification are depicted as black lines with a reference point name. Those beyond the scope of the present document (but relevant to the functional architecture) are shown with grey lines.

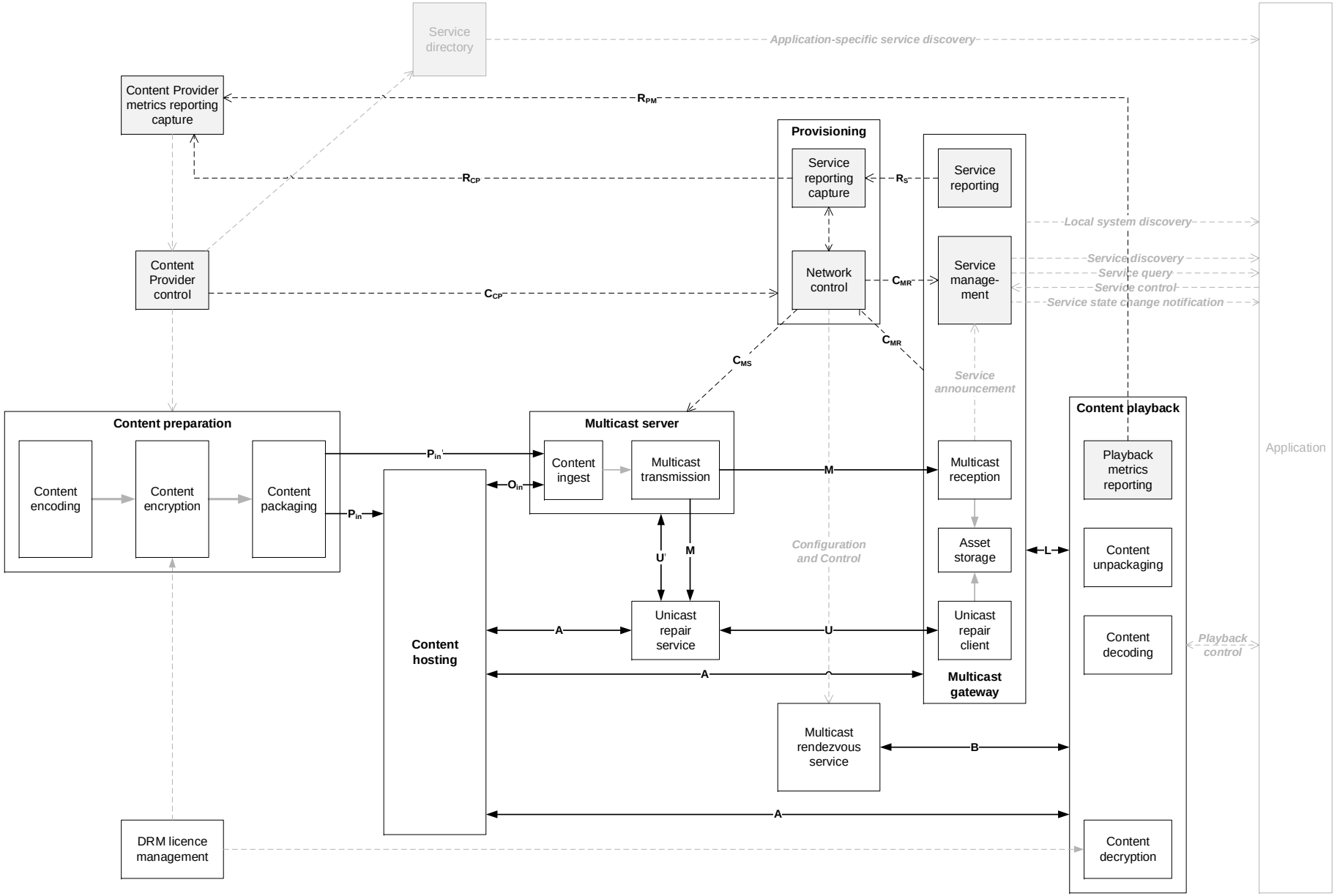


Figure 5.2-1: Reference architecture

5.3 Functions

5.3.1 Content preparation

5.3.1.0 Introduction

The operation of the *Content preparation* function is specified in clause 8.1.

5.3.1.1 Content encoding

The *Content encoding* function transforms source media streams into encoded media with the aim of reducing the bit rate. A single source media stream may be transformed into a number of different encoded representations to match delivery conditions. Virtual segment boundary markers may be placed in the encoded media representation to assist an adaptive *Content playback* function in its operation.

The output of the encoder is a cleartext stream formatted so as to be suitable for ingest by an encrypter or packager. This could, for example, be an MPEG elementary stream, an MPEG-2 Transport Stream, or some other proprietary intermediate format.

5.3.1.2 Content encryption

The *Content encryption* function takes a cleartext stream and encrypts some or all of it to form a ciphertext stream. The encryption keys are obtained from the *DRM licence management* function.

This function is optional in the case where encryption is not a requirement for a particular stream.

5.3.1.3 Content packaging

The *Content packaging* function ingests the media streams of one (or more) encoded representations and formats each one according to a desired packaging format. In the context of dynamic adaptive streaming, the output of the packager is a sequence of packaged media segments with representation switching points that are aligned across different representations of the same source media stream.

Examples of packaging formats are ISO Base Media File Format (also known as fragmented MP4) and fragmented MPEG-2 Transport Stream.

5.3.2 Content hosting

Prepared content is made available by the *Content hosting* function for unicast delivery to the *Multicast server* (for content ingest via reference point **O_{in}**), to the *Multicast gateway* (for cache misses via reference point **A)** to the *Unicast repair service* (also via reference point **A**), or for instances of the *Content playback* function that are not connecting through a multicast receiver (reference point **B**).

The *Content hosting* function may be realized as simple web servers, as part of an origin cluster, or operating as a distributed Content Delivery Network system. As such, load balancing and request distribution techniques (e.g. DNS round-robin, HTTP 302 redirect) may be used to direct clients to the most appropriate content server.

The operation of the *Content hosting* function is specified in clause 8.2.

5.3.3 Multicast server

5.3.3.0 Introduction

The *Multicast server* function ingests content from the configured content sources. In the simple case, media streams are retrieved, typically using the same protocols that a media player might employ, via reference point **O_{in}**.

In the *Multicast server*, the payloads of the ingested media stream are encapsulated into the delivery units of the multicast media transport protocol and transmitted through the *Network* to subscribed *Multicast gateway* clients using IP multicast via reference point **M**.

This entity can be configured by the *Network control* function via reference point **C_{MS}**.

NOTE: This entity uses a Source-Specific Multicast methodology for sending and serving multicast traffic.

The operation of the *Multicast server* function is specified in clause 8.3.

5.3.3.1 Content ingest

Both push and pull content ingest methods are possible for the *Multicast server*:

- **HTTP(S) Pull Ingest via reference point O_{in}:** The subfunction mimics a conventional adaptive streaming media player and downloads packaged media segments from the *Content hosting* function as described by a presentation manifest. In this case, reference point **O_{in}** may be functionally identical to **L** (although its operational behaviour may differ). Segments may, for example, be packaged using MPEG-DASH or HLS. Segments from one or more representations of the presentation may be downloaded simultaneously.

NOTE: DVB DASH, MPEG-DASH, HLS and other manifest formats may be supported.

- **HTTP(S) Push Ingest via reference point P_{in}':** The subfunction offers an HTTP(S) push interface, such as WebDAV [i.3]. The *Content packaging* subfunction uploads media segments to the *Content ingest* function immediately as they are created. Segments may, for example, be packaged using MPEG-DASH or HLS.

- **RTP Push Ingest via reference point P_{in}':** The subfunction offers an RTP-based push ingest mechanism to the *Content packaging* subfunction. The packager sends MPEG-2 Transport Stream packets using RTP. Segment boundaries are marked with virtual segment boundary markers.

5.3.3.2 Multicast transmission

This subfunction is responsible for serializing streams received by the *Content ingest* subfunction and for transmitting the serialized streams in the payloads of IP multicast packets via interface **M**.

5.3.4 Unicast repair service

The *Unicast repair service* offers a payload repair function to the *Unicast repair client* in the *Multicast gateway* via reference point **U**.

The following repair modes could be considered for the *Unicast repair service*:

1) The *Unicast repair service* listens to multicast content transmissions over reference point **M** and locally caches a copy of the packet stream which it uses to satisfy repair requests received from the *Unicast repair client*.

2) If the requested packet(s) cannot be satisfied from the *Unicast repair service*'s cache, packet repair requests may be passed to the *Multicast server* via reference point **U'**.

3) Packet repair requests are converted by the *Unicast repair service* to equivalent HTTP(S) requests (e.g. byte ranges) on the *Content hosting* function using an interface identical to reference point **A**.

4) If near-simultaneous requests for the same repair are received by the *Unicast repair service* from multiple *Multicast gateways*, it may be more efficient for the repair packets to be transmitted using multicast via reference point **M**.

5.3.5 Multicast gateway

5.3.5.0 Introduction

The primary purpose of this function is to provide packaged content segments to the *Content playback* function. The *Multicast gateway* may be realized as a forward proxy or as a local origin (including reverse proxy).

The *Multicast gateway* could be instantiated in customer premises equipment like a home gateway device or IP-connected Set-Top Box (STB). It could also be located in an upstream network node as an alternative to the customer's premises.

Content requests are received, via reference point **L**, from one or more instances of the *Content playback* function and these are serviced either directly from content cached in the *Asset storage* subfunction or indirectly via reference point **A**, with retrieved content then optionally cached in the *Asset storage* subfunction.

Unicast fill operations are performed via reference point **A** until a cache is established in *Asset storage* for a given linear service.

NOTE: Some streams may never be sent using a multicast session, while others may require a short period of time before the cache is established.

The operation of the *Multicast gateway* function is specified in clause 8.4.

5.3.5.1 Service management

The *Service management* subfunction collates multicast session configuration information about multicast content streams available via interface **M** as well as the location(s) of the *Service reporting capture* function. This information may be received from one or more of the following sources:

- Directly from *Network control* via reference point $\mathbf{C_{MR}}$ (see clauses 10.4.4.1 and 10.4.4.2).
- Indirectly via the *Multicast reception* subfunction, in the case where the information is transmitted over reference point **M** (see clauses 10.4.5 and 8.3.5).
- In unicast responses from the *Multicast rendezvous service* function carried over reference point **B** (see clauses 8.5 and 7.5).

5.3.5.2 Multicast reception

The *Multicast reception* subfunction ingests content streams via interface **M** that have been requested by or configured for an end device. Content that has been received intact may also be cached in *Asset storage* for later use. Content damaged in transit may be repaired using any specified mechanism(s) at the *Multicast gateway*'s disposal (e.g. Forward Error Correction, unicast repair by the *Unicast repair client* via **U** or unicast retrieval via **A**) prior to caching. Irreparable content should not be served via reference point **L**.

5.3.5.3 Unicast repair client

Multicast packet loss detection is performed and recovered from using either Forward Error Correction information received via interface **M**, loss recovery using the *Unicast repair service* via interface **U** (e.g. unicast packet retransmission or multicast segment loss signalling) or, as a last resort, unicast fill via reference point **A**.

5.3.5.4 Asset storage

The *Asset storage* subfunction provides temporary storage of assets to be served over reference point **L**. Authority over the storage lies with the *Multicast gateway*.

- Managed pre-positioned media content assets. For example, pre-positioning all or part of a popular asset, or advertising material in advance of its availability date to a large population of users.
- Temporary caching of linear media content segments.

5.3.5.5 Service reporting

Service-related metrics (e.g. telemetry and analytics data) are reported by the *Service reporting* subfunction to the *Service reporting capture* subfunction via interface $\mathbf{R_S}$.

5.3.6 Provisioning

5.3.6.0 Introduction

The purposes of the *Provisioning* function are:

1) To collect service reporting information centrally from the deployed *Multicast gateway* instances.

2) To configure resources in the *Network.*

3) To configure the *Multicast server* to use the configured *Network* resources.

4) To configure the *Multicast gateway* to use the configured *Network* resources.

The *Provisioning* function may be influenced by the *Content Provider control* function via reference point **C_{CP}**.

5.3.6.1 Service reporting capture

Service reporting information captured by the *Multicast gateway* is supplied to the *Service reporting capture* function via reference point **R_S**. The reports may include metrics and other key indicators describing the performance of the service (e.g. cache hit ratio, viewership). The metrics depend on which channels are requested, when channels are established and how many segments are in cache. The service reporting information could be used for instance to improve service performance and to configure multicast channels.

The *Service reporting capture* function may also export service reporting information to the *Content Provider metrics reporting capture* function via reference point **R_{CP}**. This information may include data on multicast content and bit rate.

5.3.6.2 Network control

This function is responsible for controlling, configuring and provisioning *Network* resources. This includes the resources for multicast transmission (over reference point **M**) and well as those for unicast operation (over reference points **U**, **A** and **B**).

In systems with centralized co-ordination, the *Network control* function distributes configuration information about the set of available multicast streams to the *Network* resources and may additionally distribute this configuration information to the *Multicast server* (via **C_{MS}**) and/or to the *Multicast gateway* (via **C_{MR}**). The configuration information about the set of available multicast streams can be updated according to *Content Provider control* policy rules and/or the number of client requests.

5.3.7 Content Provider control

This function uses the control interface **C_{CP}** provided by the *Network control* function to provision information about services that can be made available over the multicast delivery path **M**. A single *Content Provider control* function may be interacting with multiple *Network control* functions, each one of the latter operated by a different network provider.

5.3.8 Content playback

5.3.8.0 Introduction

This is the entity managing the request, reception, decryption and presentation of content. It only supports unicast delivery via reference point **L**. Playback behaviour is agnostic to the delivery path traversed by the content.

The *Content playback* function may be located separately from the *Multicast gateway* on an end device such as a smartphone (clauses 6.1 and 6.2). It may alternatively be combined with a *Multicast gateway*, for example in a set-top box or connected TV set (clause 6.3).

Additional functions of the *Content playback* function are:

- To retrieve, via reference point **B**, a presentation manifest for the linear service.
- To retrieve, via reference point **B**, any content that is not intended to be retrieved via the *Multicast gateway*.

The operation of the *Content playback* function is specified in clause 8.5.

5.3.8.1 Content unpackaging

The *Content unpackaging* subfunction is responsible for extracting elementary stream data from retrieved transport objects and presenting it to the *Content decryption* and *Content decoding* subfunctions. For example, with ISO Base Media File Format segments this involves extracting the appropriate media data box(es), while with MPEG-2 Transport Streams the desired PID is filtered and the payloads of reassembled PES packets are extracted.

5.3.8.2 Content decryption

If a Digital Rights Management system is in operation, the *Content decryption* subfunction is responsible for obtaining appropriate decryption keys from the *DRM licence management* function and for decrypting any encrypted elementary streams.

5.3.8.3 Content decoding

The *Content decoding* subfunction is responsible for parsing and interpreting the contents of elementary media streams, allowing them to be rendered for playback on, for example, a screen or loudspeakers.

5.3.8.4 Playback metrics reporting

The *Playback metrics reporting* subfunction reports information relating to the behaviour and quality of experience of content playback to the *Content Provider metrics reporting capture* function via reference point **R_{PM}**. The metrics may include (but are not limited to) details of HTTP request/response transactions, initial playback delay, buffer level, representation switching events and measured network throughput. The playback metrics reported by this function are directly related to the end user quality of experience and may be used to optimize the experience either at the Content Provider or in the *Network*.

5.3.9 Multicast rendezvous service

The *Multicast rendezvous service* maintains records of managed *Multicast gateway* instances, including their current status, and records of current multicast sessions, including their status. The *Network control* function is responsible for supplying all of this information to the *Multicast rendezvous service*, but the means by which it is supplied lies outside the scope of the present specification.

The *Multicast rendezvous service* handles the initial request from the *Content playback* function at reference point **B** for a presentation manifest. The *Multicast rendezvous service* determines whether there is an active multicast session for the linear service corresponding to the requested presentation manifest, and whether there is an active *Multicast gateway* suitable for use by the requesting *Content playback* function. If at least the second condition is met, the *Multicast rendezvous service* may redirect the request to that *Multicast gateway* instance. Otherwise, the *Multicast rendezvous service* redirects the request to the *Content hosting* function and the session will proceed using unicast only.

The operational procedures for the *Multicast rendezvous service* are specified in clause 7.5.

5.3.10 DRM licence management

This optional entity is responsible for core content protection services, providing appropriate encryption keys to be used by the *Content encryption* function, and supplying licences to the *Content decryption* subfunction to enable the *Content playback* function to decrypt encrypted content.

5.3.11 Application

The *Application* is responsible for controlling the *Content playback* function. Examples include an embedded control application on an integrated television set or set-top box ("EPG application") or a third-party application contributed by a Content Provider. The interface the *Application* function uses to control the *Content playback* function is outside the scope of the present specification, but would generally involve passing a reference to a presentation manifest (e.g. the URL of an MPEG-DASH MPD) to initiate playback of a particular linear service.

The *Application* may interact with the *Service management* subfunction of the *Multicast gateway* in order to discover the existence of linear services and control their reception by the *Multicast gateway*. At the present time, these interactions are also out of scope.

The *Application* may alternatively discover the existence of linear services through a private interaction with an application-specific *Service directory* function. This interaction is also outside the scope of the present document.

5.3.12 Service directory

The *Application* may use a private *Service directory* in order to locate available linear services. The *Service directory* function may be configured by the *Content provider control* function. Because the *Service directory* function is application-specific it is outside the scope of the present document.

6 Deployment models

6.0 Introduction

The reference architecture described in clause 5 is intended to support the deployment models described in this clause.

6.1 Multicast gateway deployed in network edge device

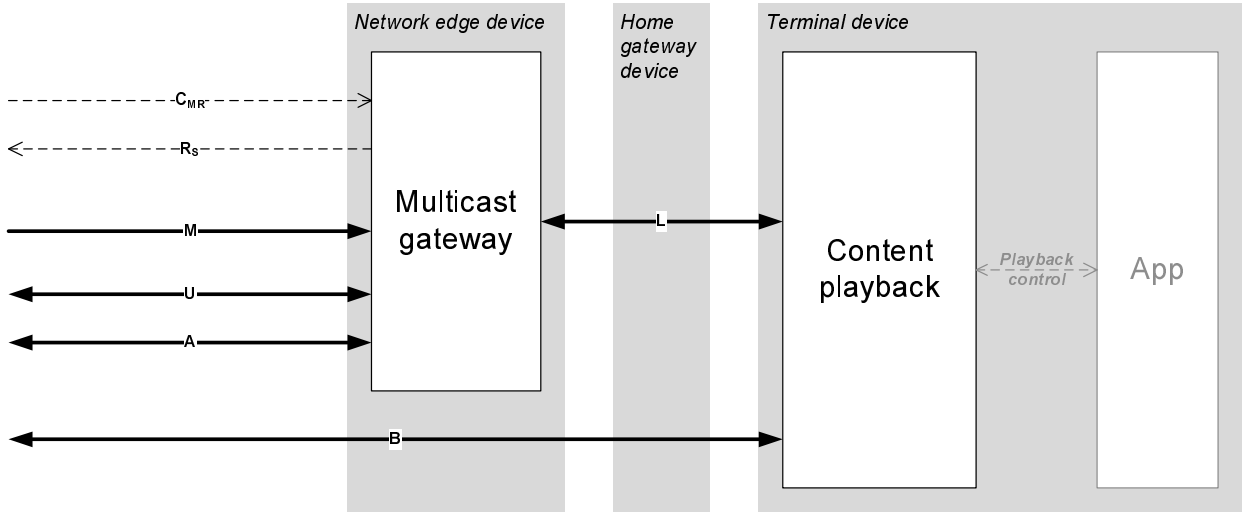


Figure 6.1-1

The terminal device does not support reception of IP multicast from the home network. It includes the *Content playback* function, and loads an *Application* to control linear playback.

The *Multicast gateway* is deployed in a network edge device upstream of the terminal device and provides multicast-to-unicast conversion facilities for several homes. All in-scope traffic on the access network between the network edge device and the home gateway device is therefore unicast.

6.2 Multicast gateway deployed in home gateway device

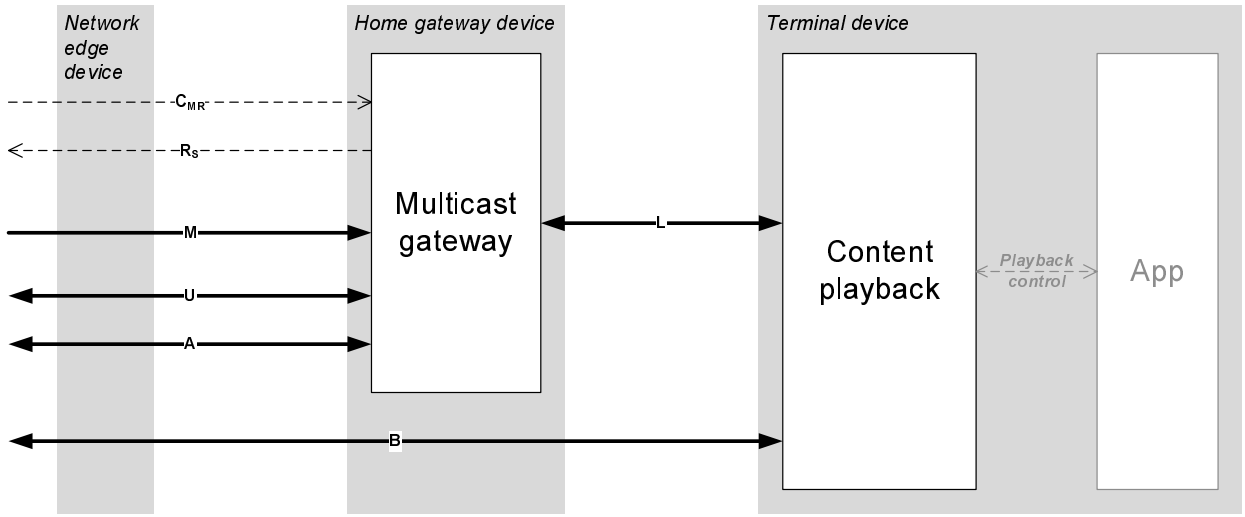


Figure 6.2-1

The *Multicast gateway* is deployed in a home gateway device, such as a router (typically supplied by the Internet Service Provider) and provides multicast-to-unicast conversion facilities for multiple terminal devices in the same home network. These terminal devices each have an instance of the *Content playback* function and load the desired *Application*.

6.3 Multicast gateway deployed in terminal device

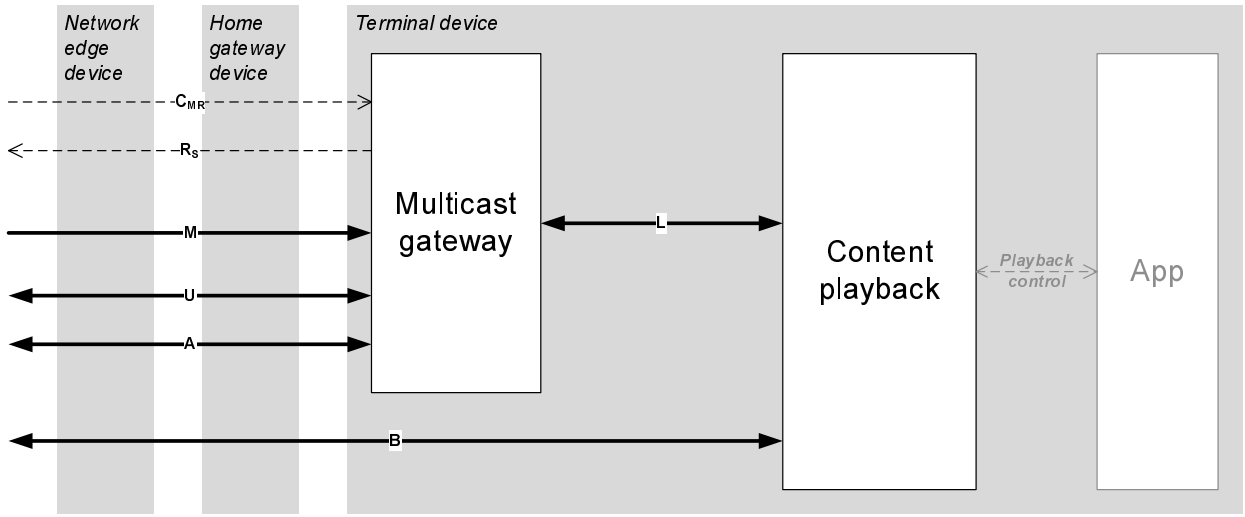


Figure 6.3-1

The terminal device supports reception of IP multicast within the home network. Each such terminal device includes both *Multicast gateway* and *Content playback* functions, and loads its own *Application* to control linear playback. In this deployment model, the *Multicast Gateway* function shall provide content services only to its host terminal device.

The home gateway device performs only multicast group subscription operations. (This may result in unpredictable quality behaviour when the home network does not fully support multicast delivery.)

7 Modes of system operation

7.0 Introduction

Two modes of operation are depicted in the following clauses allowing the support of HTTPS and the support of unidirectional deployment:

- In a **regular deployment** (clause 7.1), the *Multicast rendezvous service* is located in the *Network* and managed by the system operator.
- In a **co-located deployment** (clause 7.2), the *Multicast rendezvous service* is integrated with the *Multicast gateway* in the same entity. It may be used, for example, in the case of a unidirectional deployment scenario.

7.1 Regular deployment

The different functional entities involved in a regular deployment are shown in figure 7.1-1 below and conform to the reference architecture specified in clause 5.

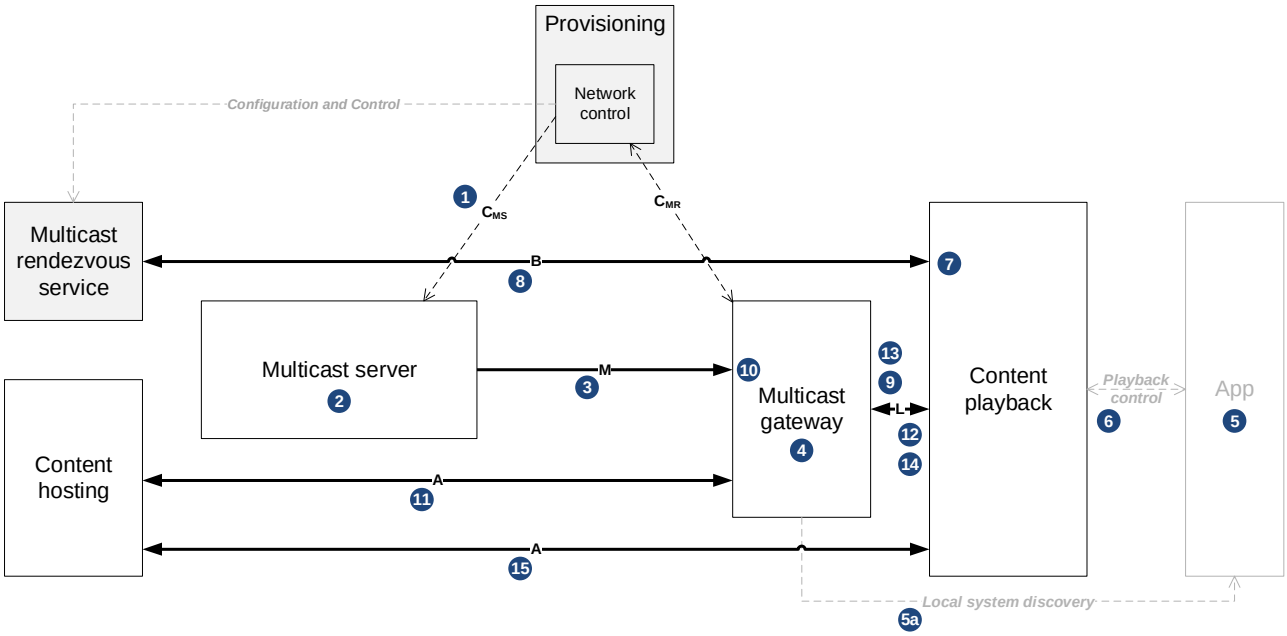


Figure 7.1-1: Regular deployment workflow

The following activities may occur asynchronously at any time:

- The *Multicast gateway* may be configured with the current set of provisioned multicast sessions at reference point **C_{MR}**, or at reference point **C_{MS}** and **M**, as specified in clause 10.1.2.
- The *Multicast gateway* may be configured with a set of basic parameters such as the endpoint address of a multicast gateway configuration transport session, as specified in clause 10.4.5.

The workflow is composed of the following steps:

1) The *Network control* subfunction configures the *Multicast server* with the current provisioned set of multicast sessions. The means for providing the multicast server configuration at reference point **C_{MS}** is specified in clause 10.4.2.

2) Once a multicast session has started, the *Multicast server* retrieves (via reference point **O_{in}**) the presentation manifest and media segments from the configured origin server in the *Content hosting* function (if the multicast session indicates the pull content ingest method), or waits for these to be posted via reference point **P_{in}'** (if the push content ingest method is indicated).

3) The *Multicast server* sends the media segments (and, optionally, the presentation manifest) over the *Network* according to the multicast server configuration.

NOTE 1: Sending over the multicast network does not imply that a *Multicast gateway* is receiving packets from the corresponding multicast transport session. The *Multicast gateway* may be required first to enable multicast IP reception as specified in clause 8.4.2.

4) The *Multicast gateway* is active and discoverable by the *Application* (see clause 7.3).

5) The *Application* obtains the URL of the presentation manifest, for example by interacting with a *Service directory* function such as that specified in [i.6]. This URL points to a remote *Multicast rendezvous service* in the network:

   a) Optionally, the *Application* may discover the *Multicast gateway* by means of local system discovery (see clause 7.3). It discovers the IP address and port number of the *Multicast gateway* and the system operator identifier associated with the *Multicast gateway*. The *Application* includes this information as query parameters in the presentation manifest request URL.

6) The *Application* launches the *Content playback* function with the presentation manifest URL.

NOTE 2: From that point the *Content playback* function behaves as a normal ABR media player. Some control/signalling information may be "piggybacked" as URL query parameters over reference point **L** in a manner that is transparent to the *Content playback* function (see clause 7.5).

7) The *Content playback* function resolves the fully-qualified domain name of the *Multicast rendezvous service*.

8) The *Content playback* function requests the presentation manifest from the *Multicast rendezvous service* via reference point **B** (see clause 7.5). The latter checks the *Multicast gateway* status either in its records or as part of the information "piggybacked" in the request URL (see clause 7.5.2.0), performs access control and sends back a redirect URL referring to the *Multicast gateway* if the requested linear service is part of the multicast session configuration. Otherwise, the redirect URL refers to the *Content hosting* function:

   a) The *Multicast rendezvous service* may "piggyback" in the redirect URL an up-to-date multicast session configuration corresponding to the requested presentation manifest (see clause 7.5.2.1).

The following steps assume that the requested service is part of the multicast session configuration.

9) The *Content playback* function follows the redirect and requests the presentation manifest from the *Multicast gateway*.

10) The *Multicast gateway* subscribes to the relevant multicast transport session(s) according to the configuration of the multicast session in question.

11) If the requested presentation manifest is not already cached (for example, received from a multicast gateway configuration transport session at reference point **M**) the *Multicast gateway* retrieves it from the *Content hosting* function via reference point **A**.

12) The *Multicast gateway* returns the presentation manifest back to the *Content playback* function via reference point **L**.

NOTE 3: From this point the *Content playback* function processes the presentation manifest and commences media playback normally.

13) The *Content playback* function requests a media segment (or presentation manifest) at reference point **L**.

14) If the requested media segment (or presentation manifest) is not already cached by the *Multicast gateway* (e.g. not yet received from the corresponding multicast transport session), the latter retrieves the media segment (or presentation manifest) from the *Content hosting* function at reference point **A**. For a segment retrieval only, the *Multicast gateway* may redirect the request to the *Content hosting* function.

15) In the case where a media segment request is redirected, the *Content playback* function retrieves the media segment from the *Content hosting* function via reference point **A**.

7.2 Co-located deployment

The *Multicast rendezvous* function is co-located with the *Multicast gateway*. This is depicted in figure 7.2-1 below.

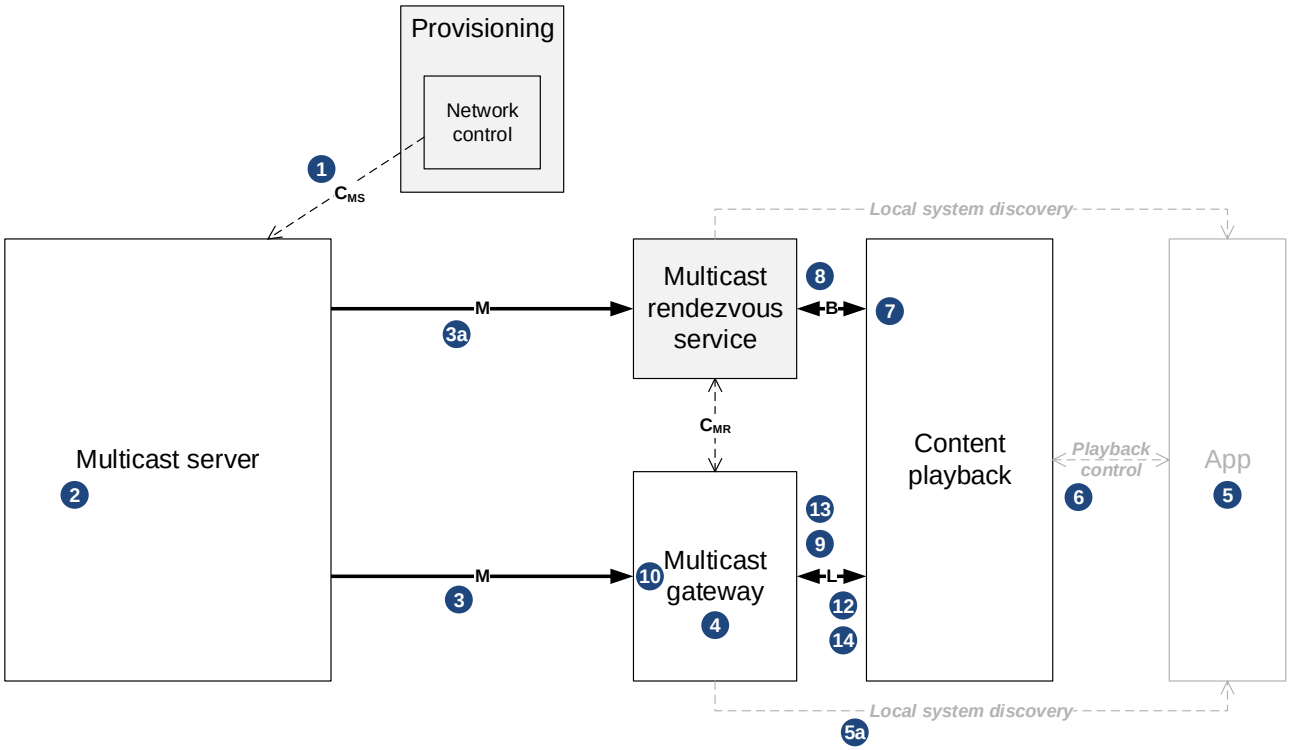


Figure 7.2-1: Co-located deployment workflow

The following activities may occur asynchronously at any time:

- The *Multicast rendezvous service* shall be configured with a set of basic parameters such as the endpoint address of a multicast gateway configuration transport session, as specified in clause 10.4.5.
- The *Multicast gateway* shall be configured with the current set of provisioned multicast sessions at reference point **M**, as specified in clause 10.4.5.

The workflow is composed of the following steps:

1) The *Network control* subfunction configures the *Multicast server* with the current provisioned set of multicast sessions. The means for providing the multicast server configuration at reference point **C_{MS}** is specified in clause 10.4.2.

2) Once a multicast session has started, the *Multicast server* retrieves (via reference point **O_{in}**) the presentation manifest and media segments from the configured origin server in the *Content hosting* function (if the multicast session indicates the pull content ingest method), or waits for these to be posted via reference point **P_{in}'** (if the push content ingest method is indicated).

3) The *Multicast server* sends the presentation manifest(s) as well as the media segments over the *Network* according to the multicast server configuration:

NOTE 1: Sending over the multicast network does not imply that a *Multicast gateway* is receiving packets from the corresponding multicast transport session. The *Multicast gateway* may be required first to enable multicast IP reception as specified in clause 8.4.2.

   a) The *Multicast server* also sends the multicast gateway configuration in a dedicated multicast gateway configuration transport session at reference point **M**. This is described in clause 8.3.5 and clause 10.4.5.

4) The *Multicast gateway* is active and discoverable by the *Application* (see clause 7.3).

5) The *Application* obtains the URL of the presentation manifest, for example by interacting with a *Service directory* function such as that specified in [i.6]. This URL should point to the remote *Multicast rendezvous* function co-localized with the *Multicast gateway*:

   a) Optionally, the *Application* may discover the *Multicast gateway* by means of local system discovery (see clause 7.3). It discovers the IP address and port number of the *Multicast gateway* and the system operator identifier associated with the *Multicast gateway*. The *Application* includes this information as query parameters in the presentation manifest request URL.

NOTE 2: If the presentation manifest request URL has an FQDN in the host part, the *Application* may substitute this FQDN with the IP address and port number of the *Multicast gateway* so discovered.

6) The *Application* launches the *Content playback* function with the presentation manifest URL.

NOTE 3: From that point the *Content playback* function behaves as a normal ABR media player. Some control/signalling information is "piggybacked" as URL query parameters over reference point **L** in a manner that is transparent to the *Content playback* function (see clause 7.5).

7) The *Content playback* function resolves the fully-qualified domain name (if any) of the *Multicast rendezvous service*.

NOTE 4: In the case where a fully qualified Internet domain name is to be resolved, it is assumed that the DNS lookup is processed through a suitable DNS server located either in the Local Area Network, or upstream of it.

8) The *Content playback* function requests the presentation manifest from the *Multicast rendezvous service* via reference point **B** (see clause 7.5). The latter checks the *Multicast gateway* status either in its records or as part of the information "piggybacked" in the request URL (see clause 7.5.2.0), performs access control and sends back a redirect URL referring to the *Multicast gateway* if the requested linear service is part of the multicast session configuration. Otherwise, the redirect URL refers to the *Content hosting* function:

   a) Using information received from the multicast gateway configuration transport session at reference point **M**, the *Multicast rendezvous service* "piggybacks" in its redirect response the current multicast session configuration for the multicast session corresponding to the requested presentation manifest (see clause 7.5.2.1).

The following steps assume that the requested service is part of the multicast session configuration.

9) The *Content playback* function follows the redirect and requests the presentation manifest from the *Multicast gateway*.

10) The *Multicast gateway* subscribes to the relevant multicast transport session(s) according to the configuration of the multicast session in question.

11) If the requested presentation manifest file is not already cached (for example, received from a multicast gateway configuration transport session at reference point **M**) the *Multicast gateway* retrieves it from the *Content hosting* function via reference point **A** (if available).

12) The *Multicast gateway* returns the presentation manifest back to the *Content playback* function via reference point **L**.

NOTE 5: From this point the *Content playback* function processes the presentation manifest and commences media playback normally.

13) The *Content playback* function requests a media segment (or presentation manifest) at reference point **L**.

14) If the requested media segment (or presentation manifest) is not already cached by the *Multicast gateway* (e.g. not yet received from the corresponding multicast transport session), the latter retrieves the media segment (or presentation manifest) from the *Content hosting* function at reference point **A** (if any). For a segment retrieval only, the *Multicast gateway* may instead redirect the request to the *Content hosting* function at reference point **A** (if any), depending on the *Multicast gateway* implementation.

15) In case of redirection, the *Content playback* function retrieves the media segment (or presentation manifest) from the *Content hosting* function via reference point **A** (if available).

7.3 Discovering the Multicast gateway using local system discovery (informative)

An *Application* may discover the presence of a *Multicast gateway* (and possibly a co-located *Multicast rendezvous service*) in its local network using, for example, the multicast DNS protocol specified in IETF RFC 6762 [i.7]. This is useful for obtaining information (identification and status) that may be required for instance when dealing with a third-party CDN broker or in the case of a unidirectional deployment.

For example, if a *Multicast gateway* implements IETF RFC 6762 [i.7], it should respond to a multicast DNS query with its IP address, transport port number and the fully-qualified domain name of its service endpoint in the local network.

Following local system discovery, the *Application* should "piggyback" the discovered information as query parameters in the request URL (targeting the *Multicast rendezvous service*) at reference point **B**, as specified in clause 7.5.1 below. In the case of co-located deployment, the *Application* may substitute the request URL's host name (FQDN) with the IP address of a previously discovered *Multicast rendezvous service* (if co-located with the *Multicast gateway*).

7.4 Discovering the Multicast rendezvous service using third-party CDN broker redirect (informative)

Where a third party, such as a content provider, has a business relationship with the system operator, the discovered presentation manifest URL may point initially to a third-party CDN broker service. This service assists the requesting *Content playback* function in locating a suitable *Multicast rendezvous service*.

The *Content playback* function sends its presentation manifest request to the third-party CDN broker service. The latter determines whether multicast operation is possible and desired for the linear service in question. If so, it responds with an HTTP redirect containing the URL of a *Multicast Rendezvous service* accessible to the *Content playback* function. If required by the *Multicast Rendezvous service*, the redirect URL may also need to include an authentication token, as specified in clause 7.5.1 below.

In order to assist the CDN broker in selecting the most suitable *Multicast rendezvous service*, it is recommended that the initial request to the CDN broker includes a query parameter that identifies the system operator. This identifier could for example be obtained through local system discovery (see clause 7.3 above).

7.5 Multicast rendezvous service operational procedures

7.5.0 Introduction

This clause specifies the interaction at reference point **B** between the *Content playback* function and the *Multicast rendezvous service* (see clause 5.3.9). This is typically a request for a presentation manifest at the start of a presentation session. The presentation manifest URL is typically provided by the *Application* and requested by the *Content playback* function.

7.5.1 Request URL format

The request URL shall comply with the following syntax:

http[s]://*<Host>*/*<ManifestPath>*[?*<field>*=*<value>*[&*<field>*=*<value>*]*]

The elements of the URL are specified in table 7.5.1-1 below. The query parameters carry various optional information useful for the *Multicast rendezvous* service when redirecting a request from the *Content playback* function to a suitable *Multicast gateway*.

Table 7.5.1-1: Syntax of request URL elements

URL element	Use	Data type	Description
Host	1	String	The FQDN (or the IP address) and optionally the port number of the *Multicast rendezvous service*.
ManifestPath	1	String	The resource path for retrieving the presentation manifest from the specified host.
field	0..n		
AToken	0..1	String	The value is an authentication token that authorizes access to the *Multicast rendezvous service*, if required by the system operator. This may have been included in the original presentation manifest URL, it may have been added by a third-party CDN broker as part of an earlier HTTP redirect URL, or it may be generated locally by the *Application*.
MGstatus	0..1	Integer	The value is the current status of the *Multicast gateway*. 0 = inactive 1 = active
MGid	0..1	String	The value is the port number of the *Multicast gateway*, optionally preceded by its IP address. The format shall be [IP address]:port.
MGhost	0..1	String	The value is the *Multicast gateway* host name.
Ori	0..1	String	The value is the host name (FQDN) of the original targeted host. As described in clause 7.3, the *Application* may substitute the original targeted host name (FQDN) with the local *Multicast rendezvous service* host name or address. Moreover, in case of relying on a third-party CDN broker, the latter indicates here the original targeted host name (FQDN) before redirecting the request to the *Multicast rendezvous service* as explained in clause 7.4.
NOTE: URI query components are required to comply with the *query* production specified in Appendix A of [15].			

7.5.2 Operation of Multicast rendezvous service

7.5.2.0 General

After receiving the presentation manifest request from the *Content playback* function (possibly following a third-party CDN broker redirection) the *Multicast rendezvous service* shall first check that the authentication token AToken is valid (if present).

Secondly, the *Multicast rendezvous service* shall identify the appropriate *Multicast gateway* to be associated with the request, either by examining the optional MGId or MGhost request query parameters, or else by consulting its internal configuration.

The *Multicast rendezvous service* shall check whether the status of the selected *Multicast gateway* is active, either by examining the optional MGstatus request query parameter, or else by consulting its internal configuration.

If the selected *Multicast gateway* is active, the *Multicast rendezvous service* shall check whether the requested presentation manifest is associated with a multicast session in the multicast session configuration (whether currently active or not).

- If the presentation manifest is associated with a multicast session in the multicast session configuration (i.e. the service can be delivered through multicast) the *Multicast rendezvous service* shall redirect the request to the selected *Multicast gateway*, as specified in clause 7.5.2.1 below.

```
HTTP/1.1 307 Temporary Redirect
Server: <Multicast gateway>
Location: http[s]://<Multicast gateway>/<ManifestPath>
```

- If the presentation manifest is not associated with a multicast session in the multicast session configuration (i.e. the service will not be delivered through multicast) then the *Multicast rendezvous service* shall redirect the request to the *Content hosting*, either by examining the optional Ori request query parameter, or else by consulting its internal configuration.

```
HTTP/1.1 307 Temporary Redirect
Server: <Content hosting>
Location: http[s]://<Content hosting>/<ManifestPath>
```

7.5.2.1 Redirecting the request to a Multicast gateway

In the case where it accepts a request, the *Multicast rendezvous service* shall return a *307 Temporary Redirect* response. The `Location` HTTP response header shall be a URL that may include a session identifier and/or a query parameter "piggybacking" a multicast gateway configuration instance document containing the multicast session corresponding to the requested presentation manifest.

NOTE: The latter allows configuration of the *Multicast gateway* on a session-by-session basis conforming to the Just-in-time multicast gateway session configuration method (see clause 10.1.2).

The redirect URL in the `Location` response header shall comply with the following syntax:

http[s]://<*Host*>[/<*Session ID*>]/<*ManifestPath*>[?conf=<*multicast session parameters*>]

Table 7.5.2.1-1: Syntax of redirect URL elements

URL element	Use	Data type	Description
Host	1	String	The IP address or FQDN of the Multicast gateway and optionally the port number (for example "router.example:8088" or "192.0.2.1:8088").
Session ID	0..1	String	A unique presentation session identifier communicated (and possibly generated) by the *Multicast rendezvous service* comprising one or more URL path elements.
ManifestPath	1	String	The resource path for retrieving the presentation manifest from the specified host.
conf	0..1	String	The multicast session parameters shall take the form of a multicast gateway configuration instance document (see clause 10.0) comprising one multicast session per clause 10.2.2. The document shall be compressed using Gzip [8] and *base64url*-encoded according to section 5 of IETF RFC 4648 [9] prior to inclusion as a URL query string parameter.
NOTE 1: URI query components are required to comply with the *query* production specified in Appendix A of [15]. NOTE 2: Implementations of the *Multicast gateway* should be able to process long URLs.			

7.5.2.2 Refusing the request

In the case where it refuses a request, the *Multicast rendezvous service* shall respond with one of the following HTTP response status codes:

Table 7.5.2.2-1: Multicast rendezvous service error responses

HTTP status code and reason phrase	Description
401 Unauthorized	The requesting *Content playback* function is not permitted to use the *Multicast rendezvous service*, for example because the authentication token supplied in the request URL is not valid.
404 Not Found	The requested presentation manifest is not known to the *Multicast rendezvous service*.

8 Data plane operations

8.0 Introduction

8.0.0 General

This clause describes operation of the data plane of relevant logical functions in the reference architecture, namely at reference points **P_{in}'**, **O_{in}**, **M**, **A** and **L**.

8.0.1 Low-latency operation (informative)

Special provision is made in the following clauses to support low-latency operation in the data plane:

- When content is pushed into a *Multicast server* at reference point **P_{in}'**, the upload of an ingest object may commence before it has been completely encoded, encrypted and packaged by the sending *Content preparation* function.
- When content is pulled by a *Multicast server* from a *Content hosting* function at reference point **O_{in}**, an ingest object may be made available for download before it has been completely received from the *Content preparation* function.
- A *Multicast server* may pass an ingest object from its *Content ingest* subfunction to its *Multicast transmission* subfunction with minimal buffering to minimize additional internal processing latency.
- If the multicast media transport protocol in use supports a low-latency transmission mode, a *Multicast transmission* subfunction may start to form multicast transmission objects and begin transmitting them at reference point **M** before an ingest object has been completely ingested by the *Content ingest* subfunction.
- A *Multicast gateway* may make a playback delivery object available for download by a *Content playback* function at reference point **L** before the corresponding multicast transmission object has been completely received.
- A *Multicast gateway* may make early use of unicast repair operations at reference point **A** to ensure the timely availability of playback delivery objects to a *Content playback* function at reference point **L**.

NOTE: In order to support low-latency operation, the ingest objects need to be prepared with this in mind, for example as specified in clause 4.2.9 of [10].

8.1 Operation of Content preparation function

When the multicast server configuration indicates the push content ingest method (see clause 10.2.3.4) for a particular multicast transport session, the *Content preparation* function shall deliver ingest objects to the *Multicast server* at reference point **P_{in}'** in a timely manner with respect to the presentation timeline indicated in the presentation manifest. Ingest Interface 2, described in section 6 of the DASH-IF Live Media Ingest Protocol specification [i.4] may be used at this reference point, in which case the *Content packaging* subfunction of the *Content preparation* function plays the role of "Ingest source" and the *Multicast server* plays the role of "Receiving entity".

When the multicast server configuration indicates the pull content ingest method (see clause 10.2.3.4) for a particular multicast transport session, the *Content preparation* function shall deliver ingest objects to the *Content hosting* function at reference point **P_{in}** in accordance with the DVB DASH profile [10], the HTTP Live Streaming specification [i.5] or equivalent.

With either content ingest method the *Content preparation* function may use HTTP/1.1 chunked transfer coding (as specified in section 4.1 of IETF RFC 7230 [1]) at its discretion, but especially to support MPEG-DASH [i.2] content delivery with low latency and/or in cases where the length of a media object is not known at the start of the HTTP upload transaction.

8.2 Operation of Content hosting function

The *Content hosting* function shall make media objects available for retrieval by the *Multicast server* at reference point **O_{in}** in accordance with the DVB DASH profile [10], the HTTP Live Streaming specification [i.5] or equivalent. The *Content hosting* function shall also make media objects available on an identical basis at reference point **A** for retrieval by the *Content playback* function, the *Multicast gateway* and the *Unicast repair* function. The *Content hosting* function shall support HTTP byte range requests according to IETF RFC 7233 [4].

The *Content hosting* subfunction may serve media objects using HTTP/1.1 chunked transfer coding [1] at its discretion, but especially to support low-latency content delivery requirements of MPEG-DASH [i.2] and/or in cases where the length of a media object is not known to the *Content hosting* function when an HTTP request for it is received.

8.3 Operation of Multicast server function

8.3.0 Introduction

The primary data plane function of a *Multicast server* is to receive ingest objects at a *Content ingest* subfunction and to produce multicast transmission objects from a *Multicast transmission* subfunction. The *Content ingest* subfunction shall support the reception of each ingest object in the body of an HTTP message at reference point **P_{in}'** and/or at reference point **O_{in}**. Each received ingest object shall be mapped to one or more multicast transport object(s) according to clause 8.3.3 and transmitted by the *Multicast transmission* subfunction on the associated multicast transport session at reference point **M** in accordance with clause 8.3.4.

8.3.1 Push-based content ingest

When the multicast server configuration indicates the push content ingest method (see clause 10.2.3.4) for a particular multicast transport session, the *Multicast server* shall expect ingest objects to be delivered to it at reference point **P_{in}'** for example using HTTP according to the specification for Ingest Interface 2 in section 6 of the DASH-IF Live Media Ingest Protocol specification [i.4]. In particular, the *Multicast server* shall implement support for HTTP/1.1 chunked transfer coding [1] to support content delivery with low latency and/or in cases where the length of a media object is not known at the start of the HTTP upload transaction.

In the context of [i.4] the *Content packaging* subfunction of the *Content preparation* function shall play the role of "Ingest source" and the *Content ingest* subfunction of the *Multicast server* shall play the role of "Receiving entity".

NOTE: The use of relative paths in the presentation manifest is recommended by clause 7.3.2 of the DASH-IF Live Media Ingest Protocol specification [i.4].

The *Content packaging* subfunction may deliver ingest objects to the *Content ingest* subfunction when the corresponding multicast transport session is in either the inactive or active state, as specified in clause 10.3.0. However, the media objects shall not be forwarded by the *Multicast transmission* subfunction at reference point **M** unless the multicast transport session concerned is in the active state.

8.3.2 Pull-based content ingest

When the multicast server configuration indicates the pull content ingest method (see clause 10.2.3.4) for a particular multicast transport session, the *Multicast server* shall be responsible for retrieving ingest objects using HTTP via reference point **O_{in}** according to the requirements of the DVB DASH profile [10], notably its clause 10.11, or the HTTP Live Streaming specification [i.5] or equivalent. In order to facilitate this, the *Content ingest* subfunction may first need to retrieve (via reference point **O_{in}**) the presentation manifest associated with the parent multicast session (see clause 10.2.2.2).

8.3.3 Mapping of content ingest URL to multicast transport object URI

For each ingest object received by the *Multicast ingest* subfunction, the *Multicast server* shall map the ingest object URL to one or more multicast transport object URIs. Every multicast transport object URI shall be prefixed with the multicast transport object base URI specified for the target multicast transport session, as specified in clause 10.2.3.13. An example mapping can be found in clause E.1.

According to the requirements of the multicast media transport protocol, the multicast transport object URI may be suffixed with one or more query parameters.

In chunked transmission mode (see clause 8.3.4.1 below), where an ingest object is mapped to several multicast transport objects, the multicast transport object URI may be suffixed with additional path elements and/or fragment identifiers, as required by the multicast media transport protocol.

The mapping of content ingest URL to multicast transport object URI is otherwise unspecified.

8.3.4 Emission of multicast transport objects

8.3.4.0 General

The *Multicast transmission* subfunction is responsible for formatting received ingest objects into multicast transport objects according to one (or more) multicast media transport protocols and transmitting them as multicast packets at reference point **M**. The multicast media transport protocol used on each resulting multicast transport session shall be exactly one of those specified in the annexes of the present document.

The *Multicast transmission* subfunction shall emit multicast packets for a multicast transport session only when that multicast transport session is in the active state, as specified in clause 10.3.0.

The configuration parameters for a multicast transport session shall specify at least one multicast transport endpoint address in line with clause 10.2.3.9. A multicast media transport protocol may allow more than one transport endpoint address to be associated with each multicast transport session.

The *Multicast transmission* subfunction shall use information in the ingest objects and/or the presentation manifest to transmit multicast transport objects in such a way to enable their timely reception with respect to the presentation timeline.

The *Multicast transmission* subfunction shall not exceed the maximum bit rate for the multicast transport session signalled per clause 10.2.3.10.

NOTE: This maximum does not account for packet transmission "bursting" downstream of the *Multicast server*. It merely indicates an expectation given ideal network behaviour.

8.3.4.1 Multicast transmission mode

Two multicast transmission modes are defined by this specification and the mode in use for a particular multicast transport session is signalled in the multicast transport session parameters of the multicast server configuration (see clause 10.2.3.5).

- In **resource transmission mode**, one ingest object shall be mapped to one multicast transmission object.
- In **chunked transmission mode**, one ingest object may be mapped to more than one multicast transmission object.

NOTE: In the case where HTTP/1.1 chunked transfer coding [1] has been used to provide the ingest object at $\mathbf{P_{in}'}$ or $\mathbf{O_{in}}$, the mapping from received HTTP chunks to multicast transmission objects need not necessarily be one-to-one.

The formatting of multicast transport objects in these transmission modes shall be defined separately by each multicast media transport protocol.

8.3.4.2 Forward Error Correction

A multicast media transport protocol may specify the use (optional or otherwise) of Application Level Forward Error Correction (AL-FEC) to assist with the recovery of data carried in the payloads of multicast packets lost by the network in transit. The multicast media transport protocol may specify that AL-FEC repair packets are conveyed to the same multicast group as the packets they protect, or that they are addressed to a different multicast group. In either case, the endpoint address of AL-FEC packets shall be signalled according to clause 10.2.3.11.

8.3.4.3 Marking of Random Access Points in multicast transport objects

Some multicast transport objects begin with a Random Access Point and are therefore suitable points for a *Content playback* function to begin decoding the service component. A multicast media transport protocol may specify a means of marking such multicast transport objects, either in the protocol syntax itself, or else in metadata associated with the multicast transport object, to facilitate fast stream acquisition by a *Multicast gateway* as specified in clause 8.4.3.1 below.

NOTE: This is especially useful in chunked transmission mode where a multicast transport object represents part of an ingest object.

8.3.5 Multicast gateway configuration transport session

The *Multicast server* may generate a special multicast transport session at reference point **M** to convey metadata and certain types of media objects to a population of *Multicast gateway* instances. The multicast transmission objects conveyed in this multicast gateway configuration transport session may include (but are not limited to):

- Multicast gateway configuration instance document as specified in clause 10.1.2 (the "in-band configuration method").
- Presentation manifest media objects.

NOTE 1: In the case where a presentation manifest is conveyed in a multicast gateway configuration transport session, the *Multicast server* may manipulate the presentation timeline to compensate for the additional delay introduced by multicast transmission and/or resulting from downstream repair operations.

- Initialization segment media objects for the Representations described by MPEG-DASH presentation manifests (Media Presentation Description documents) [i.2].

The latest version of each multicast transmission object should be transmitted repeatedly on the multicast gateway configuration transport session in order to facilitate their rapid acquisition by a *Multicast gateway*.

NOTE 2: The carousel repetition rates used for different types of multicast transmission object on the multicast gateway configuration transport session are a matter for individual *Multicast server* implementations.

If a multicast gateway configuration transport session is advertised as being available in a deployed system, the *Multicast gateway* should subscribe to it and may cache the latest version of any or all the multicast transport objects it conveys.

8.4 Operation of Multicast gateway function

8.4.0 Introduction

The main purpose of a *Multicast gateway* is to convert multicast transport objects received at reference point **M** into playback delivery objects, as specified in clause 8.4.3 below. In order to do this, the multicast transport URI is mapped to a playback delivery URL, as specified in clause 8.4.4. The presentation manifest may need to be manipulated to achieve these aims, and this is specified in clause 8.4.1.

The *Multicast gateway* exposes playback delivery objects at reference point **L** (specified in clause 8.4.5) in order to service requests from the *Content playback* function.

8.4.1 Handling of presentation manifest

8.4.1.0 General

When a *Multicast gateway* receives an HTTP request for a presentation manifest from the *Content playback* function at reference point **L** it may need to acquire a copy of the corresponding HTTP resource from the *Content hosting* function (via reference point **A**) or from the multicast gateway configuration transport session (via reference point **M**) if it does not already have a valid, unexpired copy cached locally.

NOTE 1: In unidirectional operation mode where the *Multicast gateway* receives the presentation manifest only through reference point **M**, in the case of a cache miss (e.g. the *Multicast gateway* has just booted) the *Multicast gateway* should stall the relevant HTTP request at reference point **L** until the presentation manifest arrives.

During a multicast session, the presentation manifest may be updated. The *Multicast gateway* should keep a copy of the presentation manifest in its *Asset storage* so that it can be served efficiently to the *Content playback* function on request.

The *Multicast gateway* may manipulate the presentation manifest so acquired prior to returning it to the *Content playback* function.

- Where a service component described in the presentation manifest corresponds to an active multicast transport session in the current multicast gateway configuration and its URL (or its base URL) is absolute [15], the host part of its URL (or that of its base URL) shall be adjusted to point at the reference point **L** address of the *Multicast gateway* in accordance with clause 8.4.4 below. Clause E.4 provides an example of how the playback delivery URL is modified.

- Where a service component described in the presentation manifest corresponds to an active multicast transport session in the current multicast gateway configuration, a presentation session identifier may be inserted into its URL (or into its base URL) to allow the *Multicast gateway* to associate subsequent requests for playback delivery objects with the presentation manifest request.

NOTE 2: This may be useful in monitoring playback session performance separately for each *Content playback* instance.

- Where any service component referenced by the presentation manifest corresponds to an active multicast transport session in the current multicast gateway configuration, the presentation timeline signalled in the presentation manifest may be adjusted to allow additional time for Forward Error Correction and/or unicast repair operations (see clause 9) to be performed. This is further elaborated in clause 8.4.1.1 below.

NOTE 3: FEC repair can only be applied after all symbols (source and redundancy) for a source block have been received. The presentation timeline should therefore be delayed at the least by a period equivalent to the transmission time of one source block at the multicast transport session bit rate (signalled according to clause 10.2.3.10) plus the maximum time taken to effect the repair of one source block.

8.4.1.1 MPEG-DASH presentation manifest manipulation (informative)

The *Multicast gateway* may reduce the value of **`MPD/`**`@timeShiftBufferDepth` in the presentation manifest if it exceeds the capacity of its internal cache.

Depending on the value of the relevant **`MulticastSession/`**`@contentPlaybackAvailabilityOffset` attribute in the multicast gateway configuration, the *Multicast gateway* may need to modify the presentation timeline as follows:

- In the case of an MPEG-DASH Media Presentation Description with **`SegmentTemplate`** using *$Time$*, when receiving an updated presentation manifest either through reference point **A** or through reference point **M**, the *Multicast gateway* modifies the presentation manifest exposed over reference point **L** by removing the media segments it has not yet received over reference point **M**.

- In the case of an MPEG-DASH Media Presentation Description with **`SegmentTemplate`** using *$Number$*, the *Multicast gateway* may adjust the value of **`MPD/`**`@availabilityStartTime` to accommodate the potential latency.

NOTE: Modifying the presentation timeline in this way may reduce the usable cache in the *Multicast gateway*, necessitating a further reduction of **`MPD/`**`@timeShiftBufferDepth`.

8.4.2 Acquisition of multicast transport objects

A *Multicast gateway* may begin acquiring multicast transport objects from a multicast transport session before or after a request for a presentation manifest has been received from a *Content playback* function at reference point **L**.

To start acquiring multicast transport objects from a particular multicast transport session in the current multicast session configuration, the *Multicast reception* subfunction shall subscribe to the IP multicast group(s) indicated in the multicast transport endpoint address(es), as specified in clause 10.2.3.9.

A *Multicast gateway* may subscribe to a multicast transport session before that session is in the active state (see clause 10.3.0). A *Multicast gateway* should unsubscribe from a multicast transport session when that session enters the inactive state (see clause 10.3.0).

In the case where multicast packet loss is encountered by the *Multicast reception* subfunction, it may employ Forward Error Correction techniques (if signalled according to clause 10.2.3.11) and/or unicast repair as specified in clause 9 (if signalled according to clause 10.2.3.12) to recover the missing data.

A *Multicast reception* subfunction should verify the integrity and authenticity of received multicast transport objects if the availability of this metadata in the multicast transport session is signalled according to clause 10.2.3.6. Unicast repair may be employed as described in the previous paragraph to acquire the corresponding media object in the case that either the integrity check or the authenticity check fails.

8.4.3 Construction of playback delivery objects

8.4.3.0 General

A *Multicast gateway* shall attempt to reconstruct playback delivery objects from unicast acquisition at reference point **A** and/or the multicast data packets it receives at reference point **M** according to the specification of the multicast media transport protocol signalled in the multicast media transport protocol parameters (see clause 10.2.3.8).

If chunked transmission mode has been specified for a multicast transport session, the *Multicast gateway* shall be responsible for recombining a set of multicast transport objects that comprise the media object into a single playback delivery object at reference point **L**. The recombination recipe (if any) shall be specified separately by each multicast media transport protocol.

Playback delivery objects whose integrity cannot be established by the *Multicast gateway* per clause 8.4.2 above should not be served at reference point **L**.

A *Multicast gateway* may cache the playback delivery objects that it has successfully reconstructed in its *Asset storage* subfunction.

8.4.3.1 Fast acquisition of playback session (informative)

To facilitate fast acquisition of a multicast transport session by a *Multicast gateway*, a *Multicast transmission* subfunction may mark some multicast transport objects with a Random Access Point marker, as specified in clause 8.3.4.3 above. In such cases, the *Multicast gateway* may construct a partial playback delivery object and deliver this at reference point **L**.

NOTE 1: This is particularly useful in chunked transmission mode (clause 8.3.4.1) where a *Multicast gateway* joins a multicast transport session part-way through transmission of a media object. It can wait for the start of the next multicast transport object with a Random Access Point marker and can use this to reconstruct a partial playback delivery object.

NOTE 2: It may be necessary for the *Multicast gateway* to manipulate the presentation manifest to preserve the timing model of the presentation, for example by indicating that the first segment delivered at reference point **L** is shorter than usual.

Alternatively, at the start of the presentation session, a *Multicast gateway* may fetch one or more partial or complete media objects via unicast at reference point **A**.

8.4.4 Mapping of multicast transport object URI to playback delivery object URL

For every service component listed in the presentation manifest that corresponds to a multicast transport session in the current multicast gateway configuration (whether currently active or not), the *Multicast gateway* shall expose a unique playback delivery object URL at reference point **L** for each media object available on that service component in each presentation session. The playback delivery object URL shall be the same irrespective of whether the underlying media object is acquired from an active multicast transport session at reference point **M**, from a unicast repair operation at reference point **A**, or any combination of these sources.

NOTE: At any instant in time, the *Multicast gateway* may have available for download at reference point **L** playback delivery objects in a sliding window that corresponds to a timeshift buffer indicated by the presentation manifest. However, a notional mapping exists for all media objects on relevant service components: past, present and future.

The format of the playback delivery object URL is at the discretion of the *Multicast gateway* implementation, but it may be algorithmically derived from the multicast transport object URI. Example mappings can be found in clause E.4.

In the case where the *Multicast gateway* is deployed in a terminal device (see clause 6.3), the form of the playback delivery object URL is at the discretion of the implementation.

If chunked transmission mode has been specified for a multicast transport session with each ingest object divided into several multicast transport objects, the *Multicast gateway* shall expose a single playback delivery object URL for each media object at reference point **L** that is consistent with the presentation manifest previously delivered.

Any presentation manifest served by the *Multicast gateway* shall be adjusted to reflect the structure of the playback object URL(s) chosen, in accordance with clause 8.4.1 above.

8.4.5 Serving of playback delivery objects

Where playback delivery objects acquired by the *Multicast gateway* are made available at reference point **L** in accordance with the DVB DASH profile [10] (notably its clause 10.11):

- The *Multicast gateway* is required to implement support for HTTP byte range requests [4] at the above reference point.
- The *Multicast gateway* is required to implement support for HTTP/1.1 chunked transfer coding [1] at the above reference point and may use it at its discretion, but especially to support content delivery with low latency and/or cases where the length of a playback delivery object is not known at the start of an HTTP download transaction.

NOTE: Where HTTP/1.1 chunked transfer coding is employed at reference point **L**, the arrangement of chunks in the *chunked-body* (see section 4.1 of IETF RFC 7230 [1]) need not have the same structure as those ingested by the *Content ingest* function at reference points $\mathbf{P_{in}'}$ or $\mathbf{O_{in}}$, nor need the HTTP chunks served at reference point **L** align with the boundaries of the multicast transport objects received at reference point **M** nor the boundaries of media objects retrieved at reference point **A**.

Playback delivery objects may also be made available in accordance with the HTTP Live Streaming specification [i.5] or equivalent.

The *Multicast gateway* may support the Transport Layer Security protocol [7] at reference point **L**.

If chunked transmission mode has been specified for a multicast transport session and low-latency operation is specified in the presentation manifest, the *Multicast gateway* should make the playback delivery object available for download as soon as the playback object URL has been determined. However, the HTTP message body shall not be served until any necessary Forward Error Correction and/or unicast repair operations (see clause 9) have been completed.

8.5 Operation of Content playback function

The purpose of a *Content playback* function is to retrieve and subsequently render media objects from the *Content hosting* function (via reference point **B**), some of which may be redirected to a *Rendezvous service* (also reference point **B**) and/or a *Multicast gateway* (via reference point **L**).

Where these interactions comply with the DVB DASH profile [10] (notably its clause 10.11):

- The *Content playback* function is required to implement support for HTTP byte range requests [4] at the above reference points.
- The *Content playback* function is required to implement support for HTTP/1.1 chunked transfer coding [1] at the above reference points to support content retrieval with low latency and/or cases where the length of a playback delivery object is not known at the start of the HTTP download transaction.

Alternatively, the *Content playback* function may comply with the HTTP Live Streaming specification [i.5] or equivalent.

9 Unicast repair

9.0 Introduction

In cases where a multicast transport object is not received intact by the *Multicast reception* subfunction by the required deadline and the multicast packet loss could not be repaired by the *Multicast gateway* using Forward Error Correction, repair of the media object should be attempted using one of the unicast repair protocols specified in this clause. For example:

1) Multicast transport packets are received by the *Multicast reception* subfunction, but they are in some way corrupt or unusable.

2) Multicast transport packets do not arrive in time to be usable.

3) No multicast transport packets have been received for the media object in question.

An HTTP-based repair protocol is specified in clause 9.2. Unicast repair at reference point **U** is not specified in the present document.

The unicast repair procedure shall not be used in case of unidirectional operation.

If Forward Error Correction is provided as part of a multicast transport session and is used by the *Multicast gateway*, the *Multicast gateway* should wait until the arrival of the last packet of an FEC block including repair symbols, and should attempt to recover the lost packets using these repair symbols, before triggering the unicast repair procedure.

9.1 Triggering unicast repair

The unicast repair procedure may be triggered by the *Multicast gateway* when any of the following conditions occur:

- As soon as packet loss is detected, in the case where no Forward Error Correction is provided as part of the multicast transport session, or when FEC is not used by the *Multicast gateway*.
- If no multicast transport packets have been received within the period of time indicated by the transport object reception timeout specified in clause 10.2.3.12.
- If a timeout timer specified by the multicast media transport protocol expires.
- In order to ensure that a playback delivery object is made available at reference point **L** in a timely manner with respect to the timing constraints of the presentation manifest as modified by the *Multicast server* and/or by the *Multicast gateway*.
- The end of a multicast session (as specified in clause 10.2.3.3) is reached.

The multicast media transport protocol may specify additional requirements or conditions for when the unicast repair procedure is triggered.

Once a unicast repair operation has been triggered, the *Multicast gateway* delays the unicast repair procedure as follows:

- If a fixed back-off period is indicated in the unicast repair parameters for the multicast transport session (see clause 10.2.3.12), the *Multicast gateway* shall delay the unicast repair procedure by this period of time.
- If a random back-off period is indicated in the unicast repair parameters for the multicast transport session (see clause 10.2.3.12), the *Multicast gateway* shall delay the unicast repair procedure by a randomly chosen period of time between 0 and the random back-off period.

NOTE: For a linear service that requires low-latency delivery of media objects, the values of the fixed back-off period and random back-off period should be chosen with care.

For example, if Forward Error Correction is not used in a multicast transport session or FEC is not used by the *Multicast gateway*, the unicast repair procedure will start at the latest:

min{transportObjectReceptionTimeout, multicast media transport protocol-specific object timeout timer}
+ fixedBackOffPeriod + randomBackOffPeriod

9.2 HTTP-based repair protocol

9.2.0 General

The *Multicast gateway* and the *Content hosting* function shall support the use of HTTP/1.1 [1] as the unicast repair protocol at reference point **A**. The *Multicast gateway* and the *Content hosting* function may additionally support the use of HTTP/2 as specified in IETF RFC 7540 [i.1] as the unicast repair protocol. Both the *Multicast gateway* and the *Content hosting* may use HTTPS for either HTTP/1.1 or HTTP/2.

Irrespective of the HTTP protocol version used, the *Multicast gateway* and the *Content hosting* function shall support the use of byte range requests as specified in IETF RFC 7233 [4].

When the individual gaps in the received media object can be identified by the *Multicast gateway*, it should make an HTTP byte range request containing one or more byte ranges. The request and response messages are formatted as specified in clause 9.2.4 below.

If multiple unicast repair endpoints are specified in the multicast session parameters as described in clause 10.2.3.13, the *Multicast gateway* shall choose one of them to send the byte range request(s). If this request is unsuccessful, the *Multicast gateway* may retry the repair procedure using one or more of the remaining unicast repair endpoints.

9.2.1 Selection of unicast repair base URL

Where more than one unicast repair base URL prefix is indicated for a multicast transport session, the *Multicast gateway* shall select exactly one of these to perform the unicast repair operation. The basis on which this selection is made is implementation-specific. For example, the following algorithm describes one possible implementation:

1) Place the unicast repair base URLs declared for the multicast transport session in an ordered list indexed by consecutive positive integers.

2) Sum the non-zero relative weights of all the **`UnicastRepairParameters/BaseURL`** elements.

3) Generate a random integer between 1 and the sum calculated in the previous step and use it to index the list constructed in step 1.

In the below example, three unicast repair base URLs are declared with relative weights of 3, 5 and 2 respectively:

```
<UnicastRepairParameters [...]>
  <BaseURL relativeWeight="3">http://cdn1.example.com/content/</BaseURL>
  <BaseURL relativeWeight="5">http://cdn2.example.com/content/</BaseURL>
  <BaseURL relativeWeight="2">http://cdn3.example.com/content/</BaseURL>
</UnicastRepairParameters>
```

If a random value of 6 is calculated, for example, then the second unicast repair base URL (*cdn2*) is selected, as shown in figure 9.2.1-1:

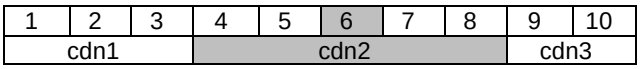


Figure 9.2.1-1: Unicast repair parameters example

9.2.2 Mapping of multicast transport object URI to unicast repair URL

In order to construct the unicast repair URL for a given multicast transport object, the *Multicast gateway* shall remove the prefix (if any) indicated by the multicast transport object base URI specified in clause 10.2.3.13 from the multicast transport object URI and shall substitute the unicast repair base URL prefix (if any) selected in clause 9.2.1 above. An example can be found in clause E.2.

NOTE: HTTPS may be used in the constructed unicast repair URL.

9.2.3 Construction of unicast request URL when no object metadata has been received

When no object metadata has been received for a media object, the *Multicast gateway* shall construct a URL for the purpose of requesting the missing object based on the relevant presentation manifest acquired at reference point **A** or **M**. The unicast request URL shall be of a form that can be addressed to the *Content hosting* function at reference point **A** that is consistent with the requirements of the presentation manifest.

9.2.4 Message format

To request a complete media object, the *Multicast gateway* should use a conventional HTTP GET request. The request URL shall be constructed according to clause 9.2.2 or clause 9.2.3, as appropriate.

To request the missing portion(s) of the media object, the *Multicast gateway* should use the partial HTTP GET request with the `Range` request header as described in IETF RFC 7233 [4]. To improve efficiency, the *Multicast gateway* may use a single partial HTTP GET message to request multiple byte ranges.

If missing data is identified in multiple multicast transport objects, the *Multicast gateway* should use separate HTTP GET requests (partial or otherwise) to repair each object separately:

- If there is an entity tag (e.g. `Etag` response header) present in the metadata for the media object, its value shall be used in the `If-Range` header of the conditional HTTP GET request as described in section 3.2 of IETF RFC 7233 [4]. Strong comparison shall be applied when comparing entity tags as described in section 2.3.2 of IETF RFC 7232 [3].
- Otherwise, the *Multicast gateway* shall send a request message without the `If-Range` header.

The HTTP response message shall be formatted as described in the section 4 of IETF RFC 7233 [4]. The *Content hosting* function may redirect the request to another server.

Example request and response messages can be found in clause E.3.

10 Multicast session configuration

10.0 Introduction

The *Multicast server* and the *Multicast gateway* need to have a common view on the set of multicast transport sessions that are currently defined in a deployed system so that the latter knows which multicast transport sessions it can subscribe to, as specified in clause 8.4.2. The concrete embodiment of this logical state is referred to in the present specification as the **multicast session configuration** and is realized as an XML instance document - the **multicast session configuration instance document** - whose data model is specified in clause 10.2 below and whose schema is specified in annex A:

- In the case of the *Multicast server*, the current configuration is referred to as the **multicast server configuration** and is embodied in a **multicast server configuration instance document**. An example can be found in clause C.1.
- For the *Multicast gateway*, the current configuration is the **multicast gateway configuration** and is embodied in a **multicast gateway configuration instance document**. An example can be found in clause C.3.

Certain configuration parameters of interest to the *Multicast gateway* may be included in the multicast server configuration but not interpreted by the *Multicast server*. These are intended to be transmitted to the *Multicast gateway* in a multicast gateway configuration transport session (see the "In-band configuration method" in clause 10.1.2 below).

10.1 Control system arrangement

10.1.1 Configuration of Multicast server

A *Multicast server* shall be configured using exactly one of the two following methods:

1) **Out-of-band pushed configuration method** whereby the *Network control* function delivers a multicast server configuration instance document instance to the *Multicast server* across reference point **C_{MS}**. The procedure for this method is specified in clause 10.4.2.1.

2) **Out-of-band pulled configuration method** whereby the *Multicast server* periodically polls the *Network control* function for the current multicast server configuration document instance across reference point **C_{MS}**. The procedure for this method is specified in clause 10.4.2.2.

10.1.2 Configuration of Multicast gateway

In a given deployed system, all *Multicast gateway* instances shall be configured using one or more of following methods:

1) **Out-of-band pushed configuration method** whereby the *Network control* function delivers a multicast gateway configuration document instance across reference point **C_{MR}**. The procedure for this method is specified in clause 10.4.4.1.

2) **Out-of-band pulled configuration method** whereby the *Multicast gateway* periodically polls the *Network control* function for the current multicast gateway configuration document instance across reference point **C_{MR}**. The procedure for this method is specified in clause 10.4.4.2.

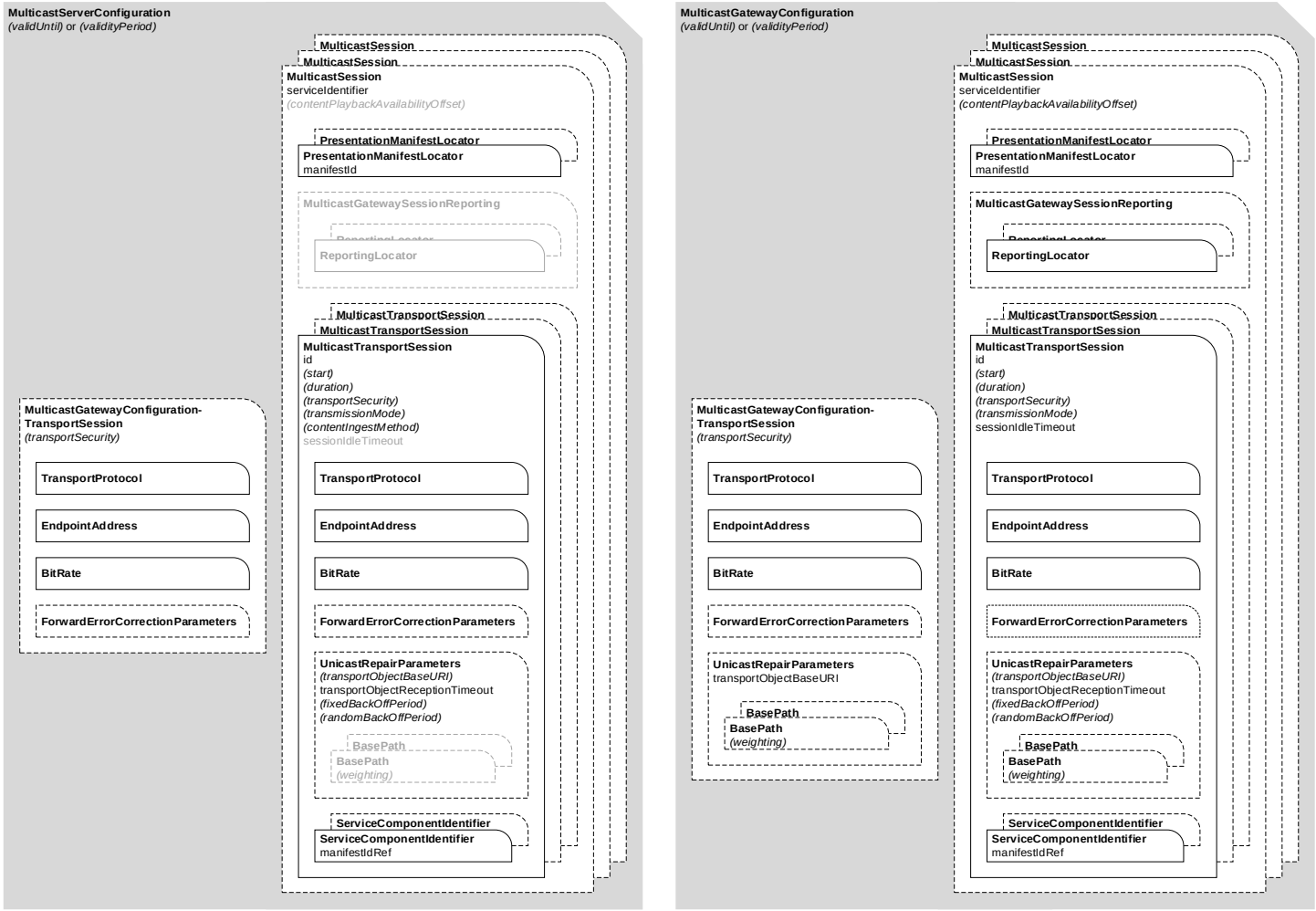
3) **In-band configuration method** whereby the *Multicast server* carousels the current multicast gateway configuration instance document instance via a configured multicast gateway configuration transport session at reference point **M** in accordance with clause 8.3.5. In this case the *Multicast server* shall be responsible for generating the multicast gateway configuration instance document based on its current multicast server configuration received over reference point **C_{MS}**. The procedure for this method is specified in clause 10.4.5.

NOTE: If the *Multicast rendezvous service* is co-located with the *Multicast gateway* (this is mandatory in case of unidirectional operation) then it can consume the multicast gateway configuration instance document and can therefore be configured through the in-band configuration method.

4) **Just-in-time configuration method** whereby the *Multicast rendezvous service* includes a single set of multicast session parameters in its redirect response to a *Content playback* function when a presentation manifest is requested via reference point **B**. The procedure for this method is specified in clause 7.5.

10.2 Multicast session configuration instance document data model

10.2.0 Overview



NOTE: Only Principal elements and selected attributes are depicted. Dotted lines indicate optional elements. Parenthesised italics denote optional attributes. Items in grey are passed through from the multicast server configuration to the multicast gateway configuration

Figure 10.2-1: Overview of the multicast server configuration instance document (left) and multicast gateway configuration instance document (right)

10.2.1 Document root element

10.2.1.0 General

A multicast session configuration instance document describes an intended configuration of multicast sessions and multicast transport sessions in a deployed system.

Multicast session configuration instance documents shall comply with the XML schema definition in annex A. Documents complying with the present version of this specification shall declare the following XML schema name space:

urn:dvb:metadata:MulticastSessionConfiguration:2019

The root element for a multicast server configuration instance document shall be **`MulticastServerConfiguration`** as specified in clause 10.2.1.1 below.

The root element for a multicast gateway configuration instance document shall be **`MulticastGatewayConfiguration`** as specified in clause 10.2.1.2 below.

In system deployments employing the *Multicast gateway* in-band configuration method (see clause 10.1.2 above) the multicast session configuration shall specify one or more multicast gateway configuration transport sessions according to clause 10.2.5 below.

A multicast session configuration instance document shall specify zero or more multicast sessions in the system according to clause 10.2.2 below.

Multicast session configuration instance documents may have an associated validity expressed as either:

1) A fixed period of time since the document was received, using the `@validityPeriod` attribute of the document root element. The value of this attribute shall comply with clause 5.5.2 of ISO 8601-1 [11], but excluding the alternative format specified in clause 5.5.2.4 of [11]. After this period has elapsed the document and its contents shall be deemed to be have expired.

2) As an absolute point in time, using the `@validUntil` attribute of the document root element. The value of this attribute shall comply with the *TimePoint* datatype specified in clause 6.4.3 of MPEG-7 Part 5 [12]. At this point in time the document and its contents shall by deemed to be have expired.

NOTE 1: The MPEG-7 *TimePoint* datatype is a restricted subset of ISO 8601-1 clause 5.4 [11].

NOTE 2: It is not possible to indicate the use of Coordinated Universal Time (UTC) using the UTC designator *Z* with this datatype. Per clause 6.4.3 of MPEG-7 Part 5 [12], if no time zone is specified a time zone of 00:00 is assumed rather than local time.

A multicast session configuration instance document that includes both of the above validity attributes shall be deemed to expire at whichever indicates the later expiry.

If neither attribute is specified, the expiry of a received multicast session configuration instance document may be determined by the use of other metadata, such as HTTP `Cache-Control` or `Expires` response headers [5].

In any case, the multicast session configuration contained in the instance document shall be deemed to be null and void after the point of expiry, and the recipient should discard that configuration.

A multicast gateway configuration instance document carouselled in a multicast gateway configuration transport session at reference point **M** (see clause 8.3.5) shall not include the `@validityPeriod` attribute.

10.2.1.1 MulticastServerConfiguration root element

The syntax of the **`MulticastServerConfiguration`** element (the root element of a multicast server configuration instance document) is specified in table 10.2.1.1-1 below.

Table 10.2.1.1-1: MulticastServerConfiguration element syntax

Element or attribute name	Use	Data type	Clause	Description
`MulticastServerConfiguration`			10.2.1.0	Root element of the multicast server configuration instance document.
`@validityPeriod`	0..1	Duration	10.2.1.0	Time period after receipt for which this instance document is valid. If this attribute is present, then `@validUntil` should not be present.
`@validUntil`	0..1	dateTime	10.2.1.0	Deadline after which this instance document ceases to be valid. If this attribute is present, then `@validityPeriod` should not be present.
`MulticastGatewayConfiguration TransportSession`	0..n		10.2.5, 8.3.5	Container for multicast gateway configuration transport session parameters.
`MulticastSession`	0..n		10.2.2	Container for multicast session parameters.

10.2.1.2 MulticastGatewayConfiguration root element

The syntax of the **`MulticastGatewayConfiguration`** element (the root element of a multicast gateway configuration instance document) is specified in table 10.2.1.2-1 below.

Table 10.2.1.2-1: MulticastGatewayConfiguration element syntax

Element or attribute name	Use	Data type	Clause	Description
`MulticastGatewayConfiguration`			10.2.1.0	Root element of the multicast gateway configuration instance document.
`@validityPeriod`	0..1	Duration	10.2.1.0	Time period after receipt for which this instance document is valid. If this attribute is present, then `@validUntil` should not be present. If the *Multicast gateway* has received the multicast gateway configuration via a cached resource and this attribute is present, then the value shall be reduced by the cache age.
`@validUntil`	0..1	dateTime	10.2.1.0	Deadline after which this instance document ceases to be valid. If this attribute is present, then `@validityPeriod` should not be present.
`MulticastGatewayConfiguration TransportSession`	0..n		10.2.5	Container for multicast gateway configuration transport session parameters.
`MulticastSession`	0..n		10.2.2	Container for multicast session parameters.

10.2.2 Multicast session parameters

10.2.2.0 General

A multicast session describes a set of multicast transport sessions (specified in clause 10.2.3 below) that convey components of a particular linear service. The multicast session parameters are used by a *Multicast server* to configure its *Multicast transmission* subfunction. The multicast session parameters are used by a *Multicast gateway* to configure its *Multicast reception* subfunction.

Each multicast session is specified using a separate **`MulticastSession`** element in the multicast session configuration instance document.

A multicast session shall be assigned a service identifier that is unique within the scope of the deployed system and this is conveyed in the `@serviceIdentifier` attribute. This service identifier may be used to cross-reference descriptive metadata for the linear service in question, such as that specified in [i.6].

To account for delay in the transmission and repair of multicast transport objects, the *Multicast gateway* may be instructed to delay the presentation timeline (e.g. by manipulating the presentation manifest or by delaying the advertised availability of the corresponding playback delivery objects). The `@contentPlaybackAvailabilityOffset` attribute may be used to specify the length of this delay. The value of this attribute shall be a time interval, as specified in clause 5.5.2 of ISO 8601-1 [11], but excluding the alternative format specified in clause 5.5.2.4 of [11]. If omitted, the delay shall be assumed to be zero. When the *Multicast gateway* in-band configuration method is used at reference point **M** (per clauses 8.3.5 and 10.2.5) this attribute and its value shall be copied from the multicast server configuration instance document into the corresponding multicast session of the multicast gateway configuration instance document. For other *Multicast gateway* configuration methods, this attribute should be omitted from the multicast server configuration instance document.

10.2.2.1 MulticastSession element

The syntax of the **`MulticastSession`** element is specified in table 10.2.2.1-1 below:

Table 10.2.2.1-1: MulticastSession element syntax

Element or attribute name	Use	Data type	Clause	Description
`MulticastSession`			10.2.2	
`@serviceIdentifier`	1	URI string	10.2.2.0	Service identifier for the logical service with which this session is associated.
`@contentPlaybackAvailabilityOffset`	0..1	Duration string	10.2.2.0	Availability time offset adjustment applied to the original presentation manifest when passed to instances of the *Content playback* function.
`PresentationManifestLocator`	1..n	URI string	10.2.2.2	URL of a presentation manifest for the linear service.
`@manifestId`	1	Name Token string	10.2.2.2	Uniquely identifies this presentation manifest within the scope of a multicast session.
`@contentType`	1	MPEG-7 *mimeType*	10.2.2.2	The MIME content type of this presentation manifest.
`MulticastGatewaySessionReporting`	0..1		10.2.2.3	Container for multicast session reporting parameters.
`ReportingLocator`	1..n	URI String	10.2.2.3	Container for a multicast gateway reporting endpoint.
`@proportion`	0..1	Decimal	10.2.2.3	Proportion of *Multicast gateway* instances that should send session reports to the specified endpoint.
`@period`	1	Duration string	10.2.2.3	Session reporting periodicity.
`@randomDelay`	1	Unsigned Integer	10.2.2.3	An additional random period that a *Multicast gateway* should delay between sending session reports.
`MulticastTransportSession`	0..n		10.2.3	Container for multicast transport session parameters.

10.2.2.2 Presentation manifest locator

The URLs of presentation manifests related to the linear service shall be conveyed in one or more **`PresentationManifestLocator`** child elements of **`MulticastSession`**.

NOTE: This allows presentation manifests of different types that reference a common stream of media objects to be associated with a single set of multicast transport sessions.

Every **`PresentationManifestLocator`** element shall carry an identifier in its `@manifestId` attribute that is unique within the scope of its parent **`MulticastSession`**. This identifier is used when associating service components with multicast transport sessions, as specified in clause 10.2.4.

The MIME media type [14] of the presentation manifest shall be indicated using the `@contentType` attribute of the **`PresentationManifestLocator`** element as follows:

Presentation manifest type	MIME media type(s)
DASH Media Presentation Description (MPD)	*application/dash+xml*
HLS Master Playlist	*application/vnd.apple.mpegURL* or *audio/mpegurl*

10.2.2.3 Multicast gateway session reporting parameters

A *Multicast gateway* may be configured to report session metrics to an external *Service reporting capture* subfunction using the optional **`MulticastGatewaySessionReporting`** child element of **`MulticastSession`**.

One or more reporting endpoints shall be declared inside the **`MulticastGatewaySessionReporting`** element, each endpoint specified as a URL in the content of a separate **`ReportingLocator`** element. The use of this endpoint locator is specified in clause 11:

- The `@proportion` attribute should be used to indicate what proportion of *Multicast gateway* instances in the deployed system should report to the endpoint specified in the enclosing **`ReportingLocator`** element. Omitting this attribute indicates that all *Multicast gateway* instances should report.
- The `@period` attribute shall be used to indicate the time gap between consecutive reports being submitted by the *Multicast gateway*.
- The `@randomDelay` attribute shall be used by the *Multicast gateway* as an additional delay after the above time gap.

When the *Multicast gateway* in-band configuration method is used at reference point **M** (per clauses 8.3.5 and 10.2.5) the **`MulticastGatewaySessionReporting`** element and all its children shall be copied from the multicast server configuration instance document into the corresponding multicast session of the multicast gateway configuration instance document. For other *Multicast gateway* configuration methods, the **`MulticastGatewaySessionReporting`** element should be omitted from the multicast server configuration instance document.

10.2.3 Multicast transport session parameters

10.2.3.0 General

The parameters of each multicast transport session are captured in a separate **`MulticastTransportSession`** child element of **`MulticastSession`**. Each such multicast transport session is explicitly associated with service component(s) in the presentation manifest(s), as described in clause 10.2.4 below.

10.2.3.1 MulticastTransportSession element

The syntax of the **`MulticastTransportSession`** element is specified in table 10.2.3.1-1 below:

Table 10.2.3.1-1: MulticastTransportSession element syntax

Element or attribute name	Use	Data type	Clause	Description
`MulticastTransportSession`			10.2.3	Container for multicast transport session parameters
`@id`	1	Name Token string	10.2.3.2	Uniquely identifies a multicast transport session within the scope of its parent multicast session. The assignment of this value is implementation-specific.
`@start`	0..1	MPEG-7 *TimePoint*	10.3.1	Start time of the multicast transport session.
`@duration`	0..1	Duration string	10.3.1	Duration of the multicast transport session.

Element or attribute name	Use	Data type	Clause	Description
@contentIngestMethod	0..1	String	10.2.3.4	Indicates how ingest objects for this multicast transport session are made available to the *Multicast server*. If a *Multicast gateway* receives this attribute, it shall be ignored.
@transmissionMode	0..1	String	10.2.3.5	Indicates whether ingest objects for this multicast transport session are mapped to one or more multicast transmission objects. If present, it shall take the value of *resource* or *chunked*.
@transportSecurity	0..1	String	10.2.3.6	Indicates which security features are enabled in this multicast transport session.
@sessionIdleTimeout	1	Integer	10.2.3.7	The period of time a *Multicast gateway* should wait for new packets on this multicast transport session before assuming the session is inactive. *Multicast server* functions shall ignore this attribute.
TransportProtocol	1		10.2.3.8	Container for multicast media transport protocol parameters.
@protocolIdentifier	1	MPEG-7 *termReference*	10.2.3.8	A fully-qualified term identifier URI from *MulticastTransportProtocolCS* (clause B.1) specifying the multicast media transport protocol used for this multicast transport session.
@protocolVersion	1	String	10.2.3.8	Indicates the version of the multicast media transport protocol.
EndpointAddress	1..n		10.2.3.9	Container for the addressing parameters of this multicast transport session.
NetworkSourceAddress	0..1	String	10.2.3.9	A host name or IP address specifying the multicast group source address for use with source-specific multicast transport.
NetworkDestinationGroup Address	1	IP address string	10.2.3.9	An IP address specifying a multicast group for the multicast transport session.
TransportDestinationPort	1	Unsigned 16-bit integer	10.2.3.9	The UDP port number of the multicast transport session.
MediaTransportSession Identifier	0..1	Positive integer	10.2.3.9	An opaque transport session identifier specified by the multicast media transport protocol.
BitRate	1		10.2.3.10	Container specifying the bit rate(s) of the multicast transport session across all declared endpoint addresses and including any FEC overheads.
@average	0..1	Positive integer	10.2.3.10	The average bit rate of the multicast transport session.
@maximum	1	Positive integer	10.2.3.10	The maximum bit rate of the multicast transport session.

Element or attribute name	Use	Data type	Clause	Description
ForwardErrorCorrectionParameters	0..n		10.2.3.11	Container for the parameters of the FEC repair blocks protecting the multicast transport session.
SchemeIdentifier	1	MPEG-7 *termReference*	10.2.3.11	A fully-qualified term identifier URI from *ForwardErrorCorrection SchemeCS* (clause B.2) specifying the scheme of the FEC repair blocks protecting the multicast transport session.
OverheadPercentage	1	Positive integer	10.2.3.11	Percentage of FEC overhead compared with source packets. For example, a value of 20 means 20 % overhead, 100 means there is a repair packet for every source packet. Values greater than 100 are permitted.
EndpointAddress	0..n		10.2.3.9	Container for the addressing parameters of FEC repair blocks protecting this multicast transport session. May be omitted if FEC repair packets are carried in band with the multicast transport session.
NetworkSourceAddress	0..1	String	10.2.3.9	An optional host name or IP address specifying the source address of FEC repair packets protecting this multicast transport session.
NetworkDestinationGroup Address	1	IP address string	10.2.3.9	An IP address specifying the multicast group for FEC repair packets protecting this multicast transport session.
TransportDestinationPort	1	Unsigned 16-bit integer	10.2.3.9	The UDP port number of FEC repair packets protecting this multicast transport session.
MediaTransportSession Identifier	0..1	Positive integer	10.2.3.9	An opaque transport session identifier of FEC repair packets protecting this multicast transport session.
UnicastRepairParameters	0..1		10.2.3.12	Container for parameters pertaining to unicast repair.
`@transportObjectBaseURI`	0..1	URI string	10.2.3.13	Multicast transport object base URI. The base URI of all multicast transport objects conveyed in this multicast transport session.
`@transportObjectReception Timeout`	1	Unsigned integer	10.2.3.12	The period of time (in milliseconds) that a *Multicast gateway* should wait for a packet relating to a multicast transport object before assuming that the object transmission is over.
`@fixedBackOffPeriod`	0..1	Unsigned integer	10.2.3.12	The minimum number of milliseconds that the *Multicast gateway* shall wait after the end of object transmission before attempting unicast repair.
`@randomBackOffPeriod`	0..1	Unsigned integer	10.2.3.12	Maximum number of milliseconds for the random delay period that the *Multicast gateway* shall wait in addition to `@fixedBackOffPeriod`.

Element or attribute name	Use	Data type	Clause	Description
BaseURL	0..n	URI string	10.2.3.13	Unicast repair base URL prefix. The base path of a unicast repair endpoint.
@relativeWeight	0..1	Unsigned integer	10.2.3.13	A relative weighting for this unicast repair endpoint.
ServiceComponentIdentifier	1..n		10.2.4	Linkages between this multicast transport session and service components(s) in presentation manifest(s) declared by the parent multicast session.

10.2.3.2 Multicast transport session identifier

Every multicast transport session shall be assigned an identifier, indicated using the `@id` attribute of the **`MulticastTransportSession`** element. This identifier shall be unique within the scope of the enclosing multicast session.

NOTE: This identifier is used, in combination with the `@serviceIdentifier` attribute of the parent multicast session, to manually (de)activate the multicast transport session, as specified in clause 10.3.2.

10.2.3.3 Multicast transport session timing

The start time and duration of the multicast transport session may be specified using the `@start` and `@duration` attributes respectively of the **`MulticastTransportSession`** element. The values of these attributes shall be set in accordance with clause 10.3.1.

If desired, the multicast transport session start time shall be indicated using the `@start` attribute. The value of this attribute shall comply with the *TimePoint* datatype, as specified in clause 6.4.3 of MPEG-7 Part 5 [12].

NOTE 1: The MPEG-7 *TimePoint* datatype is a restricted subset of ISO 8601-1, clause 5.4 [11].

NOTE 2: With this datatype it is not possible to indicate Coordinated Universal Time (UTC) using the UTC designator *Z*. Per clause 6.4.3 of MPEG-7 Part 5 [12], if no time zone is specified a time zone of 00:00 is assumed rather than local time.

If desired, the multicast transport session duration shall be indicated using the `@duration` attribute.

10.2.3.4 Content ingest method

The means by which ingest objects are to be acquired by the *Multicast server* may be indicated in a multicast server configuration instance document using the `@contentIngestMethod` attribute of the **`MulticastTransportSession`** element as follows:

- **Push content ingest method.** If ingest objects are to be pushed to the *Content ingest* subfunction at reference point **P_{in}'** (as specified in clause 8.3.1) then the attribute shall have the value *push*.
- **Pull content ingest method.** If ingest objects are to be pulled by the *Content ingest* subfunction from a *Content hosting* function at reference point **O_{in}** (as specified in clause 8.3.2) then the attribute shall have the value *pull*.

If this attribute is omitted, the pull content ingest method shall be assumed by a *Multicast server*.

The `@contentIngestMethod` attribute shall not be present in multicast gateway configuration instance documents.

10.2.3.5 Multicast transmission mode

The means by which a *Multicast server* is to map ingest objects to multicast transport objects may be indicated in a multicast server configuration instance document using the `@transmissionMode` attribute of the **`MulticastTransportSession`** element as follows:

- **Resource transmission mode.** If one ingest object is mapped to one multicast transport object then the attribute shall have the value *resource*.
- **Chunked transmission mode.** If one ingest object is mapped to more than one multicast transport objects (e.g. each HTTP chunk of an ingest object mapped to a separate multicast transport object) then the attribute shall have the value *chunked*.

If this attribute is omitted, resource transmission mode shall be assumed.

The `@transmissionMode` attribute should be present in multicast gateway configuration instance documents to signal the multicast transmission mode to the *Multicast reception* subfunction of the *Multicast gateway*.

10.2.3.6 Multicast transport security mode

The *Multicast transmission* subfunction may add metadata to each multicast transport object in order to preserve the integrity and/or authenticity of media objects in transit. The transport security mode is indicated using the `@transportSecurity` attribute of the **`MulticastTransportSession`** element as follows:

- **No security.** The absence of security is explicitly indicated using the value *none*.
- **Integrity only.** If an integrity check is provided for every multicast transport object in the multicast transport session, such as a transmission object checksum, this shall be indicated using the attribute value *integrity*.
- **Authenticity and integrity.** If both authenticity and integrity checks are provided, this shall be indicated by the attribute value *integrityAndAuthenticity*.

The interpretation of these attribute values shall be specified by each multicast media transport protocol.

If this attribute is omitted, no security shall be assumed.

The `@transportSecurity` attribute should be present in multicast gateway configuration instance documents to signal the multicast transport security mode to the *Multicast reception* subfunction of the *Multicast gateway*.

10.2.3.7 Multicast transport session idle timeout

The maximum expected inter-packet time interval for a multicast transport session shall be specified in the `@sessionIdleTimeout` attribute of the **`MulticastTransportSession`** element. The value of the attribute shall be expressed in milliseconds. This attribute takes precedence over any other timeout value for the multicast transport session.

The *Multicast reception* subfunction of a *Multicast gateway* may unsubscribe from a multicast transport session if it has not received a packet at the configured multicast transport endpoint address (clause 10.2.3.9 below) for this time period in order to release reserved resources associated with the multicast transport session.

NOTE: When a transport session times out unicast repair may be triggered immediately, unless otherwise specified by the multicast media transport protocol, and still subject to the values of the `@fixedBackOffPeriod` and `@randomBackOffPeriod` attributes specified in clause 10.2.3.12 below.

10.2.3.8 Multicast media transport protocol parameters

The multicast media transport protocol used for this multicast transport session shall be specified using the **`TransportProtocol`** child element of the **`MulticastTransportSession`** element. This information enables a Multicast gateway to determine whether it can consume the multicast transport session.

- The `@protocolIdentifier` attribute of this element shall be a controlled term from the MPEG-7 Classification Scheme *MulticastTransportProtocolCS* specified in clause B.1.
- The `@protocolVersion` attribute shall indicate the major version number of the multicast media transport protocol in use.

10.2.3.9 Multicast transport endpoint address

The transport endpoint address(es) used for a multicast transport session shall be specified using the **`EndpointAddress`** child element of the **`MulticastTransportSession`** element.

NOTE: Certain multicast media transport protocols may permit a service component to be transmitted on more than one transport address, as specified in clause 8.3.4.0. In such cases, the *Multicast reception* subfunction of a *Multicast gateway* needs to subscribe to all specified transport addresses in order to completely receive all relevant multicast transport objects.

The source network address of the multicast transport session shall be specified in the **`NetworkSourceAddress`** child element and the destination group network address shall be specified in the **`NetworkDestinationGroupAddress`** child element:

- IPv4 network addresses shall be expressed using the "quad-dotted decimal" string notation.
- IPv6 network addresses shall be expressed using the colon-separated string notation recommended in IETF RFC 5952 [13].

The transport protocol destination port number of the multicast transport session shall be specified in the **`TransportDestinationPort`** child element. It shall be an integer between 1 and 65535 inclusive.

A multicast media transport protocol session identifier may additionally be specified in the **`MediaTransportSessionIdentifier`** child element. It shall be a positive integer.

10.2.3.10 Multicast transport session bit rate

The bit rate of this multicast transport session shall be specified using the **`BitRate`** child element of the **`MulticastTransportSession`** element as follows:

- The maximum bit rate shall be indicated in the `@maximum` attribute.
- The average bit rate may additionally be indicated in the `@average` attribute.

Bit rate values in the above attributes shall be expressed in bits per second.

The values shall indicate the bit rate of the multicast media transport protocol data units conveyed by the underlying transport protocol (e.g. carried in the payload field of UDP datagrams) across all endpoints declared for this multicast transport session, including any FEC repair packets addressed to the same destination group network address.

10.2.3.11 Forward Error Correction parameters

A multicast transport session may provide Application Level Forward Error Correction (AL-FEC) repair packets to assist with multicast packet loss, as specified in clause 8.3.4.2. These repair packets may be transmitted on the same endpoint address as the packets they are intended to repair, or on a different endpoint address.

Where Forward Error Correction repair packets are available as part of a multicast transport session, the parameters for receiving and interpreting them shall be specified using the optional **`ForwardErrorCorrectionParameters`** child element of the **`MulticastTransportSession`** element as follows:

- The AL-FEC scheme shall be indicated using the **`SchemeIdentifier`** child element. Its value shall be a fully-qualified term identifier from the *ForwardErrorCorrectionSchemeCS* controlled vocabulary specified in clause B.2.
- The percentage overhead of AL-FEC repair packets compared with source packets shall be indicated using the **`OverheadPercentage`** child element.
- If the endpoint address(es) to which AL-FEC repair packets are sent differ from those of the enclosing multicast transport session, they shall be indicated using one or more **`EndpointAddress`** child elements, as specified in clause 10.2.3.9 above.

Each multicast media transport protocol shall specify what is meant when the **`ForwardErrorCorrectionParameters`** element is omitted.

10.2.3.12 Unicast repair parameters

Clause 9 specifies how a *Multicast gateway* performs unicast repair at reference point **A**. Where such unicast repair is available, the parameters governing these procedures shall be specified using the **`UnicastRepairParameters`** child element of the **`MulticastTransportSession`** element as follows:

NOTE: In the case of unidirectional system deployments this child element should be omitted.

- **Transport object reception timeout.** The `@transportObjectReceptionTimeout` attribute shall specify a timeout period, expressed in milliseconds. This shall signal the maximum time a *Multicast gateway* should wait for the arrival of the next (or final) data packet relating to a particular multicast transmission object before resorting to Forward Error Correction or a unicast repair operation.
- **Fixed back-off period.** The `@fixedBackOffPeriod` attribute may be provided to specify an additional fixed delay, expressed in milliseconds, that a *Multicast gateway* shall wait after the above object completion timeout before commencing a unicast repair operation. A value of 0 implies that there is no additional fixed delay. If this attribute is omitted, the value 0 shall be assumed.
- **Random back-off period.** The `@randomBackOffPeriod` attribute may be provided to specify an additional random delay, expressed in milliseconds, that a *Multicast gateway* shall wait after the above fixed back-off period before commencing a unicast repair operation. The *Multicast gateway* should select a different random back-off period between 0 and the specified random back-off period for each multicast transmission object. A value of 0 implies that there is no additional random delay. If this attribute is omitted, the value 0 shall be assumed.

When the *Multicast gateway* in-band configuration method is used at reference point **M** (per clauses 8.3.5 and 10.2.5) the **`UnicastRepairParameters`** element and all its children shall be copied from the multicast server configuration instance document into the corresponding multicast transport session of the multicast gateway configuration instance document. For other *Multicast gateway* configuration methods, the **`UnicastRepairParameters`** element should be omitted from the multicast server configuration instance document.

10.2.3.13 Multicast gateway path mapping parameters

A *Multicast gateway* may be configured to transform the URI associated with a multicast transport object at reference point **M** into a different URL that can be used for unicast repair operations at reference point **A**. To perform this transformation, a **multicast transport object base URI** prefix in the multicast transport object URI is substituted with a **unicast repair base URL** prefix, as specified in clause 9.2.2.

Where present, the multicast transport object base URI for this multicast transport session shall be indicated using the `@transportObjectBaseURI` attribute of the **`UnicastRepairParameters`** element:

- The multicast transport object base URI may be present in multicast server configuration instance documents. Omission shall indicate that the multicast transport object URI is to be assigned by the *Multicast server* implementation for the multicast transport session in question.
- The transport object base URI may be present in multicast gateway configuration instance documents. Omission shall indicate that the multicast transport object base URI is the empty string for the multicast transport session in question.
- The multicast transport object base URI value shall be an absolute URI as defined in section 4.3 of IETF RFC 3986 [15]. It shall not contain any query or fragment component specified for other purposes by the present document.

A **`UnicastRepairParameters`** element may declare a (possibly empty) set of unicast repair base URLs, and each one shall be indicated as the content of a separate **`BaseURL`** child element. The value of this element shall be an absolute URI as defined in section 4.3 of IETF RFC 3986 [15]. It shall not contain any query or fragment component specified for other purposes by the present document.

NOTE 1: The way in which a *Multicast gateway* chooses between multiple unicast repair base URLs is specified in clause 9.2.1.

If no **`BaseURL`** child elements are declared, the unicast repair URL for any given multicast transport object shall be determined as specified in clause 9.2.2.

A relative weight may be associated with each unicast repair base URL using the optional `@relativeWeight` attribute. If present, this attribute shall have an integer value of zero or greater. The use of this attribute in choosing between multiple unicast repair base URLs is specified in clause 9. Setting the value of this attribute to zero shall indicate that the unicast repair base URL in question is to be ignored by the *Multicast gateway*.

NOTE 2: This latter indication can be used to temporarily disable the use of a particular unicast repair base URL for operational reasons.

Omitting the `@relativeWeight` attribute shall have the same meaning at setting its value to 1.

NOTE 3: Thus, if all **`BaseURL`** child elements omit the `@relativeWeight` attribute then the corresponding unicast repair base URLs are all deemed to have equal weight.

10.2.4 Association between multicast transport session and service component

10.2.4.0 General

Every multicast transport session shall be associated with one or more service components in a presentation manifest associated with the parent multicast session. Each such association shall be realized by means of a separate **`ServiceComponentIdentifier`** child element. The presentation manifest shall be referenced by assigning the `@manifestId` value of the target **`PresentationManifestLocator`** (see clause 10.2.2.2) to the `@manifestIdRef` attribute of this element. The schema type and form of this element depends on the type of presentation manifest referenced.

In the case where the presentation manifest is not of a type described in any of the following clauses:

- The `@xsi:type` attribute of the **`ServiceComponentIdentifier`** element shall be set to the value *GenericComponentIdentifierType*.
- The value of the `@componentIdentifier` attribute shall uniquely identify a service component in the presentation.

If multiple service components of a linear service are carried by the same multicast transport session, then each component shall be explicitly identified using a separate **`ServiceComponentIdentifier`** element.

A multicast transport session may carry multiple **ServiceComponentIdentifier** elements with different values of the @xsi:type attribute, for example if an MPEG-DASH and an HLS presentation share the same multicast transport objects.

A multicast transport session may carry multiple **ServiceComponentIdentifier** elements with the same value of @xsi:type, for example if there are two MPEG-DASH presentations associated with a linear service that include overlapping but non-identical sets of representations.

10.2.4.1 Service component identification for DASH presentations

In the case where the referenced presentation manifest is a DASH media presentation description (MPD) [i.2], the @xsi:type attribute of the **ServiceComponentIdentifier** element shall be set to the value *DASHComponentIdentifierType*. The syntax of this schema type is specified in table 10.2.4.1-1 below.

Table 10.2.4.1-1: DASHComponentIdentifier syntax

Element or attribute name	Use	Data type	Description
ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType"			Container unambiguously identifying an MPEG-DASH representation whose media objects are conveyed by the parent multicast transport session.
@manifestIdRef	1	Name Token string	A cross-reference to a **PresentationManifestLocator/**@manifestId in the parent multicast session that is an MPD.
@periodIdentifier	1	String	A **Period/**@id from the referenced MPD.
@adaptationSetIdentifier	1	Unsigned integer	An **AdaptationSet/**@id from the referenced MPD.
@representationIdentifier	1	String	A **Representation/**@id from the referenced MPD.
NOTE: All **Period** elements in an MPD of type *dynamic* contain the optional @id attribute, as required by clause 5.3.2.2 of the MPEG-DASH specification [i.2]).			

10.2.4.2 Service component identification for HLS presentations

In the case where the referenced presentation manifest is an HLS Master Playlist (.m3u8) [i.5], the @xsi:type attribute of the **ServiceComponentIdentifier** element shall be set to the value *HLSComponentIdentifierType*. The syntax of this schema type is specified in table 10.2.4.2-1 below.

Table 10.2.4.2-1: HLSComponentIdentifierType syntax

Element or attribute name	Use	Data type	Description
ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType"			Container identifying an HLS Media Playlist whose media objects are conveyed by the parent multicast transport session.
@manifestIdRef	1	Name Token string	A cross-reference to a **PresentationManifestLocator/**@manifestId in the parent multicast session that is an HLS Master Playlist.
@mediaPlaylistLocator	1	URI string	The absolute URL of an HLS Media Playlist appearing in the referenced HLS Master Playlist.

10.2.5 Multicast gateway configuration transport session parameters

10.2.5.0 General

In the case where the population of *Multicast gateway* instances is configured using the in-band configuration method at reference point **M** specified in clause 8.3.5 and clause 10.4.5, one or more **MulticastGatewayConfigurationTransportSession** elements shall be present in the multicast server configuration instance document. The *Multicast server* shall carousel the current multicast gateway configuration instance document on all specified multicast gateway configuration transport sessions.

In addition, when the in-band configuration method is used, a "bootstrap" multicast gateway configuration instance document may be provided at reference point **C_{MR}** containing one or more **`MulticastGatewayConfiguration TransportSession`** elements. An example can be found in clause C.2. In this case, the *Multicast gateway* shall receive additional multicast gateway configuration instance documents at reference point **M** on one of the specified multicast gateway configuration transport sessions.

NOTE: In the case of unidirectional system deployments an alternative bootstrapping mechanism is required to deliver the information conveyed in the **`MulticastGatewayConfigurationTransportSession`** element to the terminal device. The specification of this mechanism lies beyond the scope of the present document.

The elements and attributes of the **`MulticastGatewayConfigurationTransportSession`** element are a subset of those appearing in the **`MulticastTransportSession`** element specified in clause 10.2.3 above.

The multicast media transport protocol used for the multicast gateway configuration transport session shall be specified per clause 10.2.3.8.

The transport endpoint address(es) used for the multicast gateway configuration transport session shall be specified per clause 10.2.3.9.

The bit rate of the multicast gateway configuration transport session shall be specified per clause 10.2.3.10.

The Forward Error Correction parameters of the multicast gateway configuration transport session shall be specified in the same manner as described in clause 10.2.3.11.

The unicast repair parameters of the multicast gateway configuration transport session shall be specified in the same manner as described in clause 10.2.3.12 and 10.2.3.13.

10.2.5.1 MulticastGatewayConfigurationTransportSession element

The syntax of the **`MulticastGatewayConfigurationTransportSession`** element is specified in table 10.2.5.1-1 below. The semantics of the attributes and child elements are identical to the corresponding attributes and child elements of the **`MulticastTransportSession`** element specified in clause 10.2.3.

Table 10.2.5.1-1: MulticastGatewayConfigurationTransportSession syntax

Element or attribute name	Use	Data type	Clause	Description
`MulticastGatewayConfiguration TransportSession`			10.2.5	Container for multicast gateway configuration transport session parameters.
`@transportSecurity`	0..1	String	10.2.3.6	Indicates which security features are enabled in this transport session.
`TransportProtocol`	1		10.2.3.8	Container for multicast media transport protocol parameters.
`@protocolIdentifier`	1	String	10.2.3.8	A fully-qualified term identifier URI from *MulticastTransportProtocolCS* (clause B.1) specifying the multicast media transport protocol used for this transport session.
`@protocolVersion`	1	String	10.2.3.8	Indicates the version of the multicast media transport protocol.
`EndpointAddress`	1..n		10.2.3.9	Container for the addressing parameters of this transport session.
`NetworkSourceAddress`	0..1	String	10.2.3.9	A host name or IP address specifying the multicast group source address for use with source-specific multicast transport.
`NetworkDestinationGroup Address`	1	IP address string	10.2.3.9	An IP address specifying a multicast group for the transport session.
`TransportDestinationPort`	1	Unsigned 16-bit integer	10.2.3.9	The UDP port number of the transport session.
`MediaTransportSession Identifier`	0..1	Positive integer	10.2.3.9	An opaque transport session identifier specified by the multicast media transport protocol.

Element or attribute name	Use	Data type	Clause	Description
BitRate	1		10.2.3.10	Container specifying the bit rate(s) of the transport session across all declared endpoint addresses and including any FEC overheads.
@average	0..1	Positive integer	10.2.3.10	The average bit rate of the transport session.
@maximum	1	Positive integer	10.2.3.10	The maximum bit rate of the transport session.
ForwardErrorCorrection Parameters	0..n		10.2.3.11	Container for the parameters of the FEC repair blocks protecting the transport session.
SchemeIdentifier	1	String	10.2.3.11	A fully-qualified term identifier URI from *ForwardErrorCorrectionSchemeCS* (clause B.2) specifying the scheme of the FEC repair blocks protecting the transport session.
OverheadPercentage	1	Positive integer	10.2.3.11	Percentage of FEC overhead compared with source packets. For example, a value of 20 means 20 % overhead, 100 means there is a repair packet for every source packet. Values greater than 100 are permitted.
EndpointAddress	0..n		10.2.3.9	Container for the addressing parameters of FEC repair blocks protecting this transport session. May be omitted if FEC repair packets are carried in band with the transport session.
NetworkSourceAddress	0..1	String	10.2.3.9	Host name or IP address specifying the source address of FEC repair packets protecting this transport session.
NetworkDestinationGroup Address	1	IP address string	10.2.3.9	An IP address specifying the multicast group for FEC repair packets protecting this transport session.
TransportDestinationPort	1	Unsigned 16-bit integer	10.2.3.9	The UDP port number of FEC repair packets protecting this transport session.
MediaTransportSession Identifier	0..1	Positive integer	10.2.3.9	An opaque transport session identifier of FEC repair packets protecting this transport session.
UnicastRepairParameters	0..1		10.2.3.12	Container for parameters pertaining to a unicast repair.
@transportObjectBaseURI	0..1		10.2.3.13	Multicast transport object base URI. The base URI of all multicast transport objects conveyed in this transport session.
@transportObjectReception Timeout	1	Unsigned integer	10.2.3.12	The period of time (in milliseconds) that a *Multicast gateway* should wait for a packet relating to a multicast transport object before assuming that the object transmission is over.
@fixedBackOffPeriod	0..1	Unsigned integer	10.2.3.12	The minimum number of milliseconds that the *Multicast gateway* shall wait after the end of object transmission before attempting unicast repair.
@randomBackOffPeriod	0..1	Unsigned integer	10.2.3.12	Maximum number of milliseconds for the random delay period that the *Multicast gateway* shall wait in addition to @fixedBackOffPeriod.
BaseURL	0..n		10.2.3.13	Unicast repair base URL prefix. The base path of a unicast repair endpoint.
@relativeWeight	0..1		10.2.3.13	A relative weighting for this unicast repair endpoint.

10.3 Life-cycle of multicast transport sessions

10.3.0 General

Individual multicast transport sessions in the multicast session configuration are in one of two states:

- In the **active** state, multicast media transport protocol packets may be transmitted by the *Multicast server* according to the current set of parameters specifying that multicast transport session.
- In the **inactive** state, multicast media transport protocol packets shall not be transmitted by the *Multicast server*.

A multicast transport session may be permanently in the active state or it may be (de)activated by one of two different methods, described in the following clauses.

10.3.1 Timed activation of multicast transport session

A multicast session configuration document may include parameters specifying a start time and/or duration for any of the multicast transport sessions it describes, as specified in clause 10.2.3.3.

In the general case, a multicast transport session shall become active in the deployed system at the indicated start time. Once active, a multicast transport session shall remain active for a period of time equal to that indicated by its duration.

If the start time is in the past, the multicast transport session shall be deemed to be active immediately on receipt of the multicast session configuration document unless the start time plus the duration is also in the past, in which case the multicast transport session shall be inactive.

If a start time is specified but no duration, the multicast transport session shall become active at the specified start time and shall remain active until further notice.

If a duration is specified but no start time, the multicast transport session shall be deemed to be active immediately on receipt of the multicast session configuration document and shall remain active for a period of time equal to the time of receipt plus the duration.

If neither a start time nor a duration is specified for it, a multicast transport session shall remain in its current state until this state is modified by manual (de)activation, as specified in clause 10.3.2. The initial state for such multicast transport sessions shall be inactive.

NOTE: If it is important that all instances of the *Multicast gateway* have a common view of the end time of a multicast transport session, both the `@start` and `@duration` attributes should be supplied with values in the multicast gateway configuration instance document.

10.3.2 Manual (de)activation of multicast transport session

Regardless of whether a start time and duration has been specified in the current multicast session configuration document, the state of a multicast transport session can be activated by the procedure specified in clause 10.4.3.1 and deactivated by the procedure specified in clause 10.4.3.2.

In both cases, the multicast transport session(s) affected are indicated by quoting the value of their `@id` attribute in combination with the `@serviceIdentifier` of their parent multicast session.

10.4 Configuration and control procedures

10.4.0 General

The procedures for configuring and controlling system functions at reference points **C_{MS}** and **C_{MR}** shall use HTTP request and response messages, as specified in IETF RFC 7230 [1]. The use of TLS [7] to secure the interactions is recommended. Implementations may additionally support HTTP/2 [i.1].

The structure of target resource URI paths in HTTP requests shall follow the following general format:

{rootPrefix}/{endpointName}/{endpointVersion}/{endpointSpecificSuffix}

where *{rootPrefix}* shall be an implementation-specific URI prefix according to the generic syntax specified in IETF RFC 3986 [15] with either *http* or *https* as the scheme part. *{endpointSpecificSuffix}* is a set of one or more path elements and/or query parameters specified in the following clauses.

10.4.1 Error responses

When an error occurs as the result of a request at reference point **C_{MS}** or **C_{MR}**, the most appropriate status code from table 10.4.1-1 below shall be returned to the requestor:

Table 10.4.1-1: HTTP error response status codes

Response status code and reason phrase	Applicable methods	Summary description	Normative specification
400 Bad Request	*GET*, *PUT*, *POST*	The parameters supplied in the request were incorrect for the endpoint specified by the target resource URI.	IETF RFC 7231 [2], section 6.5.1
401 Unauthorized	*GET*, *PUT*, *POST*	The request lacks a valid set of authentication credentials in the `Authorization` request header to access the target resource URI.	IETF RFC 7235 [6], section 3.1
403 Forbidden	*GET*, *PUT*, *POST*	The request message is well formed, and any authentication credentials supplied are valid, but the endpoint refuses to authorize the request for other reasons.	IETF RFC 7231 [2], section 6.5.3
404 Not Found	*GET*, *PUT*, *POST*	The target resource URI in the request message is not recognized by the endpoint.	IETF RFC 7231 [2], section 6.5.4
405 Method Not Allowed	(Any)	The method in the request is not supported by the target resource URI.	IETF RFC 7231 [2], section 6.5.5
406 Not Acceptable	*GET*	The endpoint was unable to fulfil the request within the constraints of the supplied content negotiation request headers.	IETF RFC 7231 [2], section 6.5.6
411 Length Required	*PUT*	The endpoint refuses to accept a request without a `Content-Length` header.	IETF RFC 7231 [2], section 6.5.10
413 Payload Too Large	*PUT*	The endpoint refuses to accept the request because the request body size declared in the `Content-Length` header is too large, or because the request body exceeds the indicated length.	IETF RFC 7231 [2], section 6.5.11
415 Unsupported Media Type	*PUT*	The `Content-Type` request header did not contain a value required by the specified endpoint.	IETF RFC 7231 [2], section 6.5.13
429 Too Many Requests	*GET*, *PUT*, *POST*	The endpoint is experiencing high load that prevented it from fulfilling the request. The `Retry-After` response header (see section 8.1.3 in [2]) may be provided in the response message to indicate how long the client should wait before reattempting the request.	IETF RFC 6585 [16], section 4
500 Internal Server Error	*GET*, *PUT*, *POST*	The endpoint encountered an unexpected error that prevented it from fulfilling the request.	IETF RFC 7231 [2] section 6.6.2
503 Service Unavailable	*GET*, *PUT*, *POST*	The endpoint was unable to process the request. The `Retry-After` response header (see section 8.1.3 in [2]) may be provided in the response message to indicate how long the client should wait before reattempting the request.	IETF RFC 7231 [2], section 6.6.4

10.4.2 Multicast server configuration procedures

10.4.2.0 General

This clause specifies the procedures for configuring a *Multicast server* at reference point **C_{MS}**:

- The *{endpointName}* URL element shall be dvb-multicast-server.
- The *{endpointVersion}* URL element shall be v1.

10.4.2.1 Out-of-band pushed multicast server configuration method

This procedure is invoked by a *Network control* subfunction on a *Multicast server* function to push a new multicast server configuration to the latter. To this end, the *Multicast server* function shall expose a RESTful resource [i.8] at reference point **C_{MS}** representing its current configuration.

The *{endpointSpecificSuffix}* URL element shall be the path element configuration, identifying the RESTful resource to be manipulated.

Request message	
Request method	*PUT*
Target resource URI	*{rootPrefix}*/dvb-multicast-server/v1/configuration
`Content-type` request header	*text/xml*
Request message body	A multicast server configuration instance document according to the definition in clause 10.0 and the syntax specified in clause 10.2.
Response message	
Success status code	*204 No Content*
Success response message body	Empty

A success status code in the response message signifies that the multicast server configuration has been replaced with that contained in the instance document supplied in the request message body.

10.4.2.2 Out-of-band pulled multicast server configuration method

This procedure is invoked by a *Multicast server* function on a *Network control* subfunction to retrieve the latest multicast server configuration from the latter. To this end, the *Network control* subfunction shall expose a RESTful resource [i.8] at reference point **C_{MS}** representing the current multicast server configuration in the system.

NOTE: Configuration of the *{rootPrefix}* to be used by the *Multicast server* is beyond the scope of the present specification.

The *{endpointSpecificSuffix}* URL element shall be the path element configuration, identifying the RESTful resource made available for retrieval.

Request message	
Request method	*GET*
Target resource URI	*{rootPrefix}*/dvb-multicast-server/v1/configuration
Request message body	Empty
Response message	
Success status code	*200 OK*
Success `Content-type` request header	*text/xml*
Success response message body	A multicast server configuration instance document according to the definition in clause 10.0 and the syntax specified in clause 10.2.

A success status code in the response message signifies that the current multicast server configuration is represented by the instance document supplied in the response message body.

10.4.3 Multicast server control procedures

10.4.3.0 General

This clause specifies the procedures for controlling a *Multicast server* at reference point **C_{MS}**:

- The *{endpointName}* URL element shall be *dvb-multicast-server*.
- The *{endpointVersion}* URL element shall be *v1*.

10.4.3.1 Multicast transport session activation

This procedure is invoked by a *Network control* subfunction on a *Multicast server* function to activate a single multicast transport session or to activate all multicast transport sessions in a particular multicast session. For this purpose, the *Multicast server* function shall expose a remote procedure call at reference point **C_{MS}**.

The *{endpointSpecificSuffix}* URL element shall be the path element activate, the name of the remote procedure call:

- To activate a single multicast transport session, the first form of the target resource URI below shall be used, indicating the service identifier of the parent multicast session (specified in clause 10.2.2.0) as the value of the *service* query parameter and the transport session identifier (specified in clause 10.2.3.2) as the value of the *transport-session* query parameter.
- To activate all currently inactive multicast transport sessions in a particular multicast session, the second form of the target resource URI below shall be used, indicating only the service identifier of the multicast session (clause 10.2.2.0) as the value of the *service* query parameter.

Request message	
Request method	*POST*
Target resource URI *(first form)*	*{rootPrefix}*/dvb-multicast-server/v1/activate? service=*{service-id}*&transport-session=*{transport-session-id}*
Target resource URI *(second form)*	*{rootPrefix}*/dvb-multicast-server/v1/activate?service=*{service-id}*
`Content-type` request header	Omitted
Request message body	Empty
Response message	
Success status code	*204 No Content*
Success response message body	Empty
NOTE: URI query components are required to comply with the *query* production specified in Appendix A of [15].	

A success status code in the response message signifies that the multicast transport session(s) specified in the target resource URI of the request is/are now in the active state.

10.4.3.2 Multicast transport session deactivation

This procedure is invoked by a *Network control* subfunction on a *Multicast server* function to deactivate a single multicast transport session or to deactivate all multicast transport sessions in a particular multicast session. For this purpose, the *Multicast server* function shall expose a remote procedure call at reference point **C_{MS}**.

The *{endpointSpecificSuffix}* URL element shall be the path element deactivate, the name of the remote procedure call.

- To deactivate a single multicast transport session, the first form of the target resource URI below shall be used, indicating the service identifier of the parent multicast session (specified in clause 10.2.2.0) as the value of the *service* query parameter and the transport session identifier (specified in clause 10.2.3.2) as the value of the *transport-session* query parameter.
- To deactivate all currently active multicast transport sessions in a particular multicast session, the second form of the target resource URI below shall be used, indicating only the service identifier of the multicast session (clause 10.2.2.0) as the value of the *service* query parameter.

Request message	
Request method	*POST*
Target resource URI *(first form)*	*{rootPrefix}*/dvb-multicast-server/v1/deactivate? service=*{service-id}*&transport-session=*{transport-session-id}*
Target resource URI *(second form)*	*{rootPrefix}*/dvb-multicast-server/v1/deactivate?service=*{service-id}*
`Content-type` request header	Omitted
Request message body	Empty
Response message	
Success status code	*204 No Content*
Success response message body	Empty
NOTE: URI query components are required to comply with the *query* production specified in appendix A of [15].	

A success status code in the response message signifies that the multicast transport session(s) specified in the target resource URI of the request is/are now in the inactive state.

10.4.4 Multicast gateway configuration procedures

10.4.4.0 General

This clause specifies the procedures for configuring a *Multicast gateway* at reference point **C_{MR}**:

- The *{endpointName}* URL element shall be dvb-multicast-gateway.
- The *{endpointVersion}* URL element shall be v1.

10.4.4.1 Out-of-band pushed multicast gateway configuration method

This procedure is invoked by a *Network control* subfunction on a *Multicast gateway* function to push a new multicast gateway configuration to the latter. To this end, the *Multicast gateway* function shall expose a RESTful resource [i.8] at reference point **C_{MR}** representing its current configuration.

The *{endpointSpecificSuffix}* URL element shall be the path element configuration, identifying the RESTful resource to be manipulated.

Request message	
Request method	*PUT*
Target resource URI	*{rootPrefix}*/dvb-multicast-gateway/v1/configuration
`Content-type` request header	*text/xml*
Request message body	A multicast gateway configuration instance document according to the definition in clause 10.0 and the syntax specified in clause 10.2.
Response message	
Success status code	*204 No Content*
Success response message body	Empty

A success status code in the response message signifies that the multicast gateway configuration has been replaced with that contained in the instance document supplied in the request message body.

10.4.4.2 Out-of-band pulled multicast gateway configuration method

This procedure is invoked by a *Multicast gateway* function on a *Network control* subfunction to retrieve the latest multicast gateway configuration from the latter. To this end, the *Network control* subfunction shall expose a RESTful resource [i.8] at reference point **C_{MR}** representing the current multicast gateway configuration in the system.

NOTE: Configuration of the *{rootPrefix}* to be used by each *Multicast gateway* instance is beyond the scope of the present document.

The *{endpointSpecificSuffix}* URL element shall be the path element configuration, identifying the RESTful resource made available for retrieval.

Request message	
Request method	*GET*
Target resource URI	*{rootPrefix}*/dvb-multicast-gateway/v1/configuration
Request message body	Empty
Response message	
Success status code	*200 OK*
Success `Content-type` request header	*text/xml*
Success response message body	A multicast gateway configuration instance document according to the definition in clause 10.0 and the syntax specified in clause 10.2.

A success status code in the response message signifies that the current multicast gateway configuration is represented by the instance document supplied in the response message body.

10.4.5 In-band multicast gateway configuration method

When this method is used to configure a *Multicast gateway* (or *Multicast Rendezvous service*) the *Multicast server* shall transmit a multicast gateway configuration transport session as specified in clause 8.3.5. The parameters of this transport session need to be communicated to the *Multicast gateway* so that it can subscribe to the appropriate multicast endpoint address(es). The parameters may be encapsulated in a simple "bootstrap" multicast gateway configuration instance document containing only a **`MulticastGatewayConfigurationTransportSession`** element, as specified in clause 10.2.5. This document may be provided at reference point **C_{MR}** using the out-of-band pushed method (clause 10.4.4.1 above) or the out-of-band pulled method (clause 10.4.4.2 above) or through an alternative configuration method such as TR-069 [i.9] or TR-369 [i.10].

11 Reporting interactions

This topic is for future study.

Annex A (normative): Multicast session configuration schema

The XML Schema for the multicast session configuration instance document specified in clause 10.2 is reproduced below.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns="urn:dvb:metadata:MulticastSessionConfiguration:2019"
xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:mpeg7="urn:mpeg:mpeg7:schema:2001"
targetNamespace="urn:dvb:metadata:MulticastSessionConfiguration:2019" elementFormDefault="qualified"
attributeFormDefault="unqualified">

   <xs:import namespace="urn:mpeg:mpeg7:schema:2001" schemaLocation="mpeg7_subset.xsd"/>

   <xs:simpleType name="decimalFraction">
      <xs:annotation>
         <xs:documentation>A fraction expressed as a decimal between 0.0 and 1.0</xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:decimal">
         <xs:minExclusive value="0.0"/>
         <xs:maxInclusive value="1.0"/>
      </xs:restriction>
   </xs:simpleType>

   <xs:attributeGroup name="validityAttrs">
      <xs:attribute name="validityPeriod" type="xs:duration">
         <xs:annotation>
            <xs:documentation>The period of time after receiving this document that it may no longer be
valid.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
      <xs:attribute name="validUntil" type="mpeg7:timePointType">
         <xs:annotation>
            <xs:documentation>The absolute point in time after which this document may no longer be
valid.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
   </xs:attributeGroup>

   <xs:simpleType name="stringNoWhitespaceType">
      <xs:restriction base="xs:string">
         <xs:pattern value="[^\r\n\t \p{Z}]*"/>
      </xs:restriction>
   </xs:simpleType>

   <xs:simpleType name="IPAddressType">
      <xs:annotation>
         <xs:documentation>TODO: Restrict this with a regular expression that matches IPv4 and IPv6 addresses
in their respective textual notations.</xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string"/>
   </xs:simpleType>

   <xs:simpleType name="PortNumberType">
      <xs:restriction base="xs:positiveInteger">
         <xs:maxInclusive value="65535"/>
      </xs:restriction>
   </xs:simpleType>

   <xs:simpleType name="contentAcquisitionMethodType">
      <xs:restriction base="xs:NMTOKEN">
         <xs:enumeration value="push"/>
         <xs:enumeration value="pull"/>
      </xs:restriction>
   </xs:simpleType>
```

```
   <xs:simpleType name="transmissionModeType">
      <xs:restriction base="xs:NMTOKEN">
         <xs:enumeration value="resource"/>
         <xs:enumeration value="chunked"/>
      </xs:restriction>
   </xs:simpleType>

   <xs:simpleType name="transportSecurityType">
      <xs:restriction base="xs:NMTOKEN">
         <xs:enumeration value="none">
            <xs:annotation>
               <xs:documentation/>
            </xs:annotation>
         </xs:enumeration>
         <xs:enumeration value="integrity">
            <xs:annotation>
               <xs:documentation>A digest of the multicast transport object is present in the metadata
describing it, enabling its integrity to be verified by the Multicast gateway.</xs:documentation>
            </xs:annotation>
         </xs:enumeration>
         <xs:enumeration value="integrityAndAuthenticity">
            <xs:annotation>
               <xs:documentation>A digest of the multicast transport object is present in the metadata
describing it, enabling its integrity to be verified by the Multicast gateway. A digital signature is also
provided, enabling the authenticity of (key fields within) the multicast transport object metadata to be
verified by the Multicast gateway.</xs:documentation>
            </xs:annotation>
         </xs:enumeration>
      </xs:restriction>
   </xs:simpleType>

   <xs:complexType name="ServiceComponentIdentifierType" abstract="true">
      <xs:attribute name="manifestIdRef" type="xs:NMTOKEN" use="required">
         <xs:annotation>
            <xs:documentation>A cross-reference to a PresentationManifestLocator element in the parent
MulticastSession with a manifestId of the same value.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
   </xs:complexType>

   <xs:complexType name="DASHComponentIdentifierType">
      <xs:complexContent>
         <xs:extension base="ServiceComponentIdentifierType">
            <xs:attribute name="periodIdentifier" type="xs:string" use="required"/>
            <xs:attribute name="adaptationSetIdentifier" type="xs:unsignedInt" use="required"/>
            <xs:attribute name="representationIdentifier" type="stringNoWhitespaceType" use="required"/>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>

   <xs:complexType name="HLSComponentIdentifierType">
      <xs:complexContent>
         <xs:extension base="ServiceComponentIdentifierType">
            <xs:attribute name="mediaPlaylistLocator" type="xs:anyURI" use="required"/>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>

   <xs:complexType name="GenericComponentIdentifierType">
      <xs:complexContent>
         <xs:extension base="ServiceComponentIdentifierType">
            <xs:attribute name="componentIdentifier" type="xs:NMTOKEN" use="required"/>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>

   <xs:complexType name="MulticastTransportProtocolType">
      <xs:attribute name="protocolIdentifier" type="mpeg7:termReferenceType" use="required"/>
      <xs:attribute name="protocolVersion" type="xs:positiveInteger" use="required"/>
   </xs:complexType>

   <xs:complexType name="MulticastEndpointAddressType">
      <xs:sequence>
         <xs:element name="NetworkSourceAddress" type="IPAddressType"/>
```

```
         <xs:element name="NetworkDestinationGroupAddress" type="IPAddressType"/>
         <xs:element name="TransportDestinationPort" type="PortNumberType"/>
         <xs:element name="MediaTransportSessionIdentfier" type="xs:positiveInteger" minOccurs="0">
            <xs:annotation>
               <xs:documentation>Uniquely identifying the stream of packets in the multicast group that
corresponds to this multicast transport session, e.g. the LCT Channel identifier. (Some multicast media
transport protocols do not require this additional demultiplexing identifier.)</xs:documentation>
            </xs:annotation>
         </xs:element>
      </xs:sequence>
   </xs:complexType>

   <xs:complexType name="BitRateType">
      <xs:attribute name="average" type="xs:positiveInteger" use="optional"/>
      <xs:attribute name="maximum" type="xs:positiveInteger" use="required"/>
   </xs:complexType>

   <xs:complexType name="ForwardErrorCorrectionParametersType">
      <xs:annotation>
         <xs:documentation>A set of parameters describing an Application Level Forward Error Correction
configuration.</xs:documentation>
      </xs:annotation>
      <xs:sequence>
         <xs:element name="SchemeIdentifier" type="mpeg7:termReferenceType">
            <xs:annotation>
               <xs:documentation>A term identifier from ForwardErrorCorrectionSchemeCS identifying the AL-FEC
scheme in use.</xs:documentation>
            </xs:annotation>
         </xs:element>
         <xs:element name="OverheadPercentage" type="xs:positiveInteger">
            <xs:annotation>
               <xs:documentation>The percentage AL-FEC overhead for the repair stream described by this set of
Forward Error Correction parameters.</xs:documentation>
            </xs:annotation>
         </xs:element>
         <xs:element name="EndpointAddress" type="MulticastEndpointAddressType" minOccurs="0"
maxOccurs="unbounded">
            <xs:annotation>
               <xs:documentation>The endpoint address to which AL-FEC repair packets are transmitted. May be
omitted in cases where AL-FEC is transmitted in band to the same endpoint address as the enclosing multicast
transport session.</xs:documentation>
            </xs:annotation>
         </xs:element>
      </xs:sequence>
   </xs:complexType>

   <xs:complexType name="WeightedURIType">
      <xs:annotation>
         <xs:documentation>A URI with an associated weighting attribute.</xs:documentation>
      </xs:annotation>
      <xs:simpleContent>
         <xs:extension base="xs:anyURI">
            <xs:attribute name="relativeWeight" type="xs:nonNegativeInteger" default="1"/>
         </xs:extension>
      </xs:simpleContent>
   </xs:complexType>

   <xs:complexType name="UnicastRepairParametersType">
      <xs:annotation>
         <xs:documentation>An element describing the parameters to be used by a Multicast gateway when
performing unicast repair. One or more base paths may be specified here, each with an optional weighting. If the
weighting is omitted, all base paths are assumed to have an equal weighting of 1.0.</xs:documentation>
      </xs:annotation>
      <xs:sequence>
         <xs:element name="BaseURL" type="WeightedURIType" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="transportObjectReceptionTimeout" type="xs:unsignedInt" use="required">
         <xs:annotation>
            <xs:documentation>The time (expressed in milliseconds) that a Multicast gateway should wait for a
packet relating to a particular multicast transport object before it can assume that the object transmission is
```

```
over, and commence object repair using Forward Error Correction or unicast patching
procedures.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
      <xs:attribute name="fixedBackOffPeriod" type="xs:unsignedInt" default="0">
         <xs:annotation>
            <xs:documentation>The minimum number of milliseconds that the Multicast gateway shall back off
after the mutlicast transport object timeout before attempting a unicast repair.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
      <xs:attribute name="randomBackOffPeriod" type="xs:unsignedInt" default="0">
         <xs:annotation>
            <xs:documentation>An additional period that the Multicast gateway shall wait after the fixed back-
off period before attempting a unicast repair. It shall be a randomly selected number of milliseconds between
zero and the value specified in this attribute. The Multicast gateway shall choose a different random back-off
period for each multicast transport object.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
      <xs:attribute name="transportObjectBaseURI" type="xs:anyURI" use="optional">
         <xs:annotation>
            <xs:documentation>The base path of all multicast transport objects conveyed in this multicast
transport session. This prefix string is substituated by the Multicast gateway with a unicast repair base path
when performing unicast repair.</xs:documentation>
         </xs:annotation>
      </xs:attribute>
   </xs:complexType>

   <xs:complexType name="TypedLocatorType">
      <xs:annotation>
         <xs:documentation>A URL and accompanying MIME content type.</xs:documentation>
      </xs:annotation>
      <xs:simpleContent>
         <xs:extension base="xs:anyURI">
            <xs:attribute name="contentType" type="mpeg7:mimeType" use="required">
               <xs:annotation>
                  <xs:documentation>The MIME content type of the resource pointed to by the content of this
element.</xs:documentation>
               </xs:annotation>
            </xs:attribute>
         </xs:extension>
      </xs:simpleContent>
   </xs:complexType>

   <xs:complexType name="ReportingLocatorType">
      <xs:simpleContent>
         <xs:extension base="xs:anyURI">
            <xs:attribute name="proportion" type="decimalFraction" default="1.0">
               <xs:annotation>
                  <xs:documentation>The proportion of Multicast gateways that should send reports to the
specified endpoint. At the start of a multicast transport session, each Multicast gateway shall randomly decide
whether or not to send reports based on this value.</xs:documentation>
               </xs:annotation>
            </xs:attribute>
            <xs:attribute name="period" type="xs:duration" use="required">
               <xs:annotation>
                  <xs:documentation>The period of time for the Multicast gateway to wait between sending
reports to the specified endpoint.</xs:documentation>
               </xs:annotation>
            </xs:attribute>
            <xs:attribute name="randomDelay" type="xs:unsignedInt" use="required">
               <xs:annotation>
                  <xs:documentation>An additional period that the Multicast gateway shall delay when sending
reports to the specified endpoint. It shall be a randomly selected number of milliseconds between zero and the
value specified in this attribute. The Multicast gateway shall choose a different random delay for each report
it sends.</xs:documentation>
               </xs:annotation>
            </xs:attribute>
         </xs:extension>
      </xs:simpleContent>
   </xs:complexType>
```

```
    <xs:complexType name="SessionReportingType">
        <xs:sequence>
            <xs:annotation>
                <xs:documentation>Parameters used by the Multicast gateway to report statistics about the
session.</xs:documentation>
            </xs:annotation>
            <xs:element name="ReportingLocator" type="ReportingLocatorType" maxOccurs="unbounded"/>
        </xs:sequence>
    </xs:complexType>

    <xs:complexType name="BaseMulticastTransportSessionType">
        <xs:sequence>
            <xs:element name="TransportProtocol" type="MulticastTransportProtocolType"/>
            <xs:element name="EndpointAddress" type="MulticastEndpointAddressType" maxOccurs="unbounded"/>
            <xs:element name="BitRate" type="BitRateType"/>
            <xs:element name="ForwardErrorCorrectionParameters" type="ForwardErrorCorrectionParametersType"
minOccurs="0" maxOccurs="unbounded"/>
            <xs:element name="UnicastRepairParameters" type="UnicastRepairParametersType" minOccurs="0"/>
        </xs:sequence>
        <xs:attribute name="transportSecurity" type="transportSecurityType" default="none">
            <xs:annotation>
                <xs:documentation>Controls whether the Multicast server adds integrity and/or authenticity metadata
to multicast transport objects. Informs the Multicast gateway whether this metadata should be present and
verified.</xs:documentation>
            </xs:annotation>
        </xs:attribute>
    </xs:complexType>

    <xs:complexType name="MulticastTransportSessionType">
        <xs:complexContent>
            <xs:extension base="BaseMulticastTransportSessionType">
                <xs:sequence>
                    <xs:element name="ServiceComponentIdentifier" type="ServiceComponentIdentifierType"
maxOccurs="unbounded">
                        <xs:annotation>
                            <xs:documentation>A means of referencing a single component of the linear
service.</xs:documentation>
                        </xs:annotation>
                    </xs:element>
                </xs:sequence>
                <xs:attribute name="id" type="xs:NMTOKEN" use="required"/>
                <xs:attribute name="start" type="mpeg7:timePointType" use="optional"/>
                <xs:attribute name="duration" type="xs:duration" use="optional"/>
                <xs:attribute name="contentIngestMethod" type="contentAcquisitionMethodType" default="pull">
                    <xs:annotation>
                        <xs:documentation>Used by the Multicast server to determine whether to pull content for this
service component, or expect it to be pushed.</xs:documentation>
                    </xs:annotation>
                </xs:attribute>
                <xs:attribute name="transmissionMode" type="transmissionModeType" default="resource">
                    <xs:annotation>
                        <xs:documentation>Used by the Multicast server to determine the multicast transmission mode.
In "resource" mode, the Multicast server waits until it has acquired a complete resource before attempting to
transmit it as a multicast transport object. In "chunked" mode, the Multicast server maps a single acquired
chunk to a different multicast transport object.</xs:documentation>
                    </xs:annotation>
                </xs:attribute>
                <xs:attribute name="sessionIdleTimeout" type="xs:positiveInteger" use="required">
                    <xs:annotation>
                        <xs:documentation>The time (expressed in milliseconds) that a Multicast gateway should wait
for any packet on this multicast transport session before it can assume that the session is over and unsubscribe
from the corresponding multicast group. If this attribute is omitted, reception of the multicast session never
times out due to a lack of packets, but is still bounded by the transport session duration.</xs:documentation>
                    </xs:annotation>
                </xs:attribute>
            </xs:extension>
        </xs:complexContent>
    </xs:complexType>
```

```
    <xs:complexType name="MulticastSessionType">
        <xs:annotation>
            <xs:documentation>All the multicast transport sessions required to deliver a single linear service
according to operational needs.</xs:documentation>
        </xs:annotation>
        <xs:sequence>
            <xs:element name="PresentationManifestLocator" maxOccurs="unbounded">
                <xs:annotation>
                    <xs:documentation>The URL of a presentation manifest hosted on an origin server accessible to
the system receiving this multicast session configuration.</xs:documentation>
                </xs:annotation>
                <xs:complexType>
                    <xs:simpleContent>
                        <xs:extension base="TypedLocatorType">
                            <xs:attribute name="manifestId" type="xs:NMTOKEN" use="required">
                                <xs:annotation>
                                    <xs:documentation>An opaque identifier, unique within the lexical scope of this
instance document, that identifies this XML element and allows it to be cross-referenced from elsewhere in the
same instance document.</xs:documentation>
                                </xs:annotation>
                            </xs:attribute>
                        </xs:extension>
                    </xs:simpleContent>
                </xs:complexType>
            </xs:element>
            <xs:element name="MulticastGatewaySessionReporting" type="SessionReportingType" minOccurs="0">
                <xs:annotation>
                    <xs:documentation>The reporting destination(s) used by the Multicast gateway for all Multicast
transport sessions within the scope of this Multicast session.</xs:documentation>
                </xs:annotation>
            </xs:element>
            <xs:element name="MulticastTransportSession" type="MulticastTransportSessionType"
maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:attribute name="serviceIdentifier" type="xs:anyURI" use="required">
            <xs:annotation>
                <xs:documentation>A URI that uniquely identifies a multicast session within the deployed
system.</xs:documentation>
            </xs:annotation>
        </xs:attribute>
        <xs:attribute name="contentPlaybackAvailabilityOffset" type="xs:duration" default="PT0S">
            <xs:annotation>
                <xs:documentation>The period for which the availability start time of media objects delivered at
reference point L should be delayed by the Multicast gateway</xs:documentation>
            </xs:annotation>
        </xs:attribute>
    </xs:complexType>
```

```
   <xs:element name="MulticastServerConfiguration">
      <xs:annotation>
         <xs:documentation>A document describing the currently configured Multicast sessions of a Multicast
server.</xs:documentation>
      </xs:annotation>
      <xs:complexType>
         <xs:sequence>
            <xs:element name="MulticastGatewayConfigurationTransportSession"
type="BaseMulticastTransportSessionType" minOccurs="0" maxOccurs="unbounded">
               <xs:annotation>
                  <xs:documentation>The Multicast gateway configuration can optionally be transmitted via an
in-band multicast transport session.</xs:documentation>
               </xs:annotation>
            </xs:element>
            <xs:element name="MulticastSession" type="MulticastSessionType" minOccurs="0"
maxOccurs="unbounded">
               <xs:annotation>
                  <xs:documentation>A set of multicast sessions, each one for a different linear
service.</xs:documentation>
               </xs:annotation>
            </xs:element>
         </xs:sequence>
         <xs:attributeGroup ref="validityAttrs">
            <xs:annotation>
               <xs:documentation>Attributes declaring the validity of this Multicast server configuration
document and its contents.</xs:documentation>
            </xs:annotation>
         </xs:attributeGroup>
      </xs:complexType>
   </xs:element>

   <xs:element name="MulticastGatewayConfiguration">
      <xs:annotation>
         <xs:documentation>A document describing the currently configured Multicast sessions of a Multicast
gateway.</xs:documentation>
      </xs:annotation>
      <xs:complexType>
         <xs:choice>
            <xs:element name="MulticastGatewayConfigurationTransportSession"
type="BaseMulticastTransportSessionType" minOccurs="0" maxOccurs="unbounded">
               <xs:annotation>
                  <xs:documentation>The Multicast gateway configuration can optionally be transmitted via an
in-band multicast transport session.</xs:documentation>
               </xs:annotation>
            </xs:element>
            <xs:element name="MulticastSession" type="MulticastSessionType" minOccurs="0"
maxOccurs="unbounded">
               <xs:annotation>
                  <xs:documentation>A set of multicast sessions, each one for a different linear
service.</xs:documentation>
               </xs:annotation>
            </xs:element>
         </xs:choice>
         <xs:attributeGroup ref="validityAttrs">
            <xs:annotation>
               <xs:documentation>Attributes declaring the validity of this Multicast gateway configuration
document and its contents.</xs:documentation>
            </xs:annotation>
         </xs:attributeGroup>
      </xs:complexType>
   </xs:element>
</xs:schema>
```

Annex B (normative): Classification schemes

B.1 MulticastTransportProtocolCS

```
<?xml version="1.0" encoding="UTF-8"?>
<ClassificationScheme uri="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019">
   <Term termID="FLUTE">
      <Name xml:lang="en">File Delivery over Unidirectional Transport</Name>
      <Definition xml:lang="en">Version 1 (IETF RFC 3926), as profiled by ETSI TS 126 346 Release 16 and ETSI
TS 103 769.</Definition>
   </Term>
   <Term termID="ROUTE">
      <Name xml:lang="en">Real-time Object delivery over Unidirectional Transport</Name>
      <Definition xml:lang="en">Per ATSC A/331, as profiled by ETSI TS 103 769.</Definition>
   </Term>
</ClassificationScheme>
```

B.2 ForwardErrorCorrectionSchemeCS

The *ForwardErrorCorrectionSchemeCS* controlled vocabulary is a subset of the IANA registry of FEC Encoding IDs for Reliable Multicast Transport.

```
<?xml version="1.0" encoding="UTF-8"?>
<ClassificationScheme uri="urn:ietf:rmt:fec:encoding">
   <Term termID="0">
      <Name xml:lang="en">Compact No-Code FEC Scheme</Name>
      <Definition xml:lang="en">As specified in IETF RFC 5445 Section 3.</Definition>
   </Term>
   <Term termID="1">
      <Name xml:lang="en">Raptor Forward Error Correction Scheme for Object Delivery</Name>
      <Definition xml:lang="en">As specified in IETF RFC 5053.</Definition>
   </Term>
   <Term termID="6">
      <Name xml:lang="en">RaptorQ Forward Error Correction Scheme for Object Delivery</Name>
      <Definition xml:lang="en">As specified in IETF RFC 6330.</Definition>
   </Term>
</ClassificationScheme>
```

Annex C (informative): Multicast session configuration examples

C.1 Multicast server configuration instance document

The example multicast server configuration instance document below is valid for 1 day after receipt. It describes:

1) A multicast gateway configuration transport session using the FLUTE multicast media transport protocol that is transmitted to an IPv4 multicast group. It is protected by in-band Raptor AL-FEC. The endpoint address does not need to be specified because it is the same as that of the enclosing transport session.

2) A multicast gateway configuration transport session using the ROUTE multicast media transport protocol that is transmitted to an IPv4 multicast group. It is protected by a RaptorQ Repair Flow transmitted to a different IPv4 group.

3) A multicast session for the service "BBC One Scotland" associated with an MPEG-DASH MPD and an HLS Master Playlist. There are multicast transport sessions carrying two alternative vision service components, both transmitted in the FLUTE multicast media transport protocol. These are sent to different IPv4 multicast groups. There is also a single multicast transport session carrying the sound service component that is transmitted to a third IPv4 multicast group, again using the FLUTE multicast media transport protocol. All three service components are protected by in-band Raptor FEC. All three service components use the push content ingest method and chunked transmission mode.

4) A multicast session for the service "BBC Two Scotland" associated with an MPEG-DASH MPD and an HLS Master Playlist. There is a single multicast transport session carrying the vision service component and another multicast transport session carrying the sound component, both transmitted in the ROUTE multicast media transport protocol, but to the same IPv4 multicast group. Although multiplexed together on the same multicast group, the ROUTE Source Flows are addressed to different destination UDP ports and different LCT Channel numbers. The two service components are jointly protected by an out-of-band RaptorQ Repair Flow because the destination group address, destination port and LCT Channel number are identical for both sets of Forward Error Correction parameters. Both service components use the pull content ingest method and resource transmission mode.

```
<?xml version="1.0" encoding="UTF-8"?>
<MulticastServerConfiguration xmlns="urn:dvb:metadata:MulticastSessionConfiguration:2019"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" validityPeriod="P1D">

   <!-- Special Multicast transport session used to transmit configuration to the population of FLUTE-compatible
Multicast gateways -->
   <MulticastGatewayConfigurationTransportSession transportSecurity="integrityAndAuthenticity">
      <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
      <EndpointAddress>
         <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
         <NetworkDestinationGroupAddress>232.99.1.1</NetworkDestinationGroupAddress>
         <TransportDestinationPort>9999</TransportDestinationPort>
         <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
      </EndpointAddress>
      <BitRate average="200" maximum="200"></BitRate>
      <ForwardErrorCorrectionParameters>
         <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
         <OverheadPercentage>20</OverheadPercentage>
         <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent transport
session -->
      </ForwardErrorCorrectionParameters>
   </MulticastGatewayConfigurationTransportSession>

   <!-- Special Multicast transport session used to transmit configuration to the population of ROUTE-compatible
Multicast gateways -->
   <MulticastGatewayConfigurationTransportSession transportSecurity="integrityAndAuthenticity">
      <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE"
protocolVersion="1"/>
      <EndpointAddress>
         <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
```

```
            <NetworkDestinationGroupAddress>232.98.1.1</NetworkDestinationGroupAddress>
            <TransportDestinationPort>9999</TransportDestinationPort>
            <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
        </EndpointAddress>
        <BitRate average="200" maximum="200"/>
        <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:6</SchemeIdentifier>  <!-- RaptorQ -->
            <OverheadPercentage>20</OverheadPercentage>
            <EndpointAddress>
                <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
                <NetworkDestinationGroupAddress>232.98.1.2</NetworkDestinationGroupAddress>
                <TransportDestinationPort>8888</TransportDestinationPort>
                <MediaTransportSessionIdentfier>2</MediaTransportSessionIdentfier>
            </EndpointAddress>
        </ForwardErrorCorrectionParameters>
    </MulticastGatewayConfigurationTransportSession>

    <!-- BBC One Scotland -->
    <MulticastSession serviceIdentifier="tag:bbc.co.uk;2019#bbc-one/scotland"
contentPlaybackAvailabilityOffset="PT3.84S">

        <!-- Origin locations of MPEG-DASH and HLS presentation manifests for this service -->
        <PresentationManifestLocator manifestId="bbc-one-scotland_mpd"
contentType="application/xml+mpd">http://media.bbc.co.uk/simulcast/bbc-one/scotland/manifest.mpd
</PresentationManifestLocator>
        <PresentationManifestLocator manifestId="bbc-one-scotland_hls"
contentType="application/vnd.apple.mpegURL">http://media.bbc.co.uk/simulcast/bbc-one/scotland/master.m3u8
</PresentationManifestLocator>

        <!-- Reporting destination(s) used by the Multicast gateway for this Multicast session -->
        <MulticastGatewaySessionReporting>
            <ReportingLocator proportion="0.3" period="P5M" randomDelay="50">https://reporting.isp.net/endpoint
</ReportingLocator>
            <ReportingLocator proportion="0.1" period="PT1H" randomDelay="1000">https://reporting.bbc.co.uk/
dvb_multicast_gateway.cgi</ReportingLocator>
        </MulticastGatewaySessionReporting>

        <!-- First video component -->
        <MulticastTransportSession id="vision-low" start="2019-01-01T00:00:00" transmissionMode="chunked"
contentIngestMethod="push" sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
            <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
            <EndpointAddress>
                <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
                <NetworkDestinationGroupAddress>232.100.1.1</NetworkDestinationGroupAddress>
                <TransportDestinationPort>3922</TransportDestinationPort>
                <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
            </EndpointAddress>
            <BitRate average="150000" maximum="150000"/>
            <ForwardErrorCorrectionParameters>
                <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
                <OverheadPercentage>20</OverheadPercentage>
                <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent
transport session -->
            </ForwardErrorCorrectionParameters>
            <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
                <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/vision-low</BaseURL>
                <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/vision-low</BaseURL>
            </UnicastRepairParameters>
            <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-one-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="1" representationIdentifier="V1"/>
            <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-one-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-one/scotland/V1.m3u8"/>
        </MulticastTransportSession>

        <!-- Second video component -->
        <MulticastTransportSession id="vision-medium" start="2019-05-03T20:00:00" duration="PT2H"
transmissionMode="chunked" contentIngestMethod="push" sessionIdleTimeout="3840"
transportSecurity="integrityAndAuthenticity">
            <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
            <EndpointAddress>
                <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
```

```
            <NetworkDestinationGroupAddress>232.100.1.2</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3923</TransportDestinationPort>
            <MediaTransportSessionIdentfier>2</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="250000" maximum="250000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
            <OverheadPercentage>20</OverheadPercentage>
            <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent
transport session -->
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/vision-medium</BaseURL>
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/vision-medium</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-one-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="1" representationIdentifier="V2"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-one-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-one/scotland/V2.m3u8"/>
      </MulticastTransportSession>

      <!-- Single audio component -->
      <MulticastTransportSession id="sound" start="2019-01-01T00:00:00" transmissionMode="chunked"
contentIngestMethod="push" sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
         <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
         <EndpointAddress>
            <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
            <NetworkDestinationGroupAddress>232.100.2.1</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3924</TransportDestinationPort>
            <MediaTransportSessionIdentfier>5</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="150000" maximum="150000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
            <OverheadPercentage>20</OverheadPercentage>
            <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent
transport session -->
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/sound</BaseURL>
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/sound</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-one-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="2" representationIdentifier="A1"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-one-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-one/scotland/A1.m3u8"/>
      </MulticastTransportSession>

   </MulticastSession>

   <!-- BBC Two Scotland -->
   <MulticastSession serviceIdentifier="tag:bbc.co.uk;2019#bbc-two/scotland"
contentPlaybackAvailabilityOffset="PT3.84S">

      <!-- Origin locations of MPEG-DASH and HLS presentation manifests for this service -->
      <PresentationManifestLocator manifestId="bbc-two-scotland_mpd"
contentType="application/xml+mpd">http://media.bbc.co.uk/simulcast/bbc-two/scotland/manifest.mpd
</PresentationManifestLocator>
      <PresentationManifestLocator manifestId="bbc-two-scotland_hls"
contentType="application/vnd.apple.mpegURL">http://media.bbc.co.uk/simulcast/bbc-two/scotland/master.m3u8
</PresentationManifestLocator>

      <!-- No reporting destination(s) for this Multicast session -->

      <!-- Single video component -->
      <MulticastTransportSession id="vision" start="2019-01-01T00:00:00" transmissionMode="resource"
contentIngestMethod="pull" sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
         <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE"
protocolVersion="1"/>
         <EndpointAddress>
            <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
```

```
            <NetworkDestinationGroupAddress>232.200.1.1</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3922</TransportDestinationPort>
            <MediaTransportSessionIdentfier>11</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="150000" maximum="150000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:6</SchemeIdentifier>  <!-- RaptorQ -->
            <OverheadPercentage>20</OverheadPercentage>
            <EndpointAddress>
               <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
               <NetworkDestinationGroupAddress>232.200.2.1</NetworkDestinationGroupAddress>
               <TransportDestinationPort>3922</TransportDestinationPort>
               <MediaTransportSessionIdentfier>26</MediaTransportSessionIdentfier>
            </EndpointAddress>
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-two_scotland/vision</BaseURL>
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-two_scotland/vision</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-two-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="1" representationIdentifier="V1"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-two-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-two/scotland/V1.m3u8"/>
      </MulticastTransportSession>

      <!-- Single audio component -->
      <MulticastTransportSession id="sound" start="2019-01-01T00:00:00" transmissionMode="resource"
contentIngestMethod="pull" sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
         <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE"
protocolVersion="1"/>
         <EndpointAddress>
            <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
            <NetworkDestinationGroupAddress>232.200.1.1</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3923</TransportDestinationPort>
            <MediaTransportSessionIdentfier>15</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="150000" maximum="150000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:6</SchemeIdentifier>  <!-- RaptorQ -->
            <OverheadPercentage>20</OverheadPercentage>
            <EndpointAddress>
               <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
               <NetworkDestinationGroupAddress>232.200.2.1</NetworkDestinationGroupAddress>
               <TransportDestinationPort>3922</TransportDestinationPort>
               <MediaTransportSessionIdentfier>26</MediaTransportSessionIdentfier>
            </EndpointAddress>
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/sound</BaseURL>
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/sound</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-two-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="2" representationIdentifier="A1"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-two-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-two/scotland/A1.m3u8"/>
      </MulticastTransportSession>

   </MulticastSession>

</MulticastServerConfiguration>
```

C.2 Multicast gateway configuration bootstrap instance document

The parameters of the multicast gateway configuration transport session can be provided to a *Multicast gateway* at reference point **C_{MR}** in a separate multicast session configuration instance document. This bootstrap configuration then enables the *Multicast gateway* to acquire the remainder of its multicast gateway configuration (see clause C.3 below) from a multicast gateway configuration transport session transmitted at reference point **M**.

The example multicast gateway configuration bootstrap instance document below is valid for 1 day after receipt. It describes:

1) A multicast gateway configuration transport session using the FLUTE multicast media transport protocol that is simulcast to an IPv4 multicast group and to an IPv6 multicast group. Both multicast groups are protected by in-band Raptor AL-FEC. The endpoint address does not need to be specified because it is the same as that of the enclosing transport session.

2) A multicast gateway configuration transport session using the ROUTE multicast media transport protocol that is simulcast to an IPv4 multicast group and to an IPv6 multicast group. Both multicast groups are protected by RaptorQ Repair Flows sent to different IPv4 and IPv6 multicast groups.

```
<?xml version="1.0" encoding="UTF-8"?>
<MulticastGatewayConfiguration xmlns="urn:dvb:metadata:MulticastSessionConfiguration:2019"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" validityPeriod="P1D">

   <!-- Special Multicast transport session used to transmit configuration to the population of Multicast
gateways -->
   <MulticastGatewayConfigurationTransportSession transportSecurity="integrityAndAuthenticity">
      <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
      <EndpointAddress>
         <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
         <NetworkDestinationGroupAddress>232.99.1.1</NetworkDestinationGroupAddress>
         <TransportDestinationPort>9999</TransportDestinationPort>
         <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
      </EndpointAddress>
      <EndpointAddress>
         <NetworkSourceAddress>2001:DB8::4456:424D</NetworkSourceAddress>
         <NetworkDestinationGroupAddress>FF3E::4950:4801</NetworkDestinationGroupAddress>
         <TransportDestinationPort>9999</TransportDestinationPort>
         <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
      </EndpointAddress>
      <BitRate average="200" maximum="200"/>
      <ForwardErrorCorrectionParameters>
         <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
         <OverheadPercentage>20</OverheadPercentage>
         <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent transport
session -->
      </ForwardErrorCorrectionParameters>
   </MulticastGatewayConfigurationTransportSession>

   <!-- Special Multicast transport session used to transmit configuration to the population of Multicast
gateways -->
   <MulticastGatewayConfigurationTransportSession transportSecurity="integrityAndAuthenticity">
      <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE"
protocolVersion="1"/>
      <EndpointAddress>
         <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
         <NetworkDestinationGroupAddress>232.98.1.1</NetworkDestinationGroupAddress>
         <TransportDestinationPort>9999</TransportDestinationPort>
         <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
      </EndpointAddress>
      <EndpointAddress>
         <NetworkSourceAddress>2001:DB8::4456:424D</NetworkSourceAddress>
         <NetworkDestinationGroupAddress>FF3E::4950:4701</NetworkDestinationGroupAddress>
         <TransportDestinationPort>9999</TransportDestinationPort>
         <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
      </EndpointAddress>
      <BitRate average="200" maximum="200"/>
      <ForwardErrorCorrectionParameters>
```

```
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:6</SchemeIdentifier>  <!-- RaptorQ -->
            <OverheadPercentage>20</OverheadPercentage>
            <EndpointAddress>
               <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
               <NetworkDestinationGroupAddress>232.99.1.1</NetworkDestinationGroupAddress>
               <TransportDestinationPort>8888</TransportDestinationPort>
               <MediaTransportSessionIdentfier>2</MediaTransportSessionIdentfier>
            </EndpointAddress>
            <EndpointAddress>
               <NetworkSourceAddress>2001:DB8::4456:424D</NetworkSourceAddress>
               <NetworkDestinationGroupAddress>FF3E::4950:4702</NetworkDestinationGroupAddress>
               <TransportDestinationPort>8888</TransportDestinationPort>
               <MediaTransportSessionIdentfier>2</MediaTransportSessionIdentfier>
            </EndpointAddress>
         </ForwardErrorCorrectionParameters>
      </MulticastGatewayConfigurationTransportSession>

</MulticastGatewayConfiguration>
```

C.3 Multicast gateway configuration instance document

The example multicast gateway configuration instance document below is valid until 11th July 2019. It corresponds to the multicast server configuration in clause C.1 and may be transmitted on the multicast gateway configuration transport session described in clause C.2.

```
<?xml version="1.0" encoding="UTF-8"?>
<MulticastGatewayConfiguration xmlns="urn:dvb:metadata:MulticastSessionConfiguration:2019"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" validUntil="2019-07-11T16:26:37">

   <!-- BBC One Scotland -->
   <MulticastSession serviceIdentifier="tag:bbc.co.uk;2019#bbc-one/scotland"
contentPlaybackAvailabilityOffset="PT3.84S">

      <!-- Origin locations of MPEG-DASH and HLS presentation manifests for this service -->
      <PresentationManifestLocator manifestId="bbc-one-scotland_mpd"
contentType="application/xml+mpd">http://media.bbc.co.uk/simulcast/bbc-
one/scotland/manifest.mpd</PresentationManifestLocator>
      <PresentationManifestLocator manifestId="bbc-one-scotland_hls"
contentType="application/vnd.apple.mpegURL">http://media.bbc.co.uk/simulcast/bbc-
one/scotland/master.m3u8</PresentationManifestLocator>

      <!-- Reporting destination(s) used by the Multicast gateway for this Multicast session -->
      <MulticastGatewaySessionReporting>
         <ReportingLocator proportion="0.3" period="P5M"
randomDelay="50">https://reporting.isp.net/endpoint</ReportingLocator>
         <ReportingLocator proportion="0.1" period="PT1H"
randomDelay="1000">https://reporting.bbc.co.uk/dvb_multicast_gateway.cgi</ReportingLocator>
      </MulticastGatewaySessionReporting>

      <!-- First video component -->
      <MulticastTransportSession id="vision-low" start="2019-01-01T00:00:00" transmissionMode="chunked"
sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
         <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
         <EndpointAddress>
            <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
            <NetworkDestinationGroupAddress>232.100.1.1</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3922</TransportDestinationPort>
            <MediaTransportSessionIdentfier>1</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="150000" maximum="150000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
            <OverheadPercentage>20</OverheadPercentage>
            <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent
transport session -->
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/vision-low</BaseURL>
```

```
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/vision-low</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-one-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="1" representationIdentifier="V1"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-one-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-one/scotland/V1.m3u8"/>
      </MulticastTransportSession>

      <!-- Second video component -->
      <MulticastTransportSession id="vision-medium" start="2019-05-03T20:00:00" duration="PT2H"
transmissionMode="chunked" sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
         <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
         <EndpointAddress>
            <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
            <NetworkDestinationGroupAddress>232.100.1.2</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3923</TransportDestinationPort>
            <MediaTransportSessionIdentfier>2</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="250000" maximum="250000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
            <OverheadPercentage>20</OverheadPercentage>
            <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent
transport session -->
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/vision-medium</BaseURL>
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/vision-medium</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-one-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="1" representationIdentifier="V2"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-one-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-one/scotland/V2.m3u8"/>
      </MulticastTransportSession>

      <!-- Single audio component -->
      <MulticastTransportSession id="sound" start="2019-01-01T00:00:00" transmissionMode="chunked"
sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
         <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE"
protocolVersion="1"/>
         <EndpointAddress>
            <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
            <NetworkDestinationGroupAddress>232.100.2.1</NetworkDestinationGroupAddress>
            <TransportDestinationPort>3924</TransportDestinationPort>
            <MediaTransportSessionIdentfier>5</MediaTransportSessionIdentfier>
         </EndpointAddress>
         <BitRate average="150000" maximum="150000"/>
         <ForwardErrorCorrectionParameters>
            <SchemeIdentifier>urn:ietf:rmt:fec:encoding:1</SchemeIdentifier>  <!-- Raptor -->
            <OverheadPercentage>20</OverheadPercentage>
            <!-- Endpoint address omitted for FLUTE Sessions since this is always the same as the parent
transport session -->
         </ForwardErrorCorrectionParameters>
         <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
            <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/sound</BaseURL>
            <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/sound</BaseURL>
         </UnicastRepairParameters>
         <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-one-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="2" representationIdentifier="A1"/>
         <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-one-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-one/scotland/A1.m3u8"/>
      </MulticastTransportSession>

   </MulticastSession>
```

```
    <!-- BBC Two Scotland -->
    <MulticastSession serviceIdentifier="tag:bbc.co.uk;2019#bbc-two/scotland"
contentPlaybackAvailabilityOffset="PT3.84S">

        <!-- Origin locations of MPEG-DASH and HLS presentation manifests for this service -->
        <PresentationManifestLocator manifestId="bbc-two-scotland_mpd"
contentType="application/xml+mpd">http://media.bbc.co.uk/simulcast/bbc-
two/scotland/manifest.mpd</PresentationManifestLocator>
        <PresentationManifestLocator manifestId="bbc-two-scotland_hls"
contentType="application/vnd.apple.mpegURL">http://media.bbc.co.uk/simulcast/bbc-
two/scotland/master.m3u8</PresentationManifestLocator>

        <!-- No reporting destination(s) for this Multicast session -->

        <!-- Single video component -->
        <MulticastTransportSession id="vision" start="2019-01-01T00:00:00" transmissionMode="resource"
sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
            <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE"
protocolVersion="1"/>
            <EndpointAddress>
                <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
                <NetworkDestinationGroupAddress>232.200.1.1</NetworkDestinationGroupAddress>
                <TransportDestinationPort>3922</TransportDestinationPort>
                <MediaTransportSessionIdentfier>11</MediaTransportSessionIdentfier>
            </EndpointAddress>
            <BitRate average="150000" maximum="150000"/>
            <ForwardErrorCorrectionParameters>
                <SchemeIdentifier>urn:ietf:rmt:fec:encoding:6</SchemeIdentifier>  <!-- RaptorQ -->
                <OverheadPercentage>20</OverheadPercentage>
                <EndpointAddress>
                    <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
                    <NetworkDestinationGroupAddress>232.200.2.1</NetworkDestinationGroupAddress>
                    <TransportDestinationPort>3922</TransportDestinationPort>
                    <MediaTransportSessionIdentfier>26</MediaTransportSessionIdentfier>
                </EndpointAddress>
            </ForwardErrorCorrectionParameters>
            <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
                <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-two_scotland/vision</BaseURL>
                <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-two_scotland/vision</BaseURL>
            </UnicastRepairParameters>
            <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-two-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="1" representationIdentifier="V1"/>
            <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-two-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-two/scotland/V1.m3u8"/>
        </MulticastTransportSession>

        <!-- Single audio component -->
        <MulticastTransportSession id="sound" start="2019-01-01T00:00:00" transmissionMode="resource"
sessionIdleTimeout="3840" transportSecurity="integrityAndAuthenticity">
            <TransportProtocol protocolIdentifier="urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE"
protocolVersion="1"/>
            <EndpointAddress>
                <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
                <NetworkDestinationGroupAddress>232.200.1.1</NetworkDestinationGroupAddress>
                <TransportDestinationPort>3923</TransportDestinationPort>
                <MediaTransportSessionIdentfier>15</MediaTransportSessionIdentfier>
            </EndpointAddress>
            <BitRate average="150000" maximum="150000"/>
            <ForwardErrorCorrectionParameters>
                <SchemeIdentifier>urn:ietf:rmt:fec:encoding:6</SchemeIdentifier>  <!-- RaptorQ -->
                <OverheadPercentage>20</OverheadPercentage>
                <EndpointAddress>
                    <NetworkSourceAddress>10.1.100.1</NetworkSourceAddress>
                    <NetworkDestinationGroupAddress>232.200.2.1</NetworkDestinationGroupAddress>
                    <TransportDestinationPort>3922</TransportDestinationPort>
                    <MediaTransportSessionIdentfier>26</MediaTransportSessionIdentfier>
                </EndpointAddress>
            </ForwardErrorCorrectionParameters>
            <UnicastRepairParameters transportObjectReceptionTimeout="500" fixedBackOffPeriod="10"
randomBackOffPeriod="20">
                <BaseURL relativeWeight="7">http://bbc.cdn1.com/bbc-one_scotland/sound</BaseURL>
                <BaseURL relativeWeight="3">http://bbc.cdn2.com/bbc-one_scotland/sound</BaseURL>
            </UnicastRepairParameters>
```

```
          <ServiceComponentIdentifier xsi:type="DASHComponentIdentifierType" manifestIdRef="bbc-two-
scotland_mpd" periodIdentifier="period1" adaptationSetIdentifier="2" representationIdentifier="A1"/>
          <ServiceComponentIdentifier xsi:type="HLSComponentIdentifierType" manifestIdRef="bbc-two-scotland_hls"
mediaPlaylistLocator="http://media.bbc.co.uk/simulcast/bbc-two/scotland/A1.m3u8"/>
       </MulticastTransportSession>

    </MulticastSession>
</MulticastGatewayConfiguration>
```

Annex D (informative): Media object mapping

Table D-1 below summarizes, for several common ingest object types, the end-to-end mapping between media objects ingested by the *Multicast server* and those exposed to the *Content playback* function by the *Multicast gateway* at reference point **L**.

Table D-1: Summary of object ingest and delivery for regular and low latency provisioned content.

Ingest object ($P_{in'}$ or O_{in})	**Ingest method**	**Multicast server mapping**	**Multicast transport object (M)**	**Multicast gateway conversion**	**Playback delivery object**	**Content playback retrieval (L)**
DASH Segment, identified by URL.	Regular HTTP response. HTTP/1.1 chunked transfer coding optional.	Each DASH Segment maps to a different multicast transport object. Mapping from content ingest object URL to multicast transport object URI may be specified by multicast media transport protocol. When HTTP/1.1 chunked transfer coding is used, one or more HTTP chunks are combined into one multicast transport object.	DASH Segment	Conversion between multicast transport object URI and playback delivery object URL may be specified by multicast media transport protocol.	DASH Segment	HTTP Request for a playback delivery object (DASH Segment)
CMAF chunks, each composed of one or more HTTP chunks, but only the parent DASH Segment has a URL.	HTTP/1.1 chunked transfer coding.	Combine one or multiple HTTP chunks into one multicast transport object with its own URI. Mapping from transport object URLs to DASH Segment URL.	Part of a DASH Segment (minimum size: one HTTP chunk, maximum size: one CMAF chunk).	Assemble received multicast transport objects into a DASH Segment. Conversion may be needed between multicast transport object URI and playback delivery object URL.	Depending on Content playback requests: *Low Latency:* CMAF Chunks delivered at **L** using HTTP chunked transfer coding and minimal buffering. *Conservative player:* Regular DASH Segment (progressive reception).	
DASH Segment composed of multiple CMAF chunks.		Each DASH Segment is mapped to a multicast transport object with its own a URI. CMAF chunks, parts of a DASH segment, are streamed through. Mapping from DASH Segments and CMAF Chunks to multicast transport Objects.	Parts of a transport object which correspond to streamed through CMAF chunks.	Received CMAF chunks. Mapping from multicast transmission objects to DASH Segments and CMAF Chunks.		

Annex E (informative): End-to-end worked example

E.1 Mapping of content ingest URL to multicast transport object URI by Multicast server

See clause 8.3.3.

Content ingest URL at reference point **O_{in}**	http://account9876.cdn.com/service4567/as1/rep1/**segment1234.m4s**
Content ingest URL at reference point **P_{in}'**	http://multicastserver.isp.net/service4567/as1/rep1/**segment1234.m4s**
Multicast transport object URI at reference point **M**	tag:multicastserver.isp.net,2019-01-01:mts100,3922:**segment1234.m4s**

E.2 Mapping of multicast transport object URI to unicast repair URL by Multicast gateway

See clause 9.2.2.

Multicast transport object URI at reference point **M**	tag:multicastserver.isp.net,2019-01-01:mts100,3922:**segment1234.m4s**
Unicast repair URL at reference point **A**	http://account9876.cdn.com/service4567/as1/rep1/**segment1234.m4s**

Where the URL prefix account9876.cdn.com/service4567/as1/rep1/ is derived from the **`UnicastRepairParameters/BaseURL`** element of the multicast transport session.

E.3 Example HTTP-based unicast repair messages

See clause 9.2.

Assuming that the *Multicast gateway* partially receives a multicast transport object with the unicast repair URL http://www.example.com/service1/000018.m4s and the entity tag *3a9aa6-58f5b718495de*, the *Multicast gateway* sends a repair request to the *Content hosting* function to fetch the missing bytes using single and multiple byte range as shown in table E.3-1.

Table E.3-1: Example unicast repair request and response HTTP messages

	HTTP request message	HTTP response message
Single byte range repair	**GET** /service1/000018.m4s **HTTP/1.1** **If-Range:** "3a9aa6-58f5b718495de" **Range:** bytes=500-999 **Host:** www.example.com	**HTTP/1.1 206** Partial Content **Date:** Mon, 05 Aug 2019 09:37:55 GMT **Last-Modified:** Mon, 05 Aug 2019 09:36:32 GMT **Accept-Ranges:** bytes **Content-Range:** bytes 500-999/3840678 …
Multiple byte range repair	**GET** /service1/000018.m4s **HTTP/1.1** **If-Range:** "3a9aa6-58f5b718495de" **Range:** bytes=500-999, 1500-1999 **Host:** www.example.com	**HTTP/1.1 206** Partial Content **Date:** Mon, 05 Aug 2019 09:38:41 GMT **Last-Modified:** Mon, 05 Aug 2019 09:36:32 GMT **Accept-Ranges:** bytes **Content-Length:** 1150 **Content-Type:** multipart/byteranges; boundary=THIS_STRING_SEPARATES **--** THIS_STRING_SEPARATES **Content-Range:** bytes 500-999/3840678 … -- THIS_STRING_SEPARATES **Content-Range:** bytes 1500-1999/3840678 … -- THIS_STRING_SEPARATES--

E.4 Mapping of multicast transport object URI to playback delivery object URL

The format of the playback delivery object URL is at the discretion of the *Multicast gateway* (see clause 8.4.4). The following example illustrates two different possible formats for the playback delivery object URL exposed at reference point **L**: one with a local host name that can be resolved by a DNS resolver in the local network and one with an unresolved IP address. The latter addressing format may be appropriate in the case where the *Multicast gateway* is deployed in a home gateway device (see clause 6.2) lacking local DNS resolution capability. In both examples, the *Multicast gateway* has inserted a session identifier into the URL path that enables it to track usage independently for each playback session.

Multicast transport object URI at reference point **M**	tag:multicastserver.isp.net,2019-01-01:mts100,3922:**segment1234.m4s**
Playback delivery object URL at reference point **L** *(local host name)*	http://gateway.local:8080/session5678/as1/rep1/**segment1234.m4s**
Playback delivery object URL at reference point **L** *(unresolved local IP address)*	http://192.0.2.1:8080/session5678/as1/rep1/**segment1234.m4s**

Annex F (normative): FLUTE-based multicast media transport protocol

F.0 Introduction

The 3GPP FLUTE profile specified in this annex is based on the 3GPP MBMS Download Profile as defined in clause L.4 of ETSI TS 126 346 [17] and on MBMS DASH Streaming as defined in clause 5.6 of [17]. MBMS DASH Streaming allows the sending of both non-real-time content and DASH-formatted content via MBMS.

This profile differs from the 3GPP FLUTE profile in the following ways:

- The MBMS User Service Discovery/Announcement mechanism specified in clause 5.2 of [17], including the use of SDP, is replaced by the multicast session configuration instance document specified in clause 10.2.
- The use of RTSP for session setup and control, specified in clause L.4.6 of [17], is not required.
- The use of Byte-Range based File Repair, as specified in clause 9.3.6.2 of [17] is permitted, as specified in clause F.3.2 below. However, the operation of the unicast repair procedure in the *Multicast gateway* is governed by the contents of the multicast gateway configuration, and the **`Alternate-Content-Location-1`** and **`Alternate-Content-Location-2`** elements in the FDT Instance shall be ignored. In addition, the usage of the Associated Delivery Procedure Fragment, which contains some additional parameters for the File Repair Procedure configuration, is excluded from this profile.
- Symbol-based file repair over reference points **U** or **A** (as defined in [17]) is not supported by this profile, because this profile does not support the Associated Delivery Procedure Description Fragment.
- A means of subdividing a media object into smaller multicast transport objects for low-latency operations is specified in clause F.2.2.
- In deployments with low rates of packet loss the Close Object (B) LCT header flag may be used by the *Multicast server.* In this case, the flag shall be set only in the last FLUTE packet comprising a multicast transport object.

F.1 Signalling in the multicast session configuration

The use of the multicast media transport protocol specified in this annex shall be signalled in the multicast session configuration as follows (see clause 10.2.3.8):

`TransportProtocol/@`**`protocolIdentifier`**	`TransportProtocol/@`**`protocolVersion`**
urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:FLUTE	*1*

The multicast transmission mode, as specified in clause 10.2.3.5, shall indicate whether multicast transport objects are formatted using resource transmission mode (per clause F.2.1 below) or chunked transmission mode (per clause F.2.2).

The integrity of a multicast transport object can be protected in 3GPP FLUTE by an MD5 digest conveyed in the optional **`File/`**`@Content-MD5` attribute of the FDT Instance. If every multicast transport object in a multicast transport session is so protected, the transport security mode "Integrity" (see clause 10.2.3.6) shall be indicated in the multicast session configuration. Otherwise the transport security mode "None" shall be indicated.

The IP source address (in the case of source-specific multicast), IP multicast group destination address and destination UDP port number of the FLUTE Session shall be signalled in the multicast transport endpoint address, as specified in clause 10.2.3.9. The LCT Transport Session Identifier shall be conveyed in the multicast media transport protocol session identifier, as also specified in clause 10.2.3.9.

Application Level Forward Error Correction is always carried in band (i.e. in the same FLUTE Session as the multicast transport objects protected). Accordingly, the **`ForwardErrorCorrectionParameters/EndpointAddress`** element (see clause 10.2.3.11) should be omitted.

Omitting the **`ForwardErrorCorrectionParameters`** element altogether shall imply that the "Compact No-Code" AL-FEC scheme is in use for the multicast transport session in question.

F.2 Mapping of multicast transport objects to 3GPP FLUTE Transport Objects

F.2.0 General

Each multicast transport session shall be realized as a FLUTE Session comprising one FLUTE Channel (LCT channel), per the MBMS Download Profile in clause L.4 of [17]. Each multicast session may comprise one or more of these FLUTE Sessions, e.g. one FLUTE Session for each service component.

A multicast transport object is realized in this profile by a 3GPP FLUTE Transport Object. A multicast transport object may be a media object (for resource transmission mode, per clause F.2.1) or a byte range of a media object (for chunked transmission mode, per clause F.2.2).

The multicast transport object URI shall be signalled as the **`File/`**`@Content-Location` attribute of exactly one file description entry in a FLUTE File Delivery Table (FDT) Instance. The size of the multicast transport object is signalled as the **`File/`**`@Content-Length` attribute.

NOTE: The FDT Instance is conveyed as TOI=0 in the same FLUTE Session as the FLUTE Transport Object it describes.

F.2.1 Resource transmission mode

When resource transmission mode is in use (see clause 10.2.3.5), the FLUTE FDT Instance describes the size (`@Content-Length` attribute) and multicast transport object URI (`@Content-Location` attribute) of exactly one multicast transport object.

In this transmission mode the *Multicast gateway* may start serving a playback delivery object at reference point **L** once at least the FLUTE FDT Instance for the corresponding FLUTE Transport Object is received.

F.2.2 Chunked transmission mode

If chunked transmission mode is signalled (implicitly or explicitly) for a particular multicast transport session (see clause 10.2.3.5), this indicates that a single ingest object is transmitted as a sequence of one or more related multicast transport objects. This allows for low-latency operation. In this transmission mode additional components (specified below) are present in the multicast transport object URI.

The multicast transport object is preferably a complete CMAF chunk [i.11]. Alternatively, the *Multicast server* may simply transmit ingested HTTP chunks as multicast transport objects. Accordingly, the `@Content-Length` attribute within the FLUTE FDT Instance shall reflect the size of the multicast transport object being conveyed.

The multicast transport object URI carried by the `@Content-Location` attribute shall be suffixed with a fragment identifier component (i.e. *fragment* as specified in section 3.5 of IETF RFC 3986 [15]) indicating the offset of the first byte of this multicast transmission object within the overall media object: the **chunk offset**. If some chunks are not correctly received by the *Multicast gateway*, the chunk offset may be used by the *Multicast gateway* to identify and repair the missing byte range of the affected media object according to clauses F.3.1 and/or F.3.2 below.

All multicast transport objects belonging to the same media object shall be signalled with the same URI prefix (i.e. *hier-part* in IETF RFC 3986 [15]). When the *Multicast gateway* receives a multicast transport object with byte offset 0, the *Multicast gateway* shall start assembling a new playback delivery object and may respond to requests from the *Content playback* function for that playback delivery object. The playback delivery object URL exposed by the *Multicast gateway* at reference point **L** shall not include any fragment identifier component (i.e. the chunk offset) nor any query component. Requests for playback delivery objects at reference point **L** shall elicit an HTTP chunked transfer coding response until such time as the multicast transport object representing the last chunk in the playback delivery object has been received.

The *Multicast server* shall signal the end of a media object explicitly at reference point **M**. If a *Multicast server* has determined that the last HTTP chunk of an ingest media object has been received at reference point $\mathbf{P_{in}'}$ or $\mathbf{O_{in}}$, it may add an isLast query component (i.e. *query* as specified in section 3.5 of IETF RFC 3986 [15]) to the multicast transport object URI to signal completion. Otherwise, if a *Multicast server* does not have this information at the point when it starts transmitting the last multicast transport object, it should instead transmit a zero-length multicast transport object.

A *Multicast gateway* detects the completion of a media object either by receiving a zero-length multicast transport object, or by receiving a multicast transport object carrying the isLast URI query component.

In chunked transmission mode, not all multicast transport objects contain a Random Access Point marker. The *Multicast server* may add a hasRandomAccessPoint URI query component to indicate that this multicast transport object is appropriate for commencing playback.

NOTE 1: Signalling of this information is in particular beneficial for unidirectional transmissions, i.e. when unicast start-up or unicast repair is not supported.

NOTE 2: Details of end-to-end operations for fast start-up are expected in a later specification phase.

For example:

Multicast transport object URI (**`File/`**`@Content-Location`) for *first* multicast transmission object	tag:multicastserver.isp.net,2019-01-01:mts100,3922:**segment1234.m4s?hasRandomAccessPoint#0**
Multicast transport object URI (**`File/`**`@Content-Location`) for *second* multicast transmission object	tag:multicastserver.isp.net,2019-01-01:mts100,3922:**segment1234.m4s#5321**
etc.	
Multicast transport object URI (**`File/`**`@Content-Location`) for *last* multicast transmission object	tag:multicastserver.isp.net,2019-01-01:mts100,3922:**segment1234.m4s?isLast&hasRandomAccessPoint#154360**
Resulting playback delivery object URL at reference point **L**	http://gateway.local:8080/session5678/as1/rep1/**segment1234.m4s**

In order to achieve low-latency operation, the *Multicast gateway* should start serving the content of a multicast transport object as a playback delivery object at reference point **L** as soon as the FLUTE FDT Instance for the first multicast transport object comprising that playback delivery object is received.

F.3 Multicast gateway operation

F.3.1 Forward Error Correction

Multicast gateway implementations support the reception of all encoding symbols as required by clause L.4.7 of ETSI TS 126 346 [17]. However, a *Multicast gateway* may ignore the repair symbols.

If Forward Error Correction is supported by the *Multicast gateway* and provided as part of a multicast transport session, then the *Multicast gateway* should consider already received repair symbols as defined in clause 9.3.3 of [17] as part of the unicast repair procedure.

F.3.2 Unicast repair

The *Multicast gateway* shall follow the unicast repair procedure specified in clause 9. It shall ignore the **`Alternate-Content-Location-1`** and **`Alternate-Content-Location-2`** elements in the FDT Instance.

The start time of the unicast repair procedure is at latest the expiry time of the FDT Instance as defined in clause 9.3.2 of ETSI TS 126 346 [17] or the reception of a FLUTE packet with the Close Object (B) flag set.

In the case of resource transmission mode, the range of bytes to be requested is calculated as specified in clause 9.3.6.2 of ETSI TS 126 346 [17].

In the case of chunked transmission mode, the *Multicast gateway* shall add the chunk offset value (as specified in clause F.3.1 above) to the identified byte ranges. The byte range is determined according to clause 9.3.6.2 of ETSI TS 126 346 [17]. For example, when a packet from a chunk with chunk offset 5321 is missing, the start of the byte range is 5321 + ESI × Symbol Size of the missing packet.

Annex G (informative): Implementation guidelines for FLUTE-based multicast media transport protocol

G.1 Multicast system implementation guidelines

G.1.0 Overview

This clause describes implementation guidelines for mapping DVB-DASH content onto a FLUTE-based reference point **M** realization. Other presentation and segment formats are possible but are beyond the scope of this clause.

The *Multicast server* supports push and pull content ingest methods and this clause describes the mapping of ingest objects to multicast transport objects using FLUTE at reference point **M**, the reception procedure by the *Multicast gateway*, and the mapping of multicast transport objects into playback delivery objects for delivery at reference point **L**.

G.1.1 Regular latency operation

When serving DASH content with regular latency, resource transmission mode (see clauses 8.3.4.1 and F.2.1) can be used and media objects can be ingested into the *Multicast server* using either the pull or push content ingest methods. Figure G.1.1-1 depicts pull-based ingest of segments and figure G.1.1-2 depicts push-based ingest. As can be seen, operation downstream of the *Multicast server* is identical in both cases.

In the case of pull-based ingest, either the content is not formatted for low latency (i.e. **`SegmentTemplate/`**`@availabilityTimeOffset` is absent from the DASH MPD presentation manifest, segment is not subdivided into smaller chunks, etc.) or the *Content ingest* subfunction of the *Multicast server* ignores the `@availabilityTimeOffset` value. Regardless of the reason, in both cases the *Content ingest* subfunction of the *Multicast server* fetches each DASH segment only once it is made fully available by the *Content hosting* function.

In the case of push-based ingest, either the content of a segment is not made available as CMAF chunks before the full segment is created, or the content is not provided to the *Multicast server* using HTTP chunked transfer coding. the *Content preparation* function pushes the segment to the *Content ingest* subfunction only once it is fully available. (HTTP chunked transfer coding can still be used by the *Content preparation* function in these cases, but the HTTP chunks are generated only after the full segment is available.) Alternatively, the *Multicast server* may simply wait until a full segment has been ingested before processing it further.

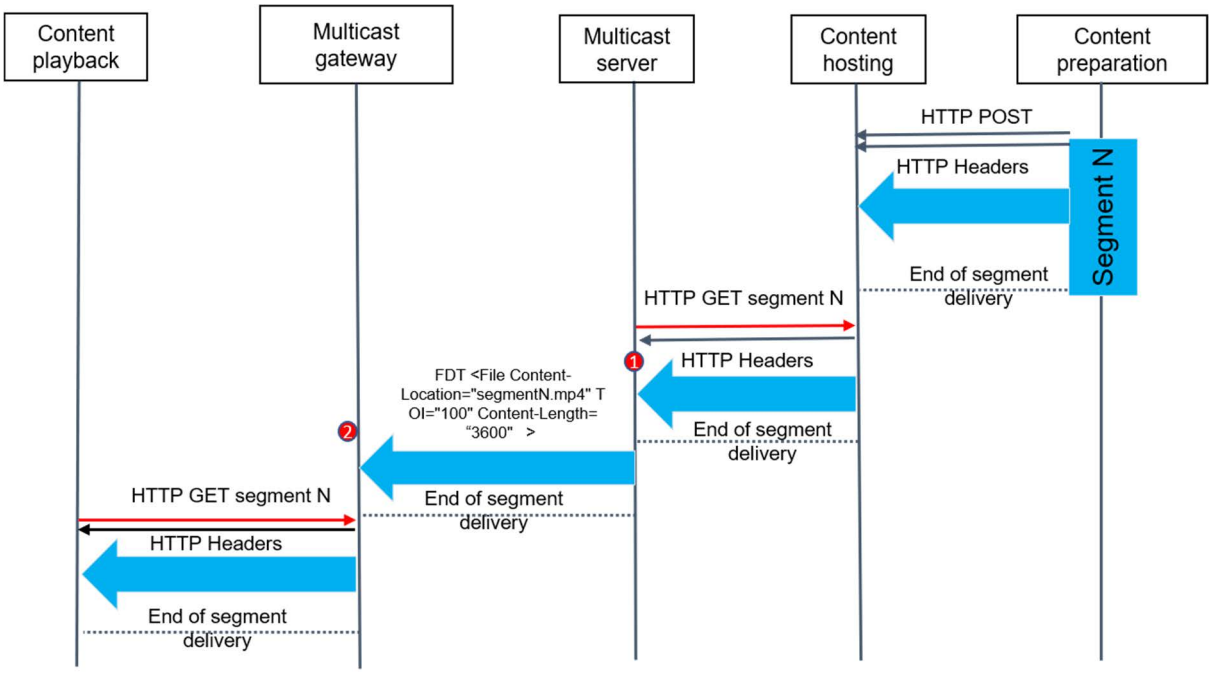


Figure G.1.1-1: Resource transmission mode with pull-based ingest

Figure G.1.1-1 depicts pull-based ingest operations. The *Content preparation* function uploads the segment to the *Content hosting* function. The *Multicast server* requests a DASH segment according to its Segment Availability Start Time (SAST), e.g. as described by clause 5.3.9.1 of MPEG-DASH [i.2]. At mark #1, the *Multicast server* issues the HTTP *GET* request and starts downloading the segment. The segment size is provided at the beginning of the download by the *Content hosting* function as the `Content-Length` HTTP response header and so the *Multicast server* can potentially commence multicast transmission (i.e. construct the FLUTE FDT and start transmitting the multicast transport object at reference point **M**) immediately after the HTTP response headers are received.

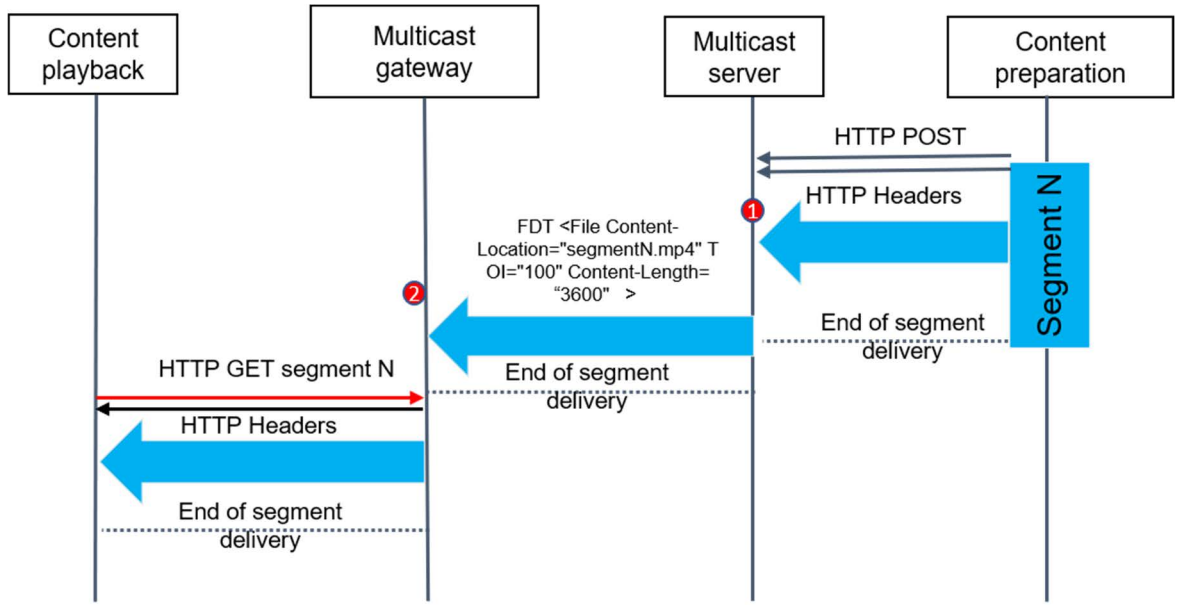


Figure G.1.1-2: Resource transmission mode with push-based ingest

Figure G.1.1-2 depicts push-based ingest operations. The *Content preparation* function pushes ingest objects according to the Segment Availability Start time (SAST) of the DASH segment. The segment is contained in the body of the HTTP request message. (HTTP *POST* is depicted in figure G.1.2-2 as an example.) The segment size is provided at the beginning of the upload by the *Content preparation* function as the `Content-Length` HTTP request header and so the *Multicast server* can potentially commence multicast transmission immediately after the HTTP headers are received.

For both push- and pull-based ingest, the *Multicast server* can use the same forwarding procedure for handling the segment in the HTTP message body (response body in case of pull and request body in case of push).

In both pull- and push-based ingest, the available network bandwidth between the *Content preparation* function and the *Multicast server* determines the transfer latency of ingest objects. When it is guaranteed that the ingest bit rate is always higher or equal to the multicast transport session bit rate (i.e. QoS-provisioned ingest), the *Multicast server* can start the multicast transmission process immediately after the HTTP headers are received. Otherwise it is recommended that the *Multicast server* buffers the ingest objects for a configurable duration.

For starting the multicast transmission process, the *Multicast server* creates the FLUTE FDT Instance for the segment, for example at time of reception of the HTTP headers (see mark #1 in figure G.1.1-1 and figure G.1.1-2). The HTTP headers include the `Content-Length` and the `Content-Type` of the ingest object, which are essential parameters in the FLUTE FDT Instance. The multicast transport object URI carried by the **`File/`**`@Content-Location` attribute is derived from the request URL.

NOTE: The *Multicast server* may rewrite the content ingest URL, as specified in clause 8.3.3.

It is recommended that the FLUTE FDT Instance, containing the metadata for the new multicast transport object, is sent on the FLUTE Session immediately before the multicast transport object it describes. The FLUTE FDT Instance can be repeated during the transmission of the multicast transport object.

Once the *Multicast gateway* receives an FDT Instance describing a new DASH segment (mark #2 in figure G.1.1-1 and figure G.1.1-2), the *Multicast gateway* can start offering the corresponding playback delivery object at reference point **L**. The *Multicast gateway* may delay offering the playback delivery object at reference point **L** for various reasons, for example to allow extra time for unicast repair operations. The *Multicast gateway* may delay offering the playback delivery object at reference point **L** until the multicast transport object has been fully received and (if necessary) repaired using AL-FEC and/or the unicast repair procedure.

G.1.2 Low-latency operation

When serving low-latency DASH content chunked transmission mode is used (see clauses 8.3.4.1 and F.2.2). The content is offered as low-latency content according to [10] (i.e. **`SegmentTemplate/`**`@availabilityTimeOffset` is present in the DASH MPD and segments are formatted according to a low-latency segment profile). In the following, the *Multicast server* is assumed to be requesting new DASH segments of a representation according to the DASH-IF Live Media Ingest Protocol [i.4].

The *Multicast server* receives the content as a sequence of HTTP chunks. Each HTTP chunk starts with a *chunk-size* field.

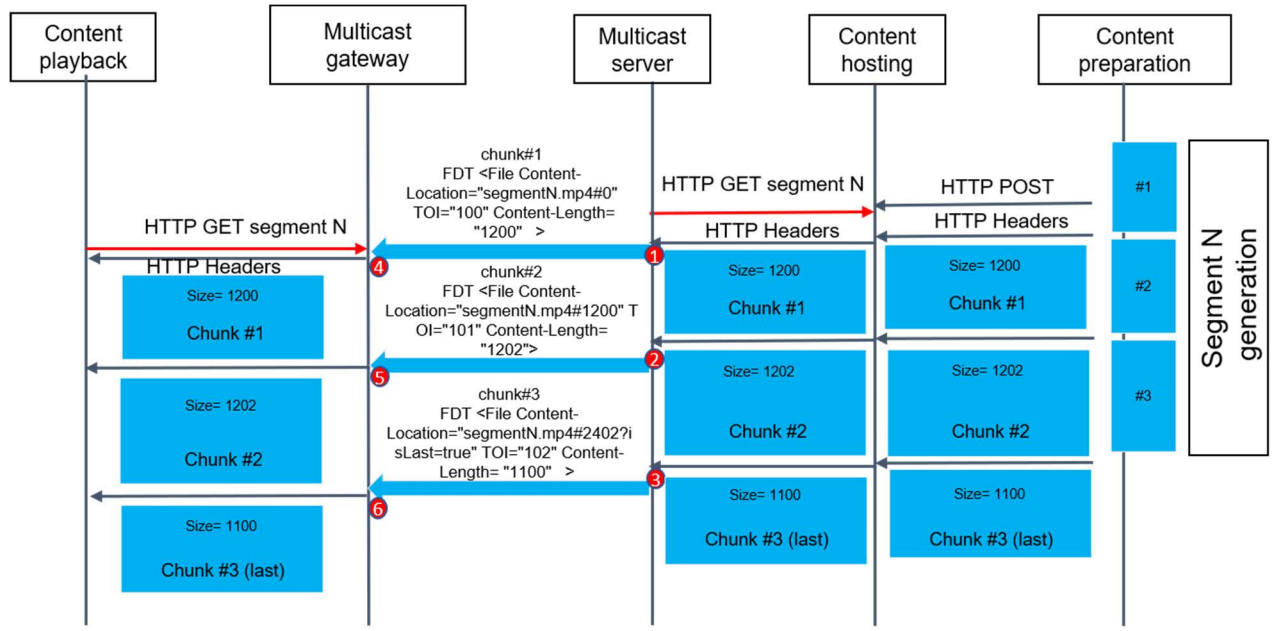


Figure G.1.2-1: Chunked transmission mode with pull ingest

Figure G.1.2-1 depicts pull-based ingest operations. The *Content preparation* function uploads the DASH segment to the *Content hosting* function as sequence of HTTP chunks. The *Multicast server* requests a segment according to its Segment Availability Start Time (SAST). At mark #1, the *Multicast server* issues the HTTP *GET* request and starts downloading the segment. In case of HTTP chunked transfer coding, the HTTP headers do not include a `Content-Length` header. The chunk size is provided at the beginning of each chunk. To maintain low-latency operation the *Multicast server* should commence multicast transmission (i.e. construct the FLUTE FDT Instance and start transmitting the multicast transport object at reference point **M**) immediately after receiving the *chunk-size* field (mark #1 in figure G.1.2-1).

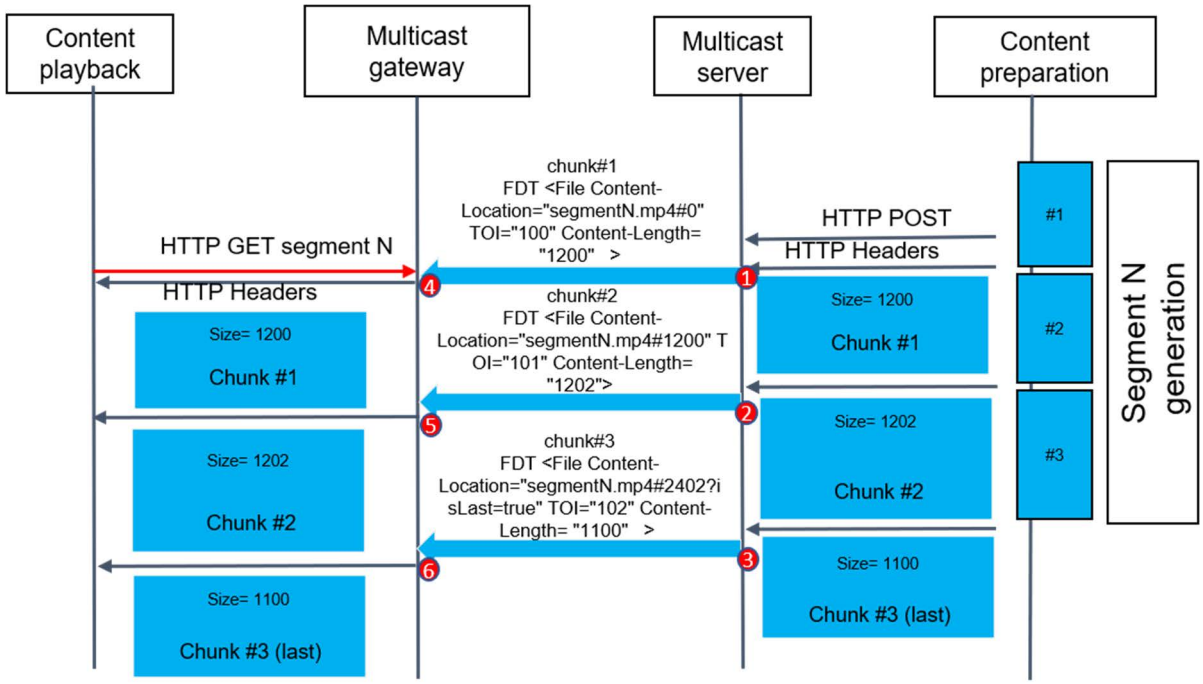


Figure G.1.2-2: Chunked Transmission Mode with push ingest

Figure G.1.2-2 depicts push-based ingest operations. The *Content preparation* function pushes ingest objects according to the Segment Availability Start time (SAST) of the corresponding DASH segment. The segment is supplied as sequence of HTTP chunks in the body of the HTTP request message. (HTTP *POST* is depicted in figure G.1.2-2 as an example.) In case of HTTP chunked transfer coding, the HTTP headers do not include a `Content-Length` header. The chunk size is provided at the beginning of each chunk. To maintain low-latency operation the *Multicast server* should commence multicast transmission immediately after receiving the *chunk-size* field (mark #1 in figure G.1.2-2).

For both push- and pull-based ingest, the *Multicast server* can use the same forwarding procedure for handling the segment in the HTTP message body (response body in case of pull and request body in case of push). In order to sustain low-latency operation the ingest bit rate should always be equal to or higher than the multicast transport session bit rate.

The *Multicast server* creates the FLUTE FDT Instance based on the following information:

- **`File/@Content-Location`** is either the ingest object URL or a rewritten version of it. The *Multicast server* appends the HTTP chunk offset as the fragment identifier. The chunk offset is the sum of all previously ingested chunk sizes of the ingest object in question. If the ingested DASH segment has a Random Access Point marker, the *Multicast server* may append hasRandomAccessPoint URI query component, as specified in clause F.2.2. If the ingested HTTP chunk is the last of a given ingest object, the *Multicast server* may append the isLast URI query component, as specified in clause F.2.2 (mark #3 in figure G.1.2-1 and figure G.1.2-2).

- **`File/@Content-Type`** is taken from the ingested HTTP response header information. The *Multicast server* uses the same MIME content type for all HTTP chunks of the same HTTP resource.

- **`File/@Content-Length`** is the HTTP chunk size taken from the *chunk-size* field.

As soon as the *Multicast gateway* receives the FDT Instance describing the first chunk of a given media object (mark #4 in figure G.1.2-1 and figure G.1.2-2) and the first bytes of the first chunk, it makes the media segment available (even partially) for download at reference point `L` while continuing to receive the remaining chunks of that media object over reference point **M**.

G.1.3 In-band carriage of presentation manifest

If a presentation manifest is delivered over reference point **M** it can be sent either in the same FDT Instance with another multicast transport object or in a separate FDT Instance.

Figure G.1.3-1 below shows the case where the presentation manifest is sent in the same FDT Instance with another multicast transport object. In this case, the FDT Instance describes two TOIs: one for the presentation manifest and the other for a DASH segment.

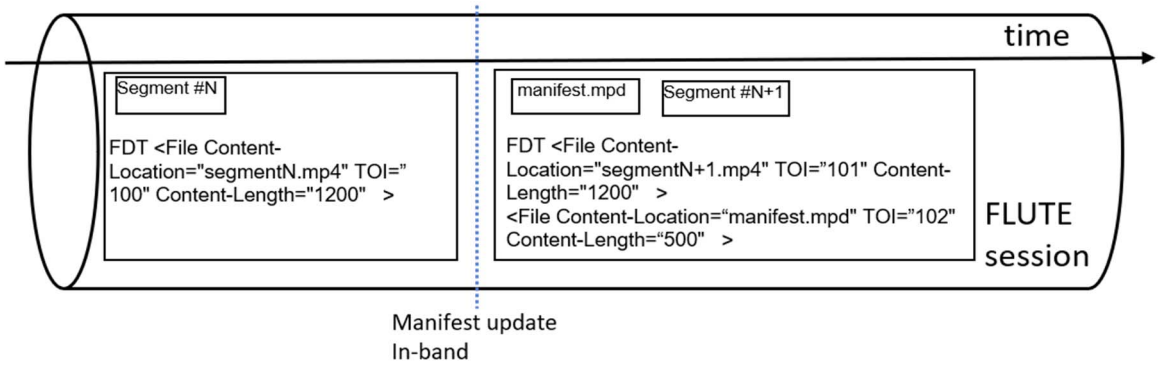


Figure G.1.3-1: Manifest update in the same FDT Instance with media segment

Figure G.1.3-2 below shows the case where the presentation manifest is sent in a different FDT Instance.

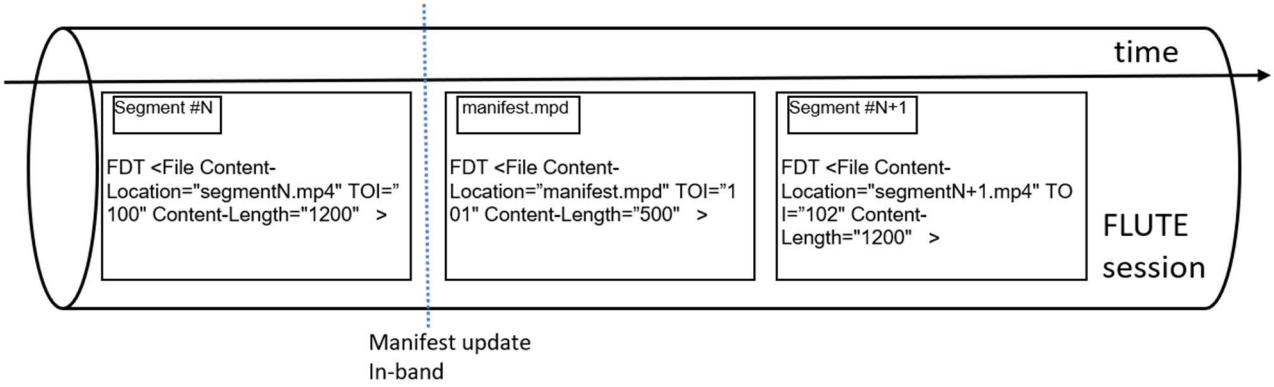


Figure G.1.3-2: Manifest update in a separate FDT Instance

G.2 Example FLUTE Session configurations

G.2.0 Introduction

This clause provides example FLUTE Session configurations that illustrate the mapping between multicast session configuration and the FLUTE Sessions. The *Multicast server* is configured to either map each service component to an individual multicast transport session (FLUTE Session), or to multiplex a set of service components (e.g. DASH representations from different adaptation sets) onto the same multicast transport session. The latter is beneficial to reduce the number of concurrent IP multicast streams in the system.

G.2.1 Multicast configuration channel over FLUTE Session

Figure G.2.1-1 depicts the in-band configuration method whereby the *Multicast server* carousels the current multicast gateway configuration instance document via a configured multicast gateway configuration transport session at reference point **M** (see clause 8.3.5) based on the multicast session configuration instance data model specified in clause 10.2. The multicast gateway configuration transport session is realized using FLUTE.

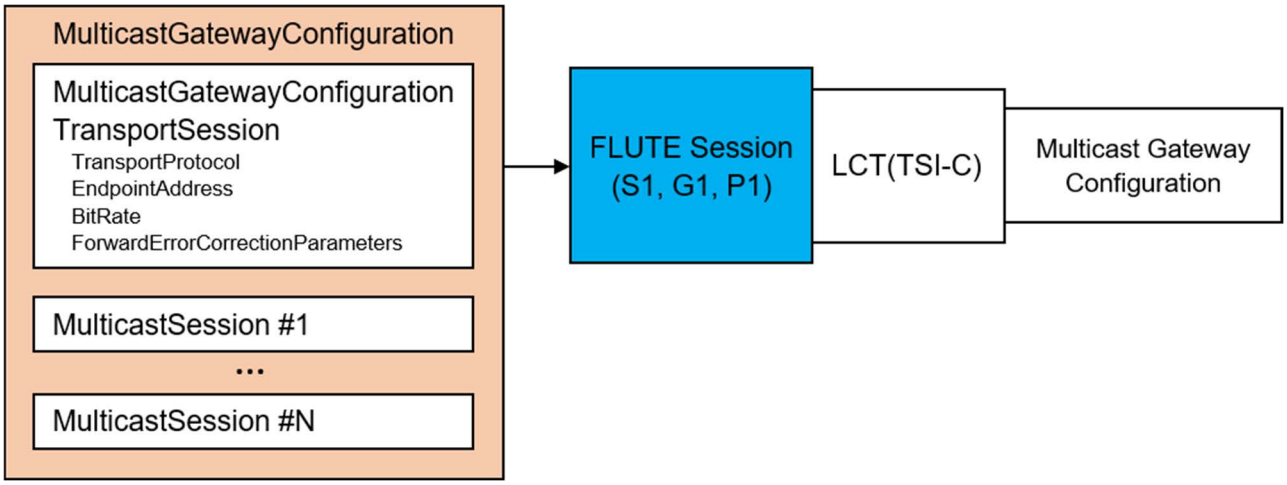


Figure G.2.1-1: Multicast configuration channel over FLUTE

G.2.2 Audio and video service components multiplexed into a single FLUTE Session

Figure G.2.2-1 depicts an example where audio and video service components are delivered over a single multicast transport session, which is realized as a single FLUTE Session. In this case, the URLs of the segments are used to separate the different service components (e.g. audio, video).

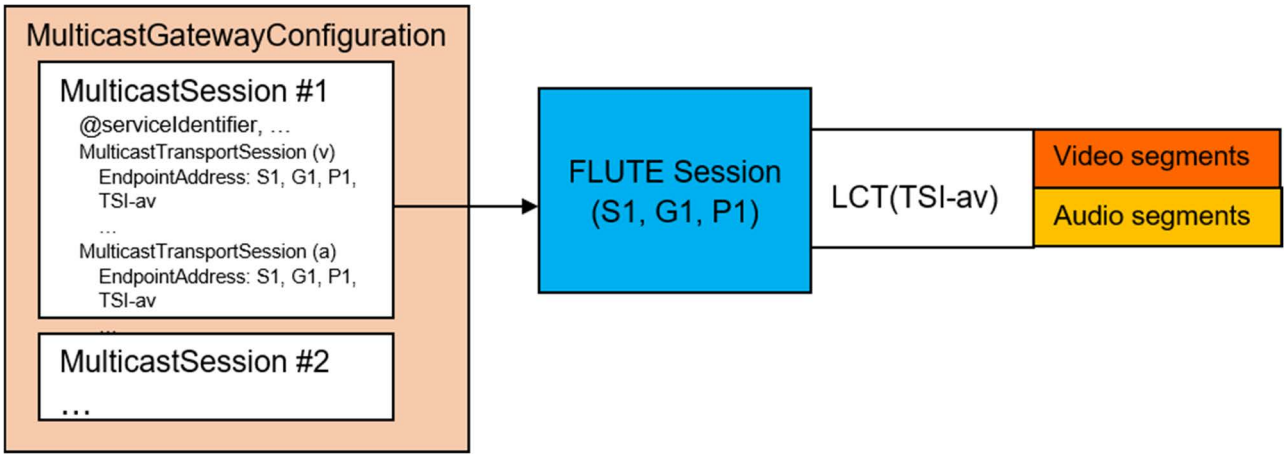


Figure G.2.2-1: Audio and video service components multiplexed into a single FLUTE Session

G.2.3 Audio and video service components carried in separate FLUTE Sessions using the same multicast group

Figure G.2.3-1 depicts an example where audio and video service components are delivered in separate multicast transport sessions, each realized as a single FLUTE Session. Here, the two multicast transport sessions are carried over the same IP multicast group G1. The two multicast transport sessions are separated based on the UDP destination port (P1 and P2).

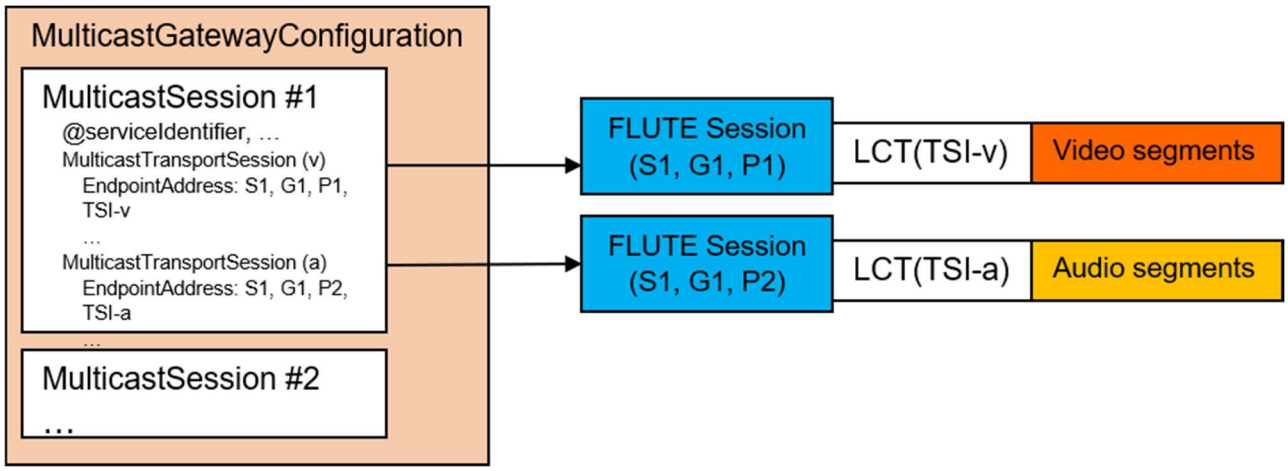


Figure G.2.3-1: Audio and video service components carried in separate FLUTE Sessions

An alternative is to use different IP multicast groups for the different multicast transport sessions, e.g. G1 and G2, so that the service components are separated even on transport level.

The manifest update can be delivered in FLUTE Session (S1, G1, P1) or FLUTE Session (S1, G1, P2) or both.

G.2.4 Audio and multiple video service components carried in separate FLUTE Sessions using independent multicast group

Figure G.2.4-1 depicts an example where audio and video service components are delivered in separate FLUTE Sessions and each video component is delivered in different FLUTE Sessions. Different IP multicast groups are used for each service component.

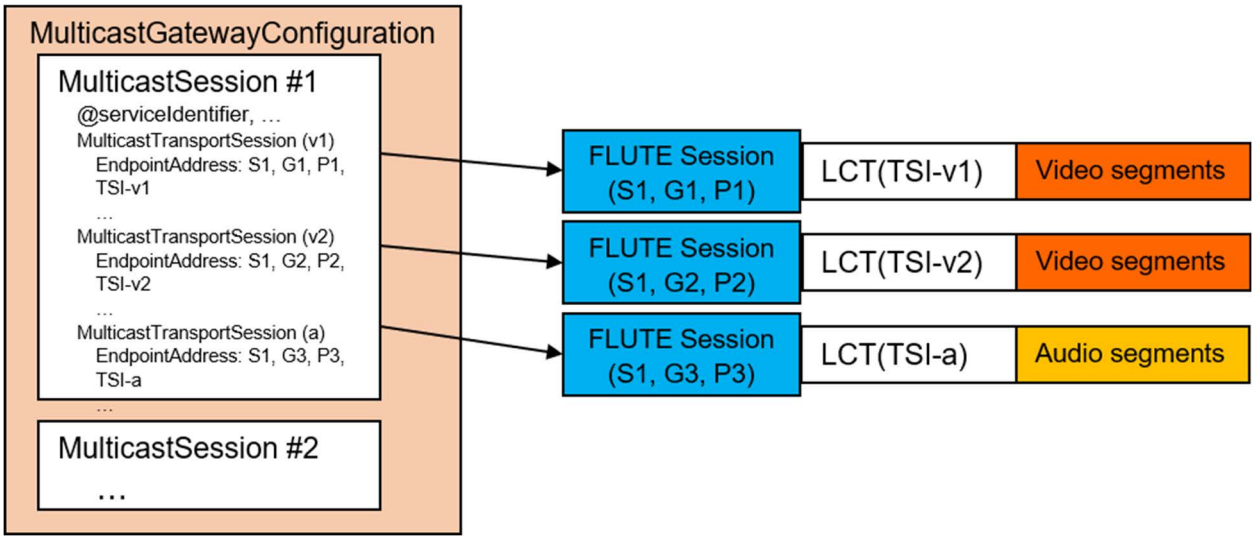


Figure G.2.4-1: Audio and multiple video service components carried in separate FLUTE Sessions

An alternative realization can use the same IP multicast groups for the multicast transport sessions of the service components.

The benefit of using different IP multicast groups for the multicast transport sessions is that only the needed multicast traffic is reaching the *Multicast gateway*, i.e. the *Multicast gateway* would join only one of the two multicast transport sessions, carrying the video service component. A potential drawback is the increase number of simultaneous multicast groups in the system which can create some routing overhead.

G.2.5 FEC data carried in FLUTE Sessions

Figure G.2.5-1 depicts an example where FEC is used for a given linear service. FEC packets separately protect audio and video service components in different FLUTE Sessions.

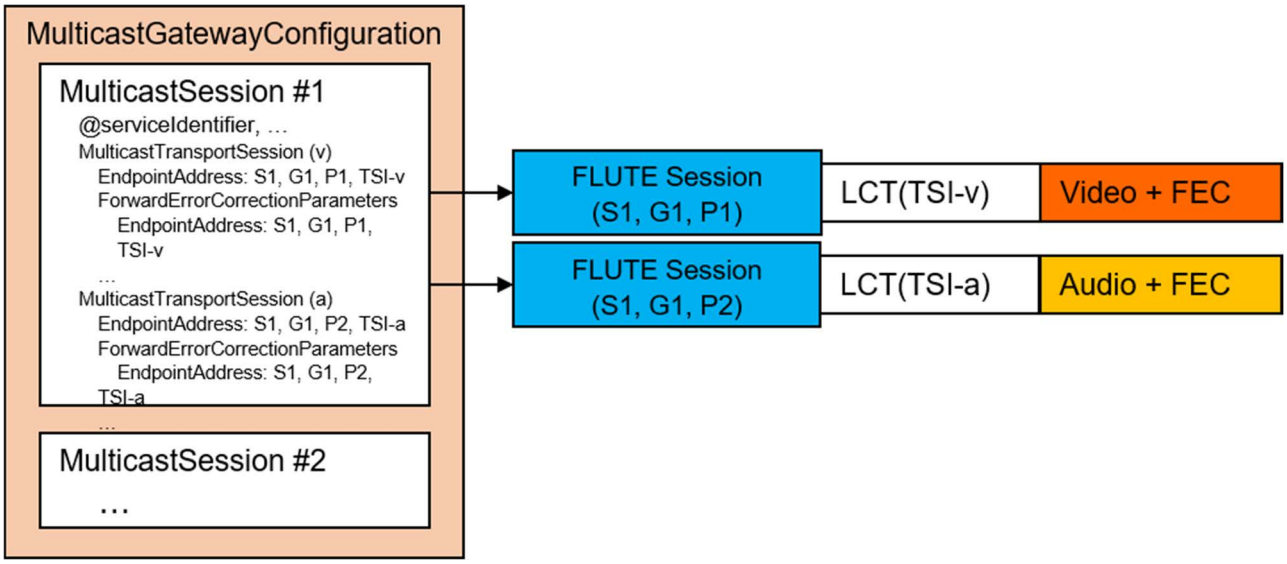


Figure G.2.5-1: Usage of FEC data to protect audio and video service components separately

Annex H (normative): ROUTE-based multicast media transport protocol

H.0 Introduction

This annex specifies a multicast media transport protocol based on ROUTE as defined in annex A of ATSC A/331 [18] with focus on linear live media streaming applications. In particular, the profile of ROUTE specified here is most beneficial in combination with live DASH and especially with low-latency live DASH as it provides similar functionalities as HTTP chunked transfer coding [1] when conveying CMAF chunks [i.10].

The ROUTE profile specified in this annex differs from ATSC A/331 [18] in the following aspects:

- Only a subset of Codepoints specified in table A.3.6 of [18] is used, as specified in clause H.4 below.
- The use of MPD-less start-up mode is prohibited by this profile (see clause H.5.1).
- The **`Alternate-Content-Location-1`** and **`Alternate-Content-Location-2`** Extended FDT elements specified in clause A.3.3.2 of [18] are ignored by the *Multicast gateway* (see clause H.6.2).
- An exception to the basic delivery object recovery operation is specified in clause H.8.0.

H.1 Signalling in the multicast session configuration

The use of the multicast media transport protocol specified in this annex shall be signalled in the multicast session configuration as follows (see clause 10.2.3.8):

TransportProtocol/@**protocolIdentifier**	TransportProtocol/@**protocolVersion**
urn:dvb:metadata:cs:MulticastTransportProtocolCS:2019:ROUTE	*1*

In Entity Mode only (see clause H.3.2) the integrity of a multicast transport object may be protected by sending a `Digest` HTTP response header, as specified in IETF RFC 3230 [20], in the ROUTE Delivery object metadata. The MD5 digest algorithm shall not be used for this purpose.

If every multicast transport object in a multicast transport session is so protected, the transport security mode "Integrity" (see clause 10.2.3.6) shall be indicated in the multicast session configuration. Otherwise the transport security mode "None" shall be indicated.

The Transport Session Identifier of the underlying LCT channel shall be conveyed in the **`EndpointAddress/ MediaTransportSessionIdentifier`** element (see clause 10.2.3.9).

Omitting the **`ForwardErrorCorrectionParameters`** element shall imply that no ROUTE Repair Flows are protecting the multicast transport session in question.

H.2 ROUTE packet format profile

H.2.0 General

The packet format used by ROUTE Source Flows and Repair Flows (specified respectively in clauses A.3 and A.4 of [18]) follows the ALC packet format specified in IETF RFC 5775 [21], with further details specified in clause A.3.5 of ATSC A/331 [18], i.e. the UDP header followed by the default LCT header and the source FEC Payload ID followed by the packet payload. The overall ROUTE packet format is as depicted in figure H.2.0-1 below.

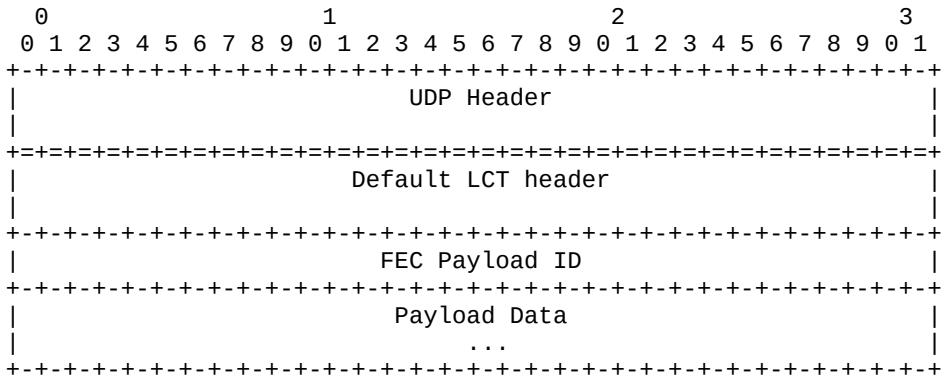


Figure H.2.0-1: Overall ROUTE packet format, from clause A.3.5 of ATSC A/331 [18]

The Default LCT header field is as defined in IETF RFC 5651 [19]. The usage of the LCT building block for ROUTE is specified in clause A.3.6 of ATSC A/331 [18].

In order to support the transmission of CMAF chunked content [i.10] the default LCT header is further constrained here as follows:

Table H.2.0-1: Usage of LCT header fields for ROUTE Source and Repair Flows

LCT header field	ROUTE Source Flows		ROUTE Repair Flows
	DASH Segments	DASH Segments comprising CMAF chunks	
Close Object (B) flag in Default LCT header	Set according to clause 7.1.7 of ATSC A/331 [18].	Set if and only if the ROUTE packet contains the last byte of the multicast transport object for both Source Flows and Repair Flows.	Set according to IETF RFC 5651 [19].
Congestion Control Information (CCI) field in Default LCT header	Should convey the earliest presentation time contained in the ROUTE packet. The length of the field may be 32 bits (C=0) or 64 bits (C=1). For more details refer to clause I.1.4.		Not applicable.
FEC Payload ID field	Conveys the *start_offset* of the LCT Payload Data field in the transmission object, as specified in clause A.3.5 (Packet Format) of ATSC A/331 [18].	Conveys the *start_offset* of the LCT Payload Data field in the transmission object, as specified in clause A.3.5 (Packet Format) of ATSC A/331 [18], with further guideline in clause I.1.4.	Not applicable.

H.2.1 LCT header extensions

The following LCT header extensions are used in this profile. All other header extensions shall be silently ignored by the *Multicast gateway*.

The length in bytes of the multicast transport object shall be signalled using *EXT_TOL* as specified in clause A.4.2.6.1 of ATSC A/331 [18] with 24 bits or, if required, 48 bits of Transfer Length. The frequency of using the *EXT_TOL* header extension is determined by channel conditions that may cause the loss of the packet carrying Close Object (B) flag, as specified in clause H.2.0 above.

NOTE: The transport object length can also be determined without the use of *EXT_TOL* by examining the LCT packet with the Close Object (B) flag. However, if this packet is lost, then the *EXT_TOL* information can be used by the receiver to determine the transport object length.

The Sender Current Time shall be signalled using *EXT_TIME* as specified in clause 8.1.1 of ATSC A/331 [18].

H.3 Delivery object mode

H.3.0 General

The delivery object mode (as indicated by the value of Delivery Object Format ID signalled in **`Payload/`**`@formatId` field in Session metadata for Source Flows per clause H.5.1), shall either be set to 1 or 2, where 1 refers to the File Mode and 2 refers to the Entity Mode.

H.3.1 File Mode

If the delivery object mode is set to 1 (File Mode), the following applies:

- File/object metadata carried in the Extended FDT shall be embedded within the session and delivery object signalling metadata, as specified in clause H.5.1 below.
- Certain parameters of the Extended FDT which may vary from one delivery object to another, such as the **`File/`**`@Content-Location` and **`File/`**`@Content-Length` attributes, are not permitted to appear in the session and delivery object signalling metadata. Instead, the **`File/`**`@Content-Location` is derived locally at the ROUTE receiver using a file template (**`FDT-Instance/`**`@fileTemplate` attribute of the session and object signalling) in the form of the *TOI* substitution parameter, and the length of the delivery object is instead conveyed using the LCT header extension *EXT_TOL*, as specified in clause H.2.1 above.

H.3.2 Entity Mode

If the delivery object mode is set to 2 (Entity Mode), the following applies:

- Delivery object metadata shall be expressed in the form of entity headers as defined in HTTP/1.1, and which correspond to one or more of the representation header fields, payload header fields and response header fields as defined in sections 3.1, 3.3 and 7, respectively, of IETF RFC 7231 [2]. Additionally, a `Digest` HTTP response header [20] may be included to enable a receiver to verify the integrity of the multicast transport object.
- The entity headers sent along with the delivery object provide all information about that multicast transport object.

Sending a media object (if the object is chunked) in Entity Mode may result in one of the following options:

1) If the length of the chunked object is known at sender, the ROUTE Entity Mode delivery object may be sent without using HTTP/1.1 chunked transfer coding, i.e. the object starts with an HTTP header containing the `Content-Length` field, followed by the concatenation of CMAF chunks:

```
|HTTP Header+Length||---chunk ----||---chunk ----||---chunk ----||---chunk ----|
```

2) If the length of the chunked object is unknown at sender when starting to send the object, HTTP/1.1 chunked transfer coding format shall be used:

```
|HTTP Header||Separator+Length||---chunk ----||Separator+Length||---chunk ----
||Separator+Length||---chunk ----||Separator+Length||---chunk ----
||Separator+Length=0|
```

Note, however, that it is not required to send a CMAF chunk in exactly one HTTP chunk.

H.4 Codepoint signalling

Irrespective of the delivery object mode in use, a Codepoint value exclusively from 5 through 9 shall be signalled in the Codepoint field of the LCT Header. The semantics of the values of this field are specified in table A.3.6 of [18]. To summarize:

- DASH initialization segments are signalled using Codepoint values 5, 6, or 7.
- DASH media segments are signalled using either Codepoint value 8 (indicating ROUTE File Mode) or Codepoint value 9 (indicating ROUTE Entity Mode).

H.5 In-band multicast session metadata signalling

H.5.0 General

The technical metadata describing each multicast transport session may be signalled following the principles of service level signalling specified in clause 7.1 of [18] in addition to the multicast session configuration specified in clause 10. Specifically and exclusively, Service-based Transport Session Instance Description (S-TSID) and MPD fragments may be signalled. If present, these fragments shall be conveyed to the *Multicast gateway* within the same multicast transport session they describe, in a dedicated LCT transport channel with TSI=0.

The S-TSID metadata fragment shall include the description for each Source Flow and Repair Flow within the ROUTE Session (see clause A.2.2 of [18]) described by this metadata, represented by the **`SrcFlow`** and **`RepairFlow`** elements, respectively, in the S-TSID.

The **`RS`** (ROUTE Session) element of the S-TSID metadata fragment shall replicate information from the **`Multicast TransportSession`** element (clause 10.2.3), as specified in table H.5.0-1 below.

Table H.5.0-1: Mapping of multicast transport session parameters to S-TSID

Multicast transport session parameter	S-TSID element or attribute
`MulticastTransportSession/EndpointAddress/NetworkSourceAddress`	**`RS/`**`@sIpAddr`
`MulticastTransportSession/EndpointAddress/NetworkDestinationGroupAddress`	**`RS/`**`@dIpAddr`
`MulticastTransportSession/EndpointAddress/TransportDestinationPort`	**`RS/`**`@dPort`
`MulticastTransportSession/EndpointAddress/MediaTransportSessionIdentifier`	**`RS/LS/`**`@tsi`
`MulticastTransportSession/``@start`	**`RS/LS/`**`@startTime`
`MulticastTransportSession/``@start` + **`MulticastTransportSession/`**`@duration`	**`RS/LS/`**`@endTime`
`MulticastTransportSession/BitRate/``@maximum`	**`RS/LS/`**`@bw`
NOTE: It is possible for a single ROUTE Session to comprise multiple multicast transport sessions, each with the same destination group IP address and port number, but distinguished by different LCT Transport Session Identifiers (**`LS/`**`@tsi`), and hence multiple **`MulticastTransportSession`** elements (clause 10.2.3) may be used to signal a single ROUTE Session.	

In the case where a Repair Flow is carried in the same ROUTE Session as the Source Flow it protects, with the two flows differing only in their respective LCT Transport Session Identifiers, the multicast transport session parameters specified in table H.5.0-2 below shall additionally be mapped into a different **`LS`** child element of the same **`RS`** that describes the Source Flow protected.

Table H.5.0-2: Mapping of multicast transport session forward error correction parameters to S-TSID for Repair Flow in the same ROUTE Session

Multicast transport session parameter	S-TSID element or attribute
`MulticastTransportSession/ForwardErrorCorrectionParameters/ EndpointAddress/MediaTransportSessionIdentifier`	**`RS/LS/`**`@tsi`
`MulticastTransportSession/ForwardErrorCorrectionParameters/ OverheadPercentage`	**`RS/LS/RepairFlow/ FECParameters/`**`@overhead`

In the case where one or more Repair Flows are carried in different ROUTE Sessions from the Source Flow they protect (for example, see clause I.3.4), an additional independent **RS** element shall be present in the S-TSID metadata fragment for each such Repair Flow replicating information from the **MulticastTransportSession/ForwardErrorCorrection Parameters** element (clause 10.2.3), as specified in table H.5.0-3 below.

Table H.5.0-3: Mapping of multicast transport session forward error correction parameters to S-TSID for Repair Flow in different ROUTE Session

Multicast transport session parameter	S-TSID element/attribute
MulticastTransportSession/ForwardErrorCorrectionParameters/ EndpointAddress/NetworkSourceAddress	**RS/**@sIpAddr
MulticastTransportSession/ForwardErrorCorrectionParameters/ EndpointAddress/NetworkDestinationGroupAddress	**RS/**@dIpAddr
MulticastTransportSession/ForwardErrorCorrectionParameters/ EndpointAddress/TransportDestinationPort	**RS/**@dPort
MulticastTransportSession/ForwardErrorCorrectionParameters/ EndpointAddress/MediaTransportSessionIdentifier	**RS/LS/**@tsi
MulticastTransportSession/ForwardErrorCorrectionParameters/ OverheadPercentage	**RS/LS/RepairFlow/ FECParameters/**@overhead

H.5.1 Session metadata for Source Flows

The session metadata for each Source Flow in a ROUTE Session is conveyed by a **SrcFlow** element in the S-TSID fragment, as specified in clause A.3 of [18].

The **MediaInfo/**@startUp attribute shall be set to false.

NOTE: MPD-less start-up mode is prohibited by this profile.

H.5.2 Session metadata for Repair Flows

The session metadata for each Repair Flow in a ROUTE Session is conveyed by a **RepairFlow** element in the S-TSID fragment, as specified in clause A.4.3 of [18].

H.6 Delivery Object signalling in File mode

H.6.1 Carriage of Extended FDT

In ROUTE File Mode, delivery object signalling uses the Extended FDT. The Extended FDT may be conveyed as the **EFDT** child element of the **SrcFlow** element (see clause H.5.1 above) or as a separate delivery object. Both mechanisms are specified in clause A.3.3.2 of [18].

H.6.2 Profile of Extended FDT

The **Alternate-Content-Location-1** and **Alternate-Content-Location-2** elements specified in clause A.3.3.2 of [18] shall be ignored by the *Multicast gateway*.

H.7 Multicast server operation

The *Multicast server* shall perform all of the functions specified in clause 8.3. The *Multicast server* shall use the session signalling specified in clause H.5 and delivery object signalling specified in clause H.6 when constructing multicast transport objects at reference point **M**. The Codepoints for signalling the ROUTE delivery mode shall be used according to the values specified in clause H.4.

Both resource transmission mode and chunked transmission mode are treated the same by this profile: in either mode one ingest object shall be mapped to one multicast transmission object. Guidelines for further optimizations for the transport of DASH/CMAF media objects at reference point **M** are outlined in clause I.1.

H.8 Multicast gateway operation

H.8.0 Overview

The *Multicast gateway* shall perform all of the functions specified in clause 8.4. The *Multicast gateway* shall use the in-band multicast session metadata signalling specified in clause H.5 and (in File Mode) the delivery object signalling specified in clause H.6 when receiving multicast transport objects at reference point **M**.

The multicast gateway shall ensure the timely publishing of playback delivery objects at reference point **L**, based on the media timing described in the presentation manifest. Specifically, HTTP/1.1 chunked transfer coding shall be enabled at reference point **L** if **`MPD/`**`@availabilityTimeOffset` is signalled in the DASH presentation manifest, to allow for timely sending of segment data to the *Content playback* function. This is an exception to the basic delivery object recovery operations specified in clause A.3.10.2 of [18], where it is specified that the delivery object is handed to the application only upon recovery of a complete set of its packet payloads.

Further optimized channel acquisition may be achieved by optional signalling as documented in clause I.2.

H.8.1 Forward Error Correction

The file repair procedures using AL-FEC shall follow the specification in clause A.4 of [18]. Specifically, this procedure uses the signalling in the **`S-TSID/RS/LS/RepairFlow`** element.

H.8.2 Unicast repair

The *Multicast gateway* shall follow the unicast repair procedure specified in clause 9. However, the file repair procedure specified in clause 7.1.7.2 of [18] may trigger an earlier unicast repair. This procedure includes the use of the Close Object (B) flag and Close Session (A) flag.

The *start_offset* field as specified in clause A.3.5 of [18] and the size of the ROUTE packet payload determines the byte range of the missing data to be requested via unicast. The missing byte range of data following a received packet *i* and preceding a subsequently received packet *k* after the lost packet(s) is *start_offset(i) + size(i)* to *start_offset(k) - 1* where *size(i)* is the packet payload of ROUTE packet *i*.

Annex I (informative): Implementation guidelines for ROUTE-based multicast media transport protocol

I.1 Multicast server implementation guidelines

I.1.0 Overview

This clause documents how a *Multicast server* should map DASH and CMAF media objects to ROUTE delivery objects based on the ROUTE profile specified in annex H. Specifically, this clause documents the conversion of ingest objects (both presentation manifest and DASH segments) at reference point **P_{in}'** to multicast transport objects at reference point **M**. The use of "Interface 2" of the DASH-IF Specification of Live Media Ingest [i.4] is assumed.

I.1.1 Presentation manifest signalling

The *Content ingest* subfunction of the *Multicast server* can read and possibly modify the presentation manifest to change the timing on the availability of the objects, e.g. in MPEG-DASH by changing the value of the **MPD/**`@availabilityStartTime` when required, since this can differ for the media components delivered over reference point **M**.

I.1.2 Service component mapping to object flows

Assuming the presentation manifest is a DASH MPD containing a Period with possibly multiple Adaptation Sets, and each Adaptation Set contains one or more Representations (each being a service component), then the following mapping is recommended:

- Each Representation is sent in a separate LCT session with its unique TSI.
- If *$Number$* templating is used in the MPD, it is recommended to use the File Mode.
- If *$Time$* templating or any other scheme for Segment addressing is used, then it is recommended to use the Entity Mode.
- Source Flow session metadata is set in the S-TSID fragment as follows:
  - **Srcflow/**`@rt` is set to *TRUE*.
  - **Srcflow/**`@timescale` is set to the *timescale* value of the Representation as present in the movie header.
  - **Srcflow/**`@codePoints` is set to *TRUE*.
  - **Srcflow/**`@type` is set to the media type of the Representation, including a codecs and profile parameter according to IETF RFC 6381 [22].
- Each DASH segment is sent with a new Transmission Object Identifier (TOI).
- If File Mode is used, then an **FDT-Instance/**`@fileTemplate` is provided.
- If Entity Mode is used, then the Extended FDT is not present.

I.1.3 Mapping of ingest objects to ROUTE packets

I.1.3.0 General

For sending DVB DASH content [10], a full segment (that may contain CMAF chunks [i.10]) represents an ingest object at reference point **P_{in}'**.

In this description, the following is assumed:

- The *Multicast transmission* subfunction operates in ROUTE File Mode.
- `$Number$` templating is used and the *Multicast transmission* subfunction knows the number of the segment.
- The *Content ingest* subfunction may receive ingest objects from the *Content preparation* function as a sequence of CMAF chunks using HTTP chunked transfer coding.

NOTE: If the segment consists of only a single CMAF chunk, then this describes the regular Segment-based processing.

- If a CMAF chunk is provided, then the *Content preparation* function is aware whether or not this is the last chunk of the DASH segment.
- The *Content preparation* function may be made aware of a CMAF Random Access chunk in addition to the first CMAF chunk in the segment (signalled by the MPD **`RandomAccess/`**`@interval` [i.2] and the presence of the brand *cmfr* in the *styp* box of the chunk).
- The sending of one Representation is described.
- The source FEC Payload ID comprises the *start_offset* field.

The principles of the ROUTE Sender operation as defined in annex A.3.9 of ATSC A/331 [18] apply.

I.1.3.1 ROUTE packetization

The following guidelines should be followed for ROUTE packetization:

1) Each ROUTE packet sent carries contiguous bytes of data from the media object to be sent.
2) The amount of data to be sent in a single ROUTE packet is limited by the maximum transfer unit of the data packets or the size of the remaining data of the CMAF chunk being sent, whichever is smaller.
3) The *start_offset* field in the LCT header of the ROUTE packet indicates the byte offset of the carried data in the media object being sent.
4) If it is the first ROUTE packet carrying a CMAF Random Access chunk, except for the first CMAF chunk in the segment, the least significant bit of the Protocol-Specific Indication (PSI) field in the LCT header may be set to 1. The receiver may use this information for optimization of random access.
5) As soon as the total length of the media object is known, potentially with the reception of the last CMAF chunk of a segment, the *EXT_TOL* extension header may be added to the LCT header.
6) The Close Object (B) flag is set to 1 if this is the last ROUTE packet carrying the data of the media object.

Pseudo-code implementing the above guidelines is described in the following:

- T is the size of the CMAF chunk to be sent, in bytes.
- X is start offset, initially set to zero.
- R is the remaining number of bytes of the chunk to be sent, set initially to R=T.
- Y is the maximum transfer unit of the data packets. The transfer unit is determined either by knowledge of underlying transport block sizes or by other constraints

Packet generation is done as follows:

1) Set *start_offset* field in the ROUTE packet to X.

2) If it is the first packet carrying a CMAF Random Access chunk, except for the first CMAF chunk in the segment, the least significant bit of the Protocol-Specific Indication (PSI) field in the LCT header may be set to 1.

3) As soon as the transport object length of the Segment is known, potentially with the reception of the last CMAF fragment of a segment, *EXT_TOL* extensions headers may be added to the LCT header.

4) If Y < R:

   a) Set the B Flag to 0.

   b) Send byte X + 1 till X + Y of the chunk in the packet.

   c) Update X = X + Y.

   d) Repeat from step 1.

5) Otherwise (Y ≥ R):

   e) Set the B Flag to 1.

   f) Send R last bytes of the CMAF chunk in this packet.

The setting of the CCI field is discussed in clause I.1.4 below.

I.1.4 CMAF/DASH timing mapping

The ROUTE sender knows the earliest presentation time of each CMAF chunk in timescale of the `@timescale` value.

If the least significant bit of the PSI field in the LCT packet header is set to 1 as described in clause I.1.3.1 above, the LCT Congestion Control Information (CCI) field is set to the earliest presentation time of the CMAF chunk included in the ROUTE packet (see table H.2.0-1). A receiver may use this information to optimize the channel acquisition time.

I.2 Multicast gateway implementation guidelines

I.2.0 Overview

This clause documents the *Multicast gateway* operations for conversion of multicast transport objects received at reference point **M** to playback delivery objects provided at reference point **L**. In this clause, delivery of a DVB DASH MPD [10] describing DVB DASH/CMAF content is described.

I.2.1 Presentation manifest

The presentation manifest is made available to the *Multicast gateway* either via reference point **M** or via unicast at reference point **A**.

I.2.2 Fast stream acquisition

When the *Multicast gateway* initially starts reception of ROUTE packets, it is likely that the reception does not start from the very first packet carrying the data of a multicast transport object, and in this case such a partially received object is normally discarded. However, the channel acquisition or "tune-in" times can be improved if the partially received object is usable by the application.

One example realization for this is as follows:

- The *Multicast gateway* checks for the first received packet with the least significant bit of the PSI set to 1, indicating the start of a CMAF Random Access chunk.
- The *Multicast gateway* may make the partially received object (a partial DASH segment starting from the packet above) available at reference point **L**.
- It may recover the earliest presentation time of this CMAF Random Access chunk from the ROUTE packet LCT Congestion Control Information field (see table H.2.0-1) and add a new Period element in the MPD exposed at reference point **L** containing just the partially received DASH segment with period continuity signalling [i.2].

I.3 Example ROUTE Session configurations

I.3.0 Overview

This clause provides a few example ROUTE session configurations to illustrate the relation of signalling between the multicast session configuration (clause 9), the S-TSID metadata fragment (clause H.5), and the resulting ROUTE Sessions.

In the following figures, *SX*, *GX*, *PX*, and *@TSI-X* represent the source IP address **RS**/`@sIpAddr`, destination group IP address **RS**/`@dIpAddr`, destination port **RS**/`@dPort`, and LCT Transport Session Identifier **LS**/`@tsi`, respectively (see clause H.5.0).

NOTE: In all examples, the S-TSID is itself conveyed in the ROUTE Session on *TSI=0*, but this is not depicted for reasons of clarity.

I.3.1 Audio and video service components multiplexed into a single ROUTE Session

The first example in figure I.3.1-1 depicts a basic multicast transport session with a single video and a single audio service component, both carried in the same ROUTE Session.

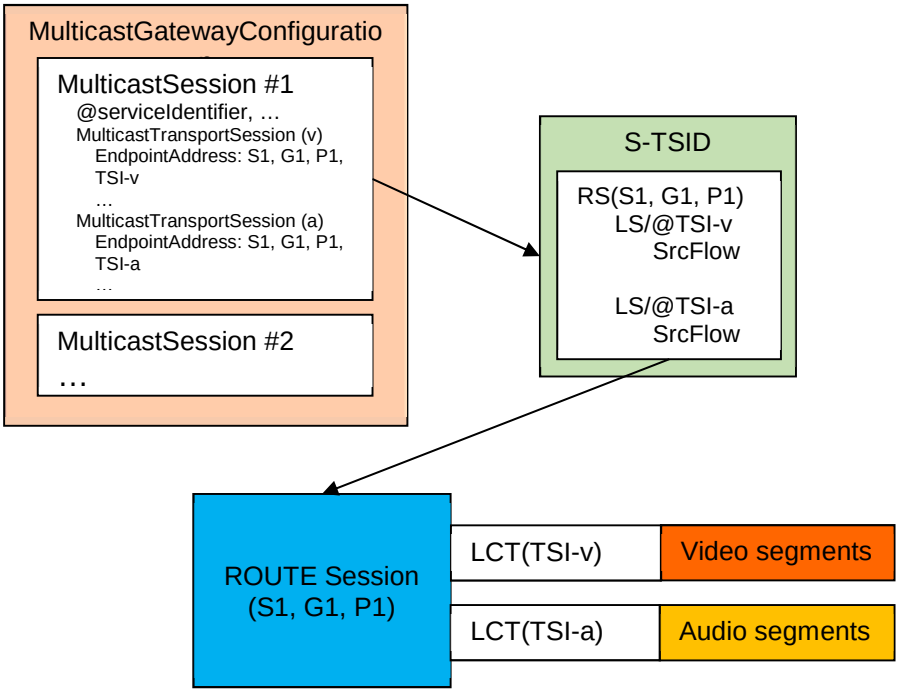


Figure I.3.1-1: Two Source Flows multiplexed on the same <S, G, P> with no Repair Flows

I.3.2 Audio and video service components carried in separate ROUTE Sessions

The second example in figure I.3.2-1 extends the first example, and in this case, the audio and the video service components are carried in their own separate ROUTE Session.

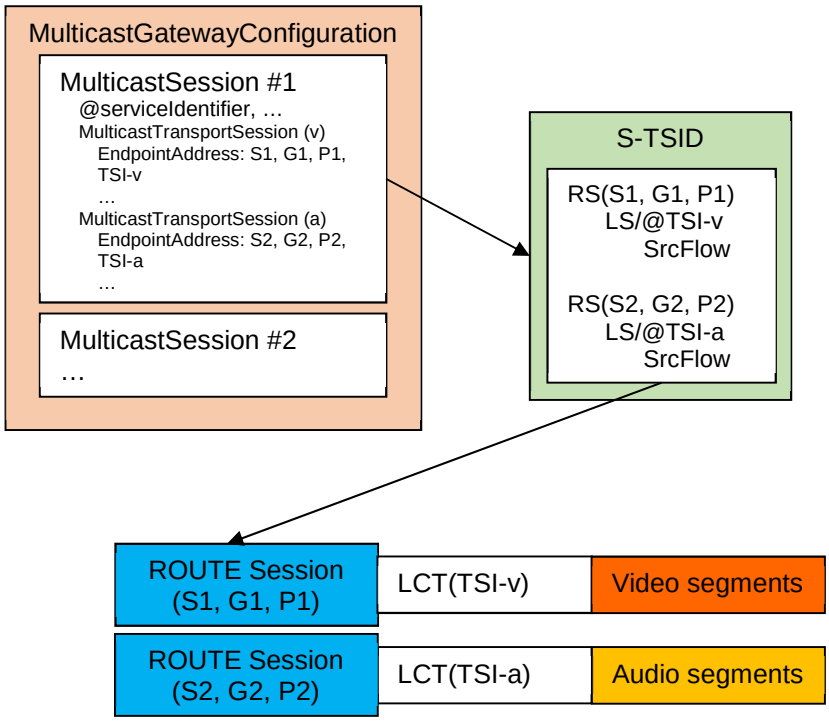


Figure I.3.2-1: Two Source Flows on different <S, G, P> with no Repair Flows

I.3.3 Audio and multiple video service components carried in separate ROUTE Sessions

The third example in figure I.3.3-1 extends the second example by depicting multiple video Source Flows with different video qualities (different video bitrates), potentially enabling adaptive multicast by the underlying network.

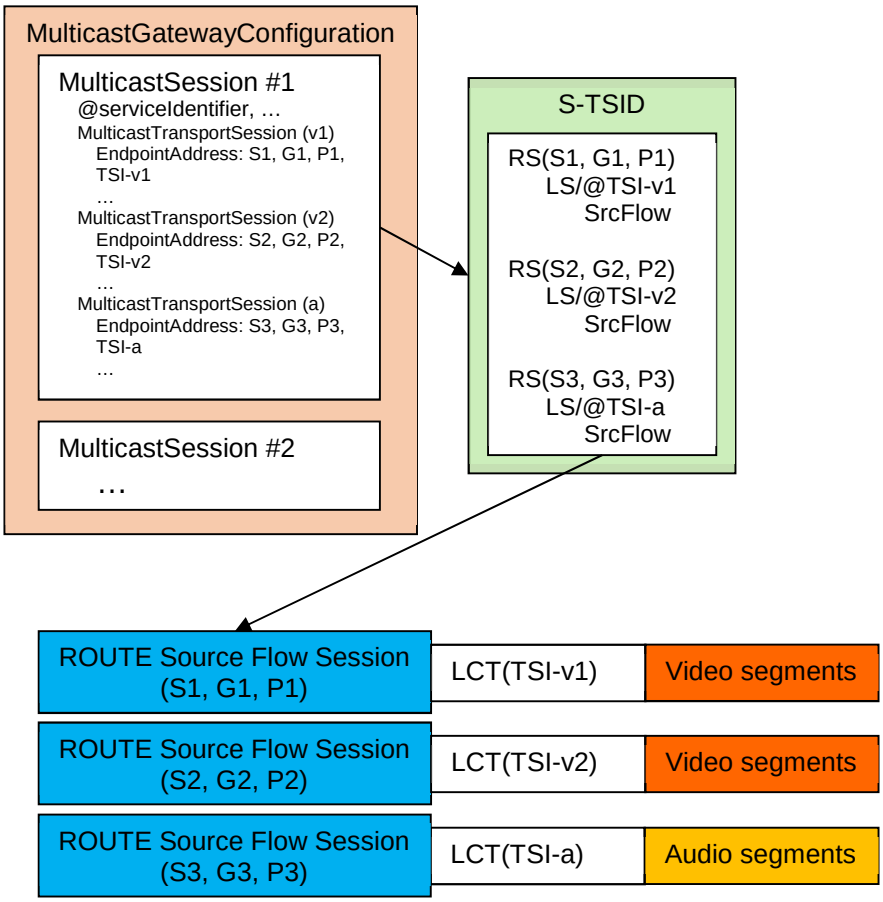


Figure I.3.3-1: Two video Source Flows with an audio on different <S, G, P>

I.3.4 Source Flows and Repair Flows carried in separate ROUTE Sessions

The final example in figure I.3.4-1 depicts Repair Flows for both audio and video service components being sent to protect their respective Source Flows.

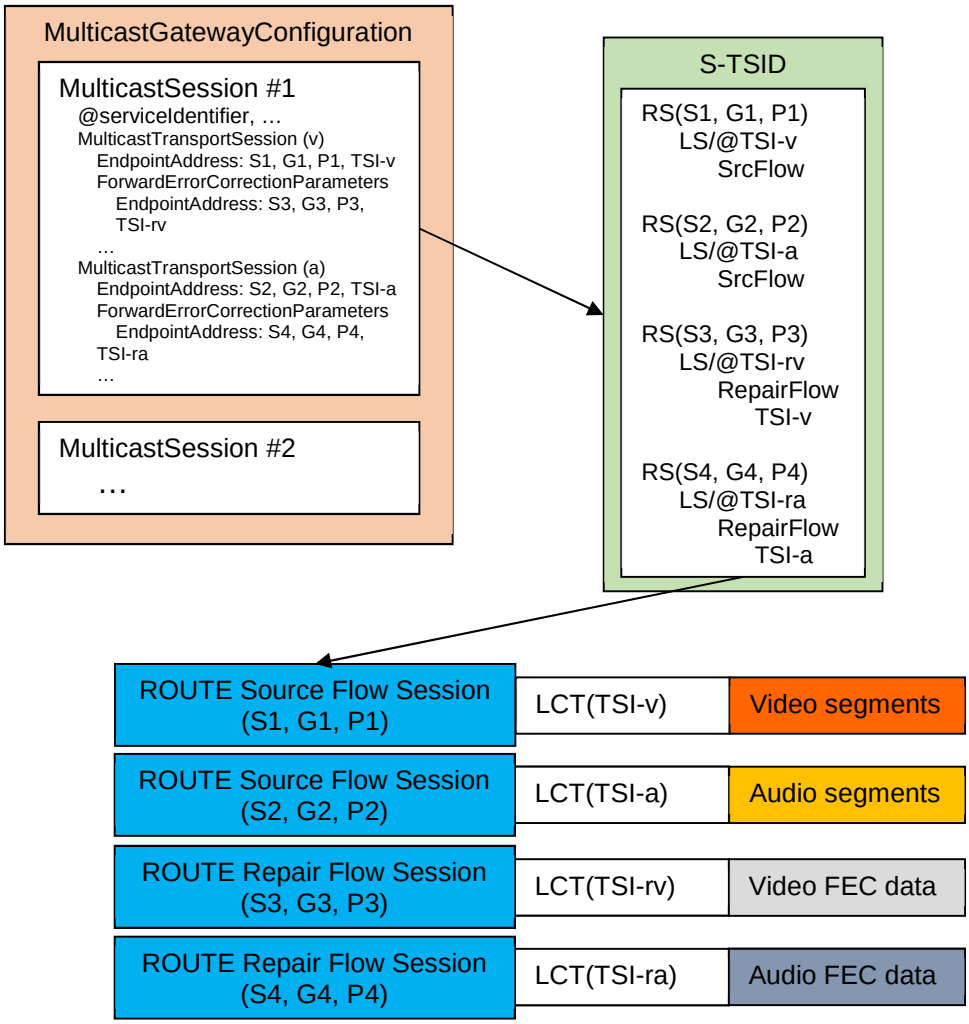


Figure I.3.4-1: Two Source Flows on different <S, G, P>, each with associated Repair Flows, also on different <S, G, P>

History

Document history		
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