Video Specifications
IP Multicast

IP Multicast Server-Client Interface Specification

OC-SP-MS-EMCI-I01-150528

ISSUED

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Key to Document Status Codes

Work in Progress	An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.
Draft	A document in specification format considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.
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Closed	A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

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1 SCOPE

1.1 Overview

This specification is part of the Video family of specifications developed by Cable Television Laboratories, Inc. (CableLabs) and published under the OpenCable License Agreement. The IP Multicast MC-EMC Interface Specification defines an interface identified in the IP Multicast Technical Report. The intent of this specification is to provide multi-vendor interoperability across this interface such that interoperable products can be brought to market which support Multicast-ABR (Adaptive Bit Rate).

The IP Multicast specifications primarily adopt web services as the standard communications mechanism between components.

1.2 Purpose

This document specifies the interface between the Multicast Server (MS) and the Embedded Multicast Client (EMC).

1.3 Scope

The interfaces defined in the IP Multicast reference architecture are shown in Figure 1. This specification defines the MS-EMC interface.

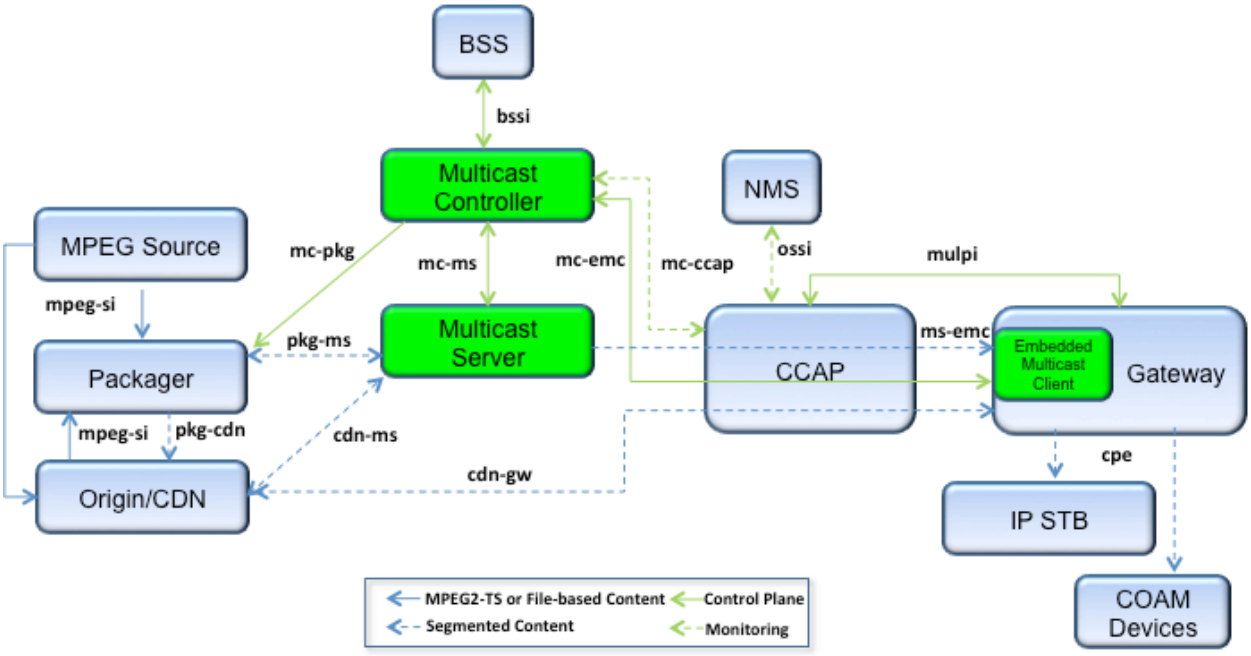

Figure 1 - IP Multicast Reference Architecture

1.4 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. For example, one vendor may choose to include the item because a particular marketplace requires it or because it enhances the product; another vendor may omit the same item.

This document defines many features and parameters, and a valid range for each parameter is usually specified. Equipment requirements are always explicitly stated. Equipment is required to comply with all mandatory (MUST and MUST NOT) requirements to be considered compliant with this specification. Support of non-mandatory features and parameter values is optional.

2 REFERENCES

2.1 Normative References

This specification uses the following normative references.

[MC-EMC]	IP Multicast Controller-Client Interface Specification, OC-SP-MC-EMCI-I01-150528, May 28, 2015, Cable Television Laboratories, Inc.
[RFC 3453]	IETF RFC 3453, The Use of Forward Error Correction (FEC) in Reliable Multicast, December 2002.
[RFC 5052]	IETF RFC 5052, Forward Error Correction (FEC) Building Block, August 2007.
[RFC 5401]	IETF RFC 5401, Multicast Negative-Acknowledgment (NACK) Building Blocks, November 2008.
[RFC 5510]	IETF RFC 5510, Reed-Solomon Forward Error Correction (FEC) Schemes, April 2009.
[RFC 5740]	IETF RFC 5740, NACK-Oriented Reliable Multicast (NORM) Transport Protocol, November 2009.

2.2 Informative References

This specification uses the following informative references.

[IPM-TR]	IP Multicast Adaptive Bit Rate Architecture Technical Report, OC-TR-IP-MULTI-ARCH-V01-141112, November 12, 2014, Cable Television Laboratories, Inc.
[MC-MS]	IP Multicast Controller-Server Interface Specification, OC-SP-MC-MSI-I01-150528, May 28, 2015, Cable Television Laboratories, Inc.
[RFC 2616]	IETF RFC 2616, Hypertext Transfer Protocol - HTTP/1.1, June 1999.
[RFC 3376]	IETF RFC 3376, Internet Group Management Protocol, Version 3, October 2002.

2.3 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027;
  Phone +1-303-661-9100, Fax +1-303-661-9199; http://www.cablelabs.com/
- Internet Engineering Task Force (IETF): http://www.ietf.org/

3 TERMS AND DEFINITIONS

This specification uses the following terms:

Access Network	The HFC network between the Gateway and the CCAP.
Adaptive Bit Rate	A streaming video technique where Players select between multiple bit rate encodings of the same video stream.
Bonding Group	A logical set of DOCSIS channels which support parallel transmission.
Companion Device	A video playback device which is not a television such as a tablet, smartphone or PC.
Converged Cable Access Platform	A system which provides DOCSIS and QAM-based video services to CMs, Gateways and set-top boxes.
Content Distribution Network	A network designed to minimizing latency by distributing network objects onto geographically diverse servers.
Embedded Multicast Client	The function embedded in the Gateway which joins multicast groups and receives multicast content.
Gateway	A customer premises device which facilitates delivery of video, data and other services.
Headend	The central location on the cable network that is responsible for injecting broadcast video and other signals in the downstream direction.
Home Network	A network within the subscriber premises which connects to the Access Network via the Gateway.
IP Multicast	A delivery mechanism whereby IP packets can be transmitted to/received from devices that have explicitly joined a multicast group.
Key Server	A server which provides keys as part of a DRM solution.
License Server	A server which checks authorization and provides licenses as part of a DRM solution.
Linear TV	A continuous content stream from a provider, e.g., a broadcast television network.
MPEG Source	A device which provides a source of MPEG-encoded video content for encoding as ABR content streams.
Multicast Controller	A device which controls what channels are provided via multicast.
Multicast Server	A device which delivers content via multicast.
Multiple-System Operator (MSO)	A company that owns and operates more than one cable system.
Packager	A device which takes continuous video streams, encodes them at different bit rates and breaks them into shorter duration segments.
PacketCable Multimedia	An application agnostic QoS architecture for services delivered over DOCSIS networks.
Player	An application for playback of ABR video.
Serving Group	A set of receivers which all receive the same transmission of a given frequency band.
Stream	A series of video segments which contain the same video asset, typically at the same bit rate encoding.
Unicast	Delivery of IP packets to a single device.

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following terms:

ABR	Adaptive Bit Rate
BSS	Business Support System
CCAP	Converged Cable Access Platform
CDN	Content Delivery Network
CM	Cable Modem
DOCSIS®	Data-Over-Cable Service Interface Specifications
EAS	Emergency Alert System
EAN	Emergency Action Notification
EMC	Embedded Multicast Client
FEC	Forward Error Correction
GW	Gateway
HD	High Definition
HDS	HTTP Dynamic Streaming
HLS	HTTP Live Streaming
HTTP	Hyper Text Transfer Protocol
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPsec	Internet Protocol Security
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
JSON	JavaScript Object Notation
M-ABR	Multicast-Adaptive Bit Rate
MC	Multicast Controller
MoCA	Multimedia over Coax Alliance
MPEG	Moving Picture Experts Group
MPEG-DASH	Moving Picture Experts Group Dynamic Adaptive Streaming over HTTP
MS	Multicast Server
MSS	Microsoft Smooth Streaming
NACK	Negative-Acknowledgement
NMS	Network Management System
NORM	NACK-Oriented Reliable Multicast
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
REST	Representational State Transfer
RTP	Real-time Transport Protocol
RTCP	RTP Control Protocol
RTSP	Real-Time Streaming Protocol
RTMP	Real-Time Messaging Protocol

SD	Standard Definition
SDV	Switched Digital Video
(S,G)	(Source IP Address, Group IP Address)

5 OVERVIEW AND THEORY OF OPERATIONS

Multicast-ABR or, perhaps more accurately, Multicast-assisted ABR, is a technique for using IP multicast to deliver ABR video segments to a Gateway. It is a network-layer efficiency mechanism which is transparent to ABR Players.

Multicast-ABR is more fully described in [IPM-TR] and the protocols in this protocol suite generally use a web services architecture. However, these protocols are generally control-plane protocols. The MS-EMC protocol is a data-plane protocol and does not utilize web services, as this protocol is intended for high-volume delivery of video content via IP multicast.

The Multicast Server is largely a slave to the Multicast Controller. The Multicast Server transmits what the Multicast Controller tells it to transmit when the Multicast Controller tells it to transmit it. However, the Multicast Controller is only concerned about the control plane and relies on the Multicast Server for data-plane transmissions.

5.1 Functional Overview

5.1.1 NORM Overview

The following sequence diagrams provide more detail on how NORM (NACK-Oriented Reliable Multicast) is used to deliver streams of M-ABR segments. Both sequences are assuming unicast repair so there are no NACKs from the Gateway Cache and no NORM repair traffic from the Multicast Server.

Figure 2 shows the process the Multicast Server utilizes for transmitting video segment files. It shows how the Multicast Server breaks up the video segment files into FEC blocks and then transmits these FEC blocks (along with their associated parity blocks) to the multicast group (i.e., (S,G)) for a given video stream.

Figure 3 shows the process of M-ABR video reception from the perspective of the Embedded Multicast Client and Player. This diagram does not distinguish between a Gateway's Embedded Multicast Client function (e.g., NORM client) and its Caching Proxy function. These two functions typically operate asynchronously. The Embedded Multicast Client receives video segment files via NORM and fills the proxy's cache with them. This provides the multicast functionality for the Gateway.

The Caching Proxy function is a unicast function and is typically the function that interacts with the Player. Figure 3 shows details omitted in most other M-ABR specification diagrams for simplicity. It recognizes that partial segments might be delivered and shows how gaps in these segments can be filled using Range Requests to the CDN.

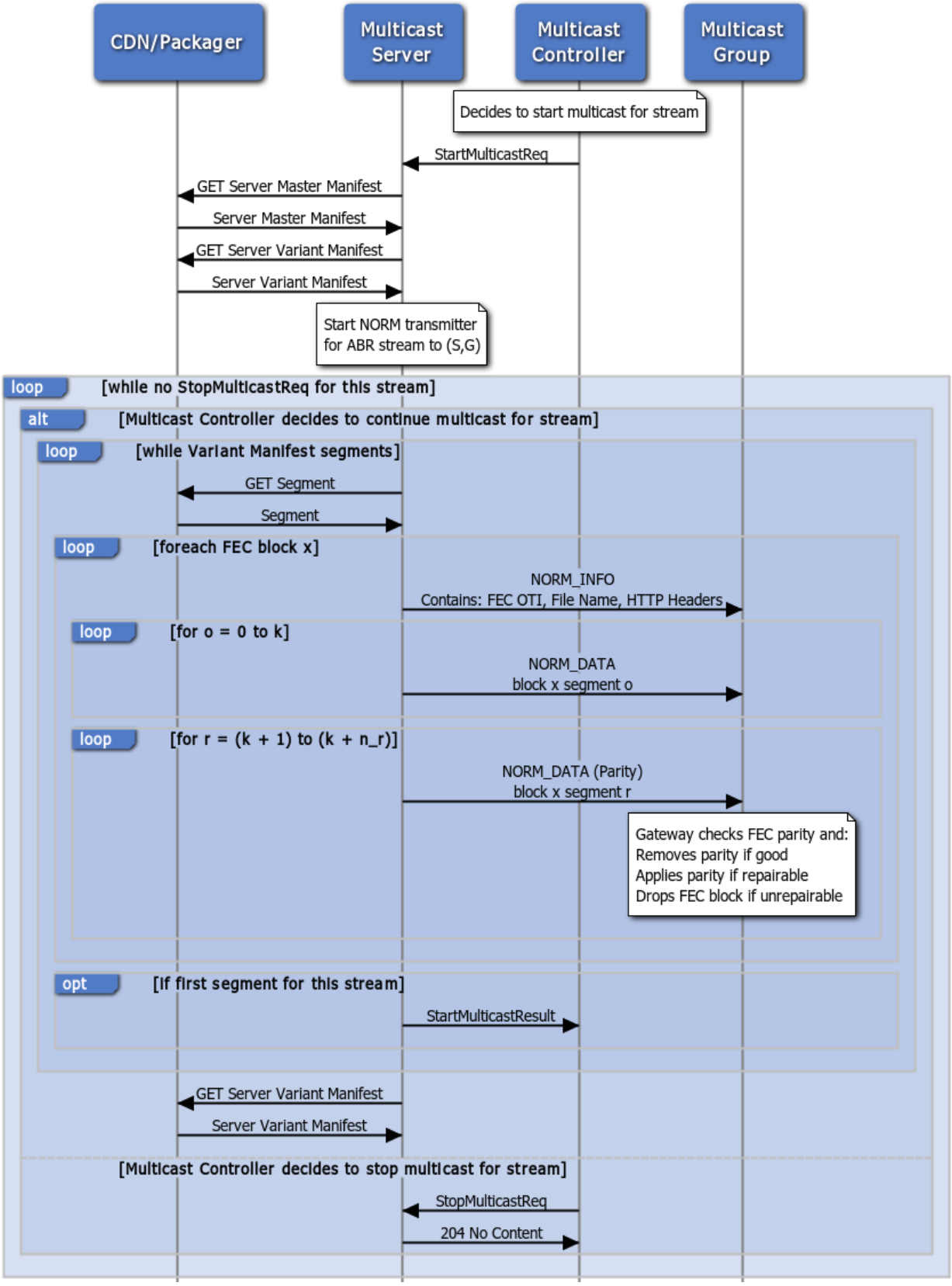

Figure 2 - NORM Transmission of Segments with FEC & Unicast Repair

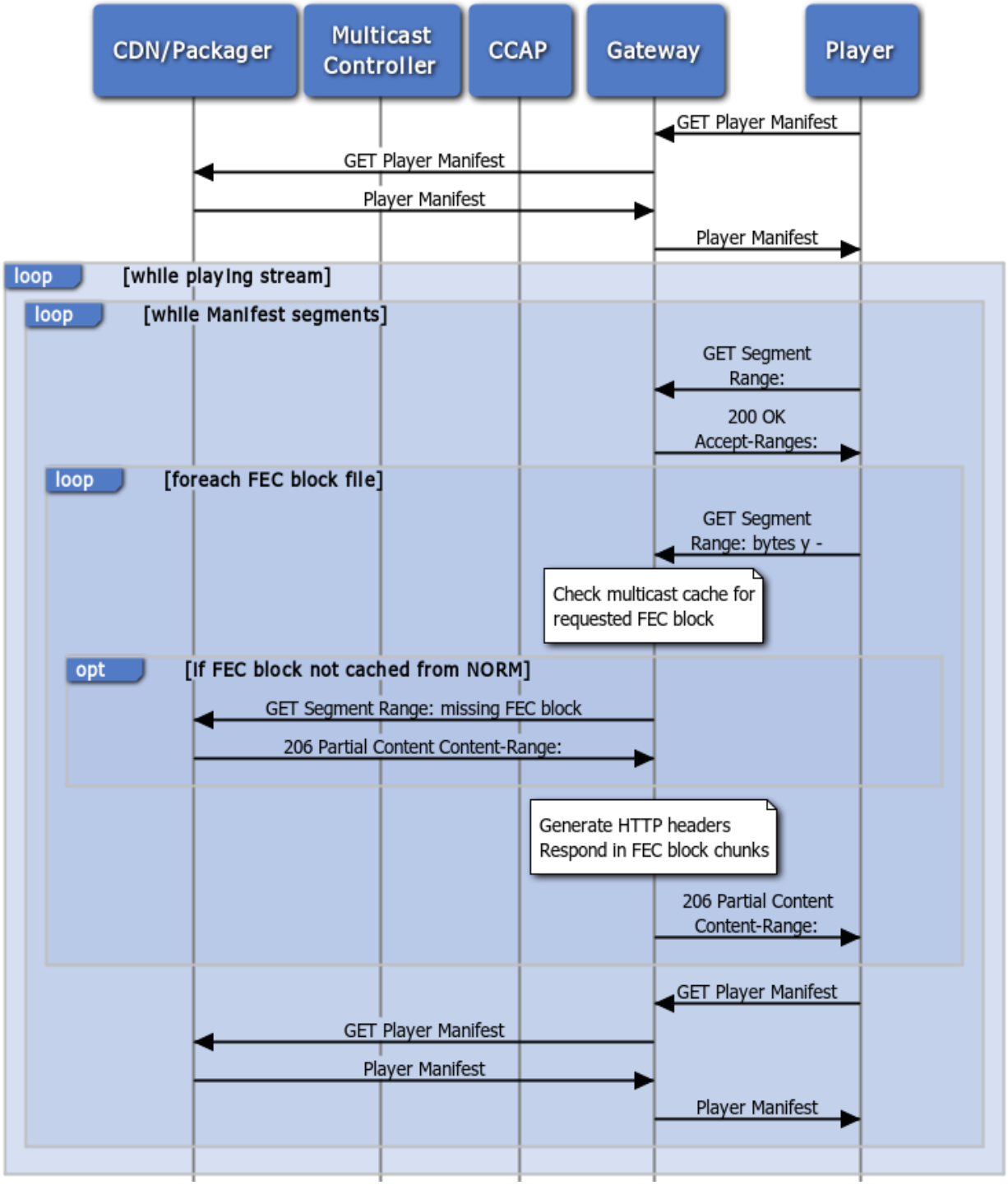

Figure 3 - NORM Reception with Unicast Repair

6 MULTICAST SERVER FUNCTIONALITY

6.1 Multicast Group Membership Control

The Multicast Controller controls the start/stop of multicast transmissions to a given (S,G) by the Multicast Server as described in [MC-MS].

The Multicast Controller explicitly or implicitly controls the multicast group membership of the Gateway as described in [MC-EMC].

6.2 NORM Modes

NORM is an extremely flexible protocol. It has numerous parameters which can be configured on the Multicast Server. Of particular interest are parameters related to NORM FEC and the NORM data repair mechanism.

The Multicast Server MUST support transmitting using NORM as described in [RFC 5740]. The Multicast Server MUST support transmitting data with NORM using the FEC building block as described in [RFC 5052]. The Multicast Server MUST support encoding using Reed-Solomon FEC as described in [RFC 5510]. The Multicast Server MUST support proactive FEC as described in [RFC 3453]. The Multicast Server MAY support NACKs as described in [RFC 5401], but generally NORM is used as an unreliable protocol when utilized for Multicast-ABR.

The Multicast Server SHOULD support configuration for the amount of FEC protection utilized. The details of Multicast Server configuration are beyond the scope of this specification.

The Gateway MUST support receiving using NORM as described in [RFC 5740]. The Gateway MUST support receiving data with NORM that is transmitted using the FEC building block as described in [RFC 5052]. The Gateway MUST support decoding data encoded using Reed-Solomon FEC as described in [RFC 5510]. The Gateway MAY support NACKs as described in [RFC 5401], but generally NORM is used as an unreliable protocol when used for Multicast-ABR.

The Gateway MUST detect lost FEC blocks. The Gateway MUST repair lost FEC blocks using received parity blocks, when sufficient parity blocks have been received. The Gateway MUST drop FEC blocks when insufficient parity data exists to repair them. The Gateway MUST utilize HTTP GET messages using the Range-Request header to repair video segment files when portions of that file (i.e., FEC blocks) have been dropped as unrepairable.

NORM Congestion Control is not generally used for Multicast-ABR applications. However, it should be noted that some Multicast Server implementations transmit NORM_CMD(CC) messages even when Congestion Control is disabled. Thus, the Gateway MUST support reception of NORM_CMD(CC) messages. The Gateway MAY ignore NORM_CMD(CC) messages.

6.3 Multicast Content Delivery

The specifics of content delivery to the Multicast Server are beyond the scope of this specification. However, the Multicast Server MAY retrieve video segment files as any streaming client would. Upon the receipt of a StartMulticastReq from the Multicast Controller, the Multicast Server begins acquiring video segments for the ABR stream indicated by the manifestUrl and bit rate in the request per [MC-MS]. Until it receives a StopMulticast request for this stream, the Multicast Server MUST transmit video segments using NORM to the multicast address and port indicated in the StartMulticastReq per the requirements of this specification.

NORM supports delivery of content either as NORM_OBJECT_DATA, NORM_OBJECT_FILE or NORM_OBJECT_STREAM types. The difference is that DATA and FILE objects have a predetermined size, while STREAM objects are potentially infinite. ABR video is a potentially infinite stream of files, each of which has a finite file size. Thus, although it might initially seem counterintuitive, the Multicast Server does not treat the delivery of video segment files as a STREAM object. The Multicast Server MUST transmit video segments using NORM_OBJECT_DATA or NORM_OBJECT_FILE types.

Regardless of how the Multicast Server acquires video segment files, it MUST create an HTTP Response Header for each video segment file. The Multicast Server MAY create the HTTP Response Header by copying all or some of

the HTTP Response Header from the server response to the Multicast Server's HTTP request for the video segment file. In the NORM_INFO messages associated with the delivery of a given video segment file, the Multicast Server MUST include, as part of a SegmentMetadata element, all of the HTTP headers to be associated with the video segment when the Gateway delivers the video segment via unicast (refer to Section 7.3.1). Typically, these are the HTTP Response Headers for the video segment file that the Multicast Server received when it retrieved the segment itself. In the NORM_INFO messages associated with the delivery of a given video segment file, the Multicast Server MUST include the URL of the video segment file encoded as part of a SegmentMetadata element.

NORM_INFO messages are limited to the length of a single NormSegmentSize. If the HTTP Response Header does not fit in a single NormSegmentSize, the Multicast Server SHOULD truncate the HTTP Response Header such that it fits in the NORM_INFO message.

The Multicast Server transmission rate SHOULD NOT exceed a maximum transmission rate per stream/session. Operators are advised to configure the maximum transmission rate(s) on the Multicast Server such that they are consistent with the data rates for the matching Group Service Flows configured on the CCAP. This will minimize the potential for data loss on M-ABR streams.

6.4 Multicast Content Reception

The Gateway starts NORM receivers per [MC-EMC].

The Gateway's NORM receivers assemble NORM FEC blocks into video segments and puts these segments into its cache. The Gateway serves HTTP GET requests for segment files in its cache (without sending an HTTP GET of its own) per [MC-EMC]. The Gateway MUST utilize the httpHeaders included in the NORM_INFO message(s) for a given video segment file to create the HTTP headers it includes in its HTTP responses to requests for that file. The Gateway SHOULD identify the video segment by the segmentUrl included in the NORM_INFO message(s) for a given video segment file.

If the unicastNackDestination configuration attribute has been set by the Multicast Controller in the ConfigResult, the Gateway MUST send NORM NACKs to the configured address. Otherwise, the Gateway MUST NOT send NORM NACKs. When configured to not send NORM NACKs (the default behavior), the Gateway MUST silently receive any data transmitted to one of its joined NORM groups. Any portion of a video segment file which is not successfully received by NORM will be requested by the Gateway via unicast.

6.5 Multicast Channel Map Delivery

Upon receipt of a SendChannelMapReq message, the Multicast Server MUST extract the ChannelMap element and insert it, unmodified, in the ChannelMap element of a ChannelMapMsg (refer to Section 7.2.1). Then the Multicast Server MUST transmit the ChannelMapMsg as either a NORM_OBJECT_DATA or NORM_OBJECT_FILE type to the (S,G) specified in the SendChannelMapReq. If the SendChannelMapReq message does not include a sourceAddress, the Multicast Server assigns a sourceAddress to the (S,G) utilized for multicasting this stream.

6.6 Multicast Channel Map Reception

ChannelMap objects can be delivered via unicast or multicast. [MC-EMC] defines how channel maps are handled when received via either mechanism.

The Gateway MUST replace any internally cached channel map with the most recent ChannelMapMsg received via multicast. Depending on the Gateway's specific configuration, reception of a new ChannelMap can lead to other behaviors (such as leaving/joining multicast groups) as described in the Multicast Group Membership control section of [MC-EMC].

7 MS-EMC INTERFACE DEFINITION

7.1 NORM

NORM is used per the referenced RFCs and as described in Sections 6.2 and 6.3.

7.2 Multicast Channel Map

7.2.1 Channel Map Message

As described in the Protocol Operation Section of [MC-EMC], the Gateway can receive ChannelMap information which links StreamId (the channelId and bit rate tuple) to an (S,G) via two different mechanisms. The first mechanism is via unicast in a StreamStatusResult message and the second mechanism is via multicast in a ChannelMapMsg. A system can use unicast, multicast or both mechanisms for delivering ChannelMap information; however, it is typically either unicast or multicast. The Gateway treats the most recently received ChannelMap as the current ChannelMap, regardless of how it was delivered.

Request Direction: N/A (this message is unsolicited)

Method: Delivered via NORM sent to multicast.channelMap.groupAddress

Message URL: N/A

7.2.1.1 ChannelMapMsg Message

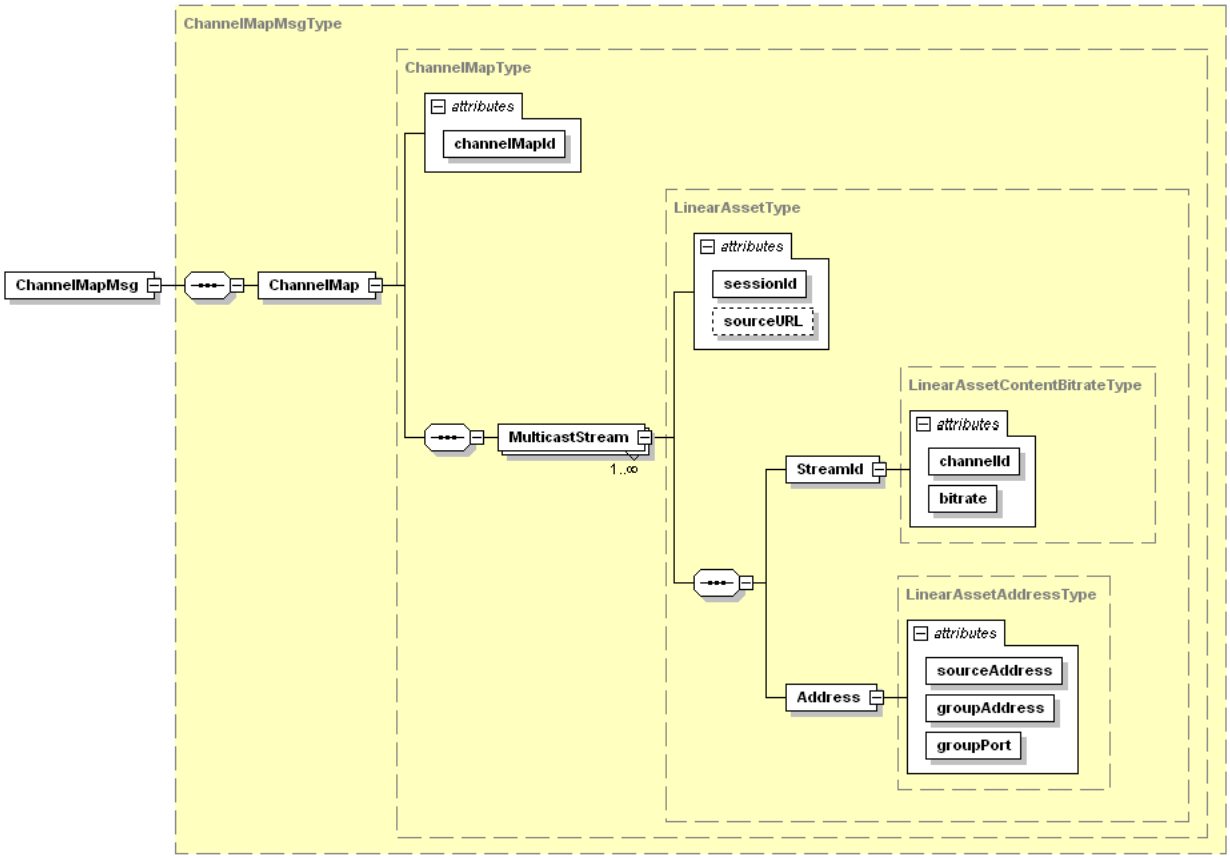

Figure 4 - ChannelMapMsg

Children: ChannelMap (1)

7.2.1.1.1 ChannelMap

The ChannelMap element contains a series of Multicast Streams which provide a mapping between a tuple of channelId and bitrate to (S,G). It is defined in the ChannelMap Section of [MC-EMC].

7.3 NORM_INFO Metadata Encoding

Each ABR video segment file is treated by NORM as a NormObject. Each NormObject can have associated metadata which can be delivered via NORM_INFO messaging. The payload_data portion of the NORM_INFO message is in an "application defined" format. This section defines a generic XML schema for NORM_INFO messages used for M-ABR systems.

7.3.1 SegmentMetadata

The Multicast Server MUST encode the payload_data portion of its NORM_INFO messages as a SegmentMetadata element.

Request Direction: N/A (this message is unsolicited)

Method: Delivered in payload_data portion of NORM_INFO messages associated with a video segment file

Message URL: N/A

Children: Metadata (1..n)

7.3.1.1 Metadata

The Metadata element contains data about a video segment file.

Children: None

Common Type: KVPType

Table 1 - Standard Metadata

Key	Use	Description
segmentUrl	Required	The URL of the associated video segment file.
httpHeaders	Required	Contains all of the HTTP headers the Multicast Server wants associated with the corresponding video segment when the Gateway delivers the video segment via unicast.

7.3.1.2 SegmentMetadata Example

```
<SegmentMetadata xmlns="urn:com:cablelabs:ipmulticast:2015:02:13">
  <Metadata
    key=”segmentUrl”
    value=”http://cdn.mso.com/LIVE/ABC/02112015120000_54300.ts”/>
  <Metadata
    key=”httpHeaders”
    value=”HTTP/1.1 200 OK
Server: Apache
ETag: "17a9d47ae133f0bae8a0651fe97386d2:1239907490"
Last-Modified: Thu, 16 Apr 2009 18:44:50 GMT
Accept-Ranges: bytes
Content-Length: 923080
Content-Type: video/mp2t
Date: Wed, 27 Aug 2014 15:50:01 GMT
Connection: keep-alive”/>
</SegmentMetadata>
```

Appendix I Acknowledgements

On behalf of the cable industry and our member companies, CableLabs would like to thank the following individuals for their contributions to the development of this specification.

Contributor	Company Affiliation
Will Jennings	ARRIS
Dan Torbet	ARRIS
Ian Wheelock	ARRIS

Matt White – CableLabs

Andrew Sundelin – Consultant to CableLabs