



SLOVENSKI STANDARD
oSIST prEN 302 878-4 V1.1.0:2011
01-junij-2011

Dostop, priključki, prenos in multipleksiranje (ATTM) - Tretja generacija prenosnih sistemov za storitve interaktivne kableske televizije - IP-kabelski modemi - 4. del: MAC in protokoli zgornje plasti - DOCSIS 3.0

Access, Terminals, Transmission and Multiplexing (ATTM) - Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems - Part 4: MAC and Upper Layer Protocols; DOCSIS 3.0

(standards.iteh.ai)

[SIST EN 302 878-4 V1.1.1:2012](https://standards.iteh.ai/catalog/standards/sist/a4212e38-73b1-4d51-93b2-253342aa1853/sist-en-302-878-4-v1-1-1-2012)
<https://standards.iteh.ai/catalog/standards/sist/a4212e38-73b1-4d51-93b2-253342aa1853/sist-en-302-878-4-v1-1-1-2012>

Ta slovenski standard je istoveten z: EN 302 878-4 Version 1.1.0

ICS:

35.180	Terminalska in druga periferna oprema IT	IT Terminal and other peripheral equipment
--------	--	--

oSIST prEN 302 878-4 V1.1.0:2011 **en**

Draft ETSI EN 302 878-4 V1.1.0 (2011-04)

European Standard

Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 4: MAC and Upper Layer Protocols; DOCSIS 3.0

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[SIST EN 302 878-4 V1.1.1:2012](https://standards.iteh.ai/catalog/standards/sist/a4212e38-73b1-4d51-93b2-253342aa1853/sist-en-302-878-4-v1-1-1-2012)

<https://standards.iteh.ai/catalog/standards/sist/a4212e38-73b1-4d51-93b2-253342aa1853/sist-en-302-878-4-v1-1-1-2012>



Reference

DEN/ATTM-003006-4

Keywords

access, broadband, cable, data, IP, IPCable,
modem

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST EN 302 878-4 V1.1.1:2012

<https://standards.iteh.ai/catalog/standards/sist-en-302-878-4-v1-1-1-2012>
Important notice

Individual copies of the present document can be downloaded from:

<http://www.etsi.org>

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at

<http://portal.etsi.org/tb/status/status.asp>

If you find errors in the present document, please send your comment to one of the following services:

http://portal.etsi.org/chaicor/ETSI_support.asp

Copyright Notification

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© European Telecommunications Standards Institute 2011.
All rights reserved.

DECT™, **PLUGTESTS™**, **UMTS™**, **TIPHON™**, the TIPHON logo and the ETSI logo are Trade Marks of ETSI registered for the benefit of its Members.

3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

LTE™ is a Trade Mark of ETSI currently being registered

for the benefit of its Members and of the 3GPP Organizational Partners.

GSM® and the GSM logo are Trade Marks registered and owned by the GSM Association.

Contents

Intellectual Property Rights	22
Foreword.....	22
1 Scope	23
1.1 Introduction and Purpose.....	23
1.2 Requirements.....	23
1.3 Conventions.....	23
2 References	23
2.1 Normative references	24
2.2 Informative references.....	27
3 Definitions and abbreviations.....	27
3.1 Definitions	27
3.2 Abbreviations	37
4 Void.....	41
5 Overview and Theory of Operations	41
5.1 DOCSIS 3.0 MULPI Key Features	41
5.2 Technical Overview	42
5.2.1 CMTS and CM Models.....	42
5.2.1.1 CMTS Model	42
5.2.1.1.1 Types of CMTS	42
5.2.1.1.2 CMTS Internal Forwarding Model.....	44
5.2.1.1.3 CMTS MAC Domain	45
5.2.1.2 CM Model.....	46
5.2.2 DOCSIS MAC Operation	46
5.2.2.1 QoS	46
5.2.2.1.1 Individual and Group Service Flows	47
5.2.2.2 Channel Bonding.....	48
5.2.2.2.1 Downstream Channel Bonding.....	48
5.2.2.2.2 Upstream Channel Bonding.....	49
5.2.2.3 Autonomous Load Balancing	51
5.2.3 Multicast Operation	51
5.2.4 Network and Higher Layer Protocols	52
5.2.5 CM and CPE Provisioning and Management	52
5.2.5.1 Initialization, Provisioning and Management of CMTS	52
5.2.5.2 Initialization, Provisioning and Management of CPEs	53
5.2.6 Relationship to the Physical HFC Plant Topology	53
5.2.6.1 RF Topology Configuration.....	53
5.2.6.2 Frequency Assignment.....	55
5.2.7 Cable Modem Service Group (CM-SG)	56
5.2.7.1 MAC Domain Channel Assignment.....	57
5.2.7.2 Multiple MAC Domains per Fiber Node	58
5.2.7.3 MAC Domain Downstream and Upstream Service Groups.....	59
5.2.7.4 Channel Bonding Topology Considerations	59
5.2.8 CMTS Downstream Service Model Example.....	60
6 Media Access Control Specification	61
6.1 Introduction	61
6.1.1 Overview	61
6.1.2 Definitions	61
6.1.2.1 MAC-Sublayer Domain	61
6.1.2.2 MAC Service Access Point.....	62
6.1.2.3 Service Flows	62
6.1.2.4 Upstream Intervals, Mini-Slots and 6,25-Microsecond Increments	62
6.1.2.4.1 TDMA mode	62
6.1.2.4.2 S-CDMA mode.....	63

6.1.2.5	MAC Frame	63
6.1.2.6	Logical Upstream Channels	63
6.1.2.6.1	Type 3 Logical Upstreams.....	64
6.1.2.6.2	Type 4 Logical Upstreams.....	64
6.1.3	Future Use.....	65
6.2	MAC Frame Formats.....	65
6.2.1	Generic MAC Frame Format	65
6.2.1.1	PMD Overhead	65
6.2.1.2	MAC Frame Transport.....	66
6.2.1.3	Ordering of Bits and Octets.....	66
6.2.1.3.1	Representing Negative Numbers	67
6.2.1.3.2	Type-Length-Value Fields.....	67
6.2.1.4	MAC Header Format.....	67
6.2.1.5	Data PDU	68
6.2.2	Packet-Based MAC Frames	69
6.2.2.1	Packet PDU and Isolation Packet PDU.....	69
6.2.3	ATM Cell MAC Frames	70
6.2.4	MAC-Specific Headers	70
6.2.4.1	Timing Header	70
6.2.4.2	MAC Management Header	71
6.2.4.3	Request Frame.....	71
6.2.4.4	Fragmentation Header	72
6.2.4.5	Queue-depth Based Request Frame	73
6.2.4.6	Concatenation Header	73
6.2.5	Extended MAC Headers	74
6.2.5.1	Piggyback Requests	76
6.2.5.2	Request Extended Header	76
6.2.5.3	Fragmentation Extended Header.....	76
6.2.5.4	Service Flow Extended Header	77
6.2.5.4.1	Payload Header Suppression Header.....	77
6.2.5.4.2	Unsolicited Grant Synchronization Header	78
6.2.5.5	BP_UP2 Extended Header	78
6.2.5.6	Downstream Service Extended Header	78
6.2.5.7	DPV Extended Header	80
6.3	Segment Header Format	80
6.4	MAC Management Messages.....	81
6.4.1	MAC Management Message Header	81
6.4.2	Time Synchronization (SYNC).....	84
6.4.3	Upstream Channel Descriptor (UCD).....	84
6.4.3.1	Example of UCD Encoded TLV Data.....	92
6.4.4	Upstream Bandwidth Allocation Map (MAP)	93
6.4.5	Ranging Request Messages	95
6.4.5.1	Ranging Request (RNG-REQ).....	97
6.4.5.2	Initial Ranging Request (INIT-RNG-REQ)	98
6.4.5.3	Bonded Initial Ranging Request (B-INIT-RNG-REQ).....	99
6.4.5.3.1	Capability Flags.....	99
6.4.6	Ranging Response (RNG-RSP)	100
6.4.6.1	Encodings.....	101
6.4.6.2	Example of TLV Data	102
6.4.6.3	Transmit Equalization Encodings	103
6.4.6.4	RNG-RSP Channel Overrides.....	103
6.4.6.5	Upstream Channel Adjustments	104
6.4.6.6	T4 Timeout Multiplier.....	104
6.4.7	Registration Request Messages.....	105
6.4.7.1	Registration Request (REG-REQ)	106
6.4.7.2	Multipart Registration Request (REG-REQ-MP)	106
6.4.8	Registration Response Messages	107
6.4.8.1	Registration Response (REG-RSP).....	109
6.4.8.2	Multipart Registration Response (REG-RSP-MP).....	110
6.4.8.3	Encodings.....	111
6.4.8.3.1	Modem Capabilities.....	111
6.4.8.3.2	DOCSIS 1.0 Service Class Data.....	111

6.4.9	Registration Acknowledge (REG-ACK)	112
6.4.10	Upstream Channel Change Request (UCC-REQ).....	113
6.4.11	Upstream Channel Change Response (UCC-RSP).....	114
6.4.12	Dynamic Service Addition - Request (DSA-REQ).....	114
6.4.12.1	CM-Initiated Dynamic Service Addition	115
6.4.12.2	CMTS-Initiated Dynamic Service Addition.....	115
6.4.13	Dynamic Service Addition - Response (DSA-RSP).....	116
6.4.13.1	CM-Initiated Dynamic Service Addition	117
6.4.13.2	CMTS-Initiated Dynamic Service Addition.....	117
6.4.14	Dynamic Service Addition - Acknowledge (DSA-ACK).....	117
6.4.15	Dynamic Service Change - Request (DSC-REQ).....	118
6.4.16	Dynamic Service Change - Response (DSC-RSP)	120
6.4.17	Dynamic Service Change - Acknowledge (DSC-ACK)	121
6.4.18	Dynamic Service Deletion - Request (DSD-REQ).....	122
6.4.19	Dynamic Service Deletion - Response (DSD-RSP).....	122
6.4.20	Dynamic Channel Change - Request (DCC-REQ)	123
6.4.20.1	Encodings.....	124
6.4.20.1.1	Upstream Channel ID	124
6.4.20.1.2	Downstream Parameters	124
6.4.20.1.3	Initialization Technique	125
6.4.20.1.4	UCD Substitution	126
6.4.20.1.5	Security Association Identifier (SAID) Substitution	127
6.4.20.1.6	Service Flow Substitutions	127
6.4.20.1.7	CMTS MAC Address	128
6.4.21	Dynamic Channel Change - Response (DCC-RSP).....	129
6.4.21.1	Encodings.....	129
6.4.21.1.1	CM Jump Time.....	130
6.4.22	Dynamic Channel Change - Acknowledge (DCC-ACK)	130
6.4.23	Device Class Identification Request (DCI-REQ)	131
6.4.24	Device Class Identification Response (DCI-RSP).....	132
6.4.25	Upstream Transmitter Disable (UP-DIS).....	132
6.4.26	Test Request (TST-REQ).....	134
6.4.27	Downstream Channel Descriptor (DCD)	135
6.4.28	MAC Domain Descriptor (MDD).....	135
6.4.28.1	TLV Encodings	136
6.4.28.1.1	Downstream Active Channel List TLV	136
6.4.28.1.2	MAC Domain Downstream Service Group (MD-DS-SG) TLV	137
6.4.28.1.3	Downstream Ambiguity Resolution Frequency List TLV.....	138
6.4.28.1.4	Receive Channel Profile Reporting Control TLV	138
6.4.28.1.5	IP Initialization Parameters TLV	139
6.4.28.1.6	Early Authentication and Encryption (EAE) Enable/Disable TLV	139
6.4.28.1.7	Upstream Active Channel List TLV.....	140
6.4.28.1.8	Upstream Ambiguity Resolution Channel List TLV	140
6.4.28.1.9	Upstream Frequency Range TLV	141
6.4.28.1.10	Symbol Clock Locking Indicator	141
6.4.28.1.11	CM-STATUS Event Control	141
6.4.28.1.12	Upstream Transmit Power Reporting	142
6.4.28.1.13	DSG DA-to-DSID Association Entry.....	142
6.4.28.1.14	CM-STATUS Event Enable for Non-Channel-Specific Events	142
6.4.28.1.15	Extended Upstream Transmit Power Support	143
6.4.29	Dynamic Bonding Change Request (DBC-REQ).....	143
6.4.30	Dynamic Bonding Change Response (DBC-RSP)	144
6.4.31	Dynamic Bonding Change Acknowledge (DBC-ACK)	146
6.4.32	DOCSIS Path Verify Request (DPV-REQ).....	146
6.4.33	DOCSIS Path Verify Response (DPV-RSP)	148
6.4.34	Status Report (CM-STATUS).....	148
6.4.34.1	TLV Encodings	149
6.4.35	CM Control Request (CM-CTRL-REQ).....	149
6.4.35.1	TLV Encodings	150
6.4.36	CM Control Response (CM-CTRL-RSP).....	150
7	Media Access Control Protocol Operation.....	151

7.1	Timing and Synchronization	151
7.1.1	Global Timing Reference.....	151
7.1.2	CM Synchronization	152
7.1.3	Ranging	152
7.1.3.1	Broadcast Initial Ranging	152
7.1.3.2	Unicast Initial Ranging	153
7.1.4	Timing Units and Relationships.....	153
7.1.4.1	TDMA Timing Units and Relationships	153
7.1.4.1.1	Mini-Slot Capacity	153
7.1.4.1.2	Mini-Slot Numbering	154
7.1.4.2	S-CDMA Timing Units and Relationships	154
7.1.4.2.1	Mini-Slot Capacity	154
7.1.4.2.2	Mini-Slot Numbering	154
7.2	Upstream Data Transmission	155
7.2.1	Upstream Bandwidth Allocation.....	155
7.2.1.1	The Allocation MAP MAC Management Message	156
7.2.1.2	Information Elements.....	156
7.2.1.2.1	The Request IE	156
7.2.1.2.2	The Request/Data IE.....	157
7.2.1.2.3	The Initial Maintenance IE.....	157
7.2.1.2.4	The Station Maintenance IE	157
7.2.1.2.5	Short and Long Data Grant IEs	157
7.2.1.2.6	Data Acknowledge IE.....	158
7.2.1.2.7	Expansion IE	158
7.2.1.2.8	Null IE	158
7.2.1.2.9	Advanced PHY Short and Long Data Grant IEs	158
7.2.1.2.10	Advanced PHY Unsolicited Grant IE.....	159
7.2.1.3	Requesting with Multiple Transmit Channel Mode Disabled	159
7.2.1.4	Requesting with Multiple Transmit Channel Mode Enabled	160
7.2.1.4.1	Request Mechanisms for Segment Header OFF Service Flows	160
7.2.1.4.2	Request Mechanisms for Segment Header ON Service Flows.....	160
7.2.1.5	Information Element Feature Usage Summary	165
7.2.1.6	Map Transmission and Timing	165
7.2.1.7	Protocol Example	166
7.2.1.8	MAP Generation Example - Two Logical Upstreams.....	167
7.2.2	Upstream Transmission and Contention Resolution.....	168
7.2.2.1	Contention Resolution Overview	168
7.2.2.1.1	Contention Resolution with Multiple Transmit Channel Mode Disabled	168
7.2.2.1.2	Contention Resolution with Multiple Transmit Channel Mode Enabled.....	169
7.2.2.2	Transmit Opportunities	171
7.2.2.3	CM Bandwidth Utilization.....	172
7.2.3	Upstream Service Flow Scheduling Services	172
7.2.3.1	Unsolicited Grant Service	173
7.2.3.2	Real-Time Polling Service	173
7.2.3.3	Unsolicited Grant Service with Activity Detection.....	174
7.2.3.4	Non-Real-Time Polling Service	175
7.2.3.5	Best Effort Service	175
7.2.3.6	Other Services	175
7.2.3.6.1	Committed Information Rate (CIR).....	175
7.2.3.7	Parameter Applicability for Upstream Service Scheduling.....	175
7.2.3.8	CM Transmit Behavior	176
7.2.4	Continuous Concatenation and Fragmentation	176
7.2.5	Pre-3.0 DOCSIS Concatenation and Fragmentation.....	177
7.2.5.1	Concatenation.....	177
7.2.5.2	Fragmentation	178
7.2.5.2.1	CM Fragmentation Support	180
7.2.5.2.2	CMTS Fragmentation Support	182
7.2.5.2.3	Fragmentation Example.....	183
7.2.5.2.4	Pre-Registration Fragmentation.....	185
7.2.5.2.5	Considerations for Concatenated Packets and Fragmentation.....	186
7.3	Upstream - Downstream Channel Association within a MAC Domain	186
7.3.1	Primary Downstream Channels	186

7.3.2	MAP and UCD Messages	187
7.3.3	Multiple MAC Domains	187
7.4	DSID Definition	187
7.5	Quality of Service.....	188
7.5.1	Concepts	188
7.5.1.1	Service Flows	188
7.5.1.2	Classifiers.....	190
7.5.1.2.1	Upstream and Downstream QoS Classifiers.....	190
7.5.1.2.2	Upstream Drop Classifiers.....	192
7.5.2	Object Model	192
7.5.3	Service Classes	194
7.5.4	Authorization	195
7.5.5	States of Service Flows.....	195
7.5.5.1	Deferred Service Flows.....	195
7.5.5.1.1	Provisioned Service Flows	196
7.5.5.1.2	Authorized Service Flows	196
7.5.5.2	Admitted Service Flows.....	196
7.5.5.3	Active Service Flows	197
7.5.6	Service Flows and Classifiers	197
7.5.6.1	Policy-Based Classification and Service Classes.....	198
7.5.7	General Operation.....	198
7.5.7.1	Static Operation.....	198
7.5.7.2	Dynamic Service Flow Creation - CM Initiated.....	199
7.5.7.3	Dynamic Service Flow Creation - CMTS Initiated.....	200
7.5.7.4	Dynamic Service Flow Modification and Deletion.....	200
7.5.8	QoS Support for Joined IP Multicast Traffic	201
7.5.8.1	Overview.....	202
7.5.8.2	Group Configuration and Group QoS Configuration Tables	203
7.5.8.3	Instantiating Group Classifier Rules and Group Service Flows	204
7.5.8.3.1	Examples of GCR and GSF Instantiation.....	206
7.5.8.4	Default Group Service Flows.....	212
7.5.8.5	Service Class QoS Parameter Changes	212
7.5.8.6	Group QoS Configuration Changes	212
7.5.9	Other Multicast and Broadcast Traffic.....	213
7.6	Downstream Traffic Priority	213
7.6.1	Traffic Priority Ordering and Mapping to CM Output Queues.....	213
7.7	Payload Header Suppression	214
7.7.1	Overview	214
7.7.1.1	PHSI-indexed PHS.....	215
7.7.1.2	DSID-indexed PHS	215
7.7.2	Example Applications.....	216
7.7.3	Operation	216
7.7.4	Signalling.....	218
7.7.4.1	Signalling PHSI-Indexed Payload Header Suppression.....	218
7.7.4.2	Signalling DSID-Indexed Payload Header Suppression	219
7.7.5	Payload Header Suppression Examples.....	220
7.7.5.1	Upstream Example	220
7.7.5.2	Downstream Example	221
7.7.5.3	DSID-Indexed Multicast Example	222
7.8	Data Link Encryption Support.....	223
7.8.1	MAC Messages.....	223
7.8.2	Framing.....	223
7.8.3	Multiple Transmit Channel Mode Operation and Packet Encryption.....	223
8	Channel Bonding.....	223
8.1	Upstream and Downstream Common Aspects.....	224
8.1.1	Service Flow Assignment	224
8.1.2	CMTS Bonding and Topology Requirements	227
8.2	Downstream Channel Bonding.....	228
8.2.1	Multiple Downstream Channel Overview	228
8.2.2	CMTS Downstream Bonding Operation.....	229
8.2.3	Sequenced Downstream Packets.....	229

8.2.3.1	Downstream Sequencing.....	230
8.2.3.2	Skew Requirements.....	232
8.2.3.3	Resequencing DSID Signalling.....	233
8.2.4	Cable Modem Physical Receive Channel Configuration.....	233
8.2.4.1	Receive Channels.....	234
8.2.4.2	Receive Modules.....	234
8.2.4.2.1	Receive Module Interconnection.....	236
8.2.4.3	Receive Channel Profile.....	237
8.2.4.3.1	Standard Receive Channel Profiles.....	237
8.2.4.4	Receive Channel Configuration.....	238
8.2.4.4.1	Static Receive Module Assignments.....	239
8.2.4.5	RCC Message Sequence Example.....	240
8.2.5	QoS for Downstream Channel Bonding.....	241
8.3	Upstream Channel Bonding.....	241
8.3.1	Granting Bandwidth.....	241
8.3.2	Upstream Transmissions with Upstream Channel Bonding.....	241
8.3.2.1	Segment Header ON Operation.....	241
8.3.2.2	Segment Header OFF Operation.....	242
8.3.3	Dynamic Range Window.....	242
8.3.3.1	Channels Added During Registration.....	242
8.3.3.2	Channels Added by a DBC-REQ.....	243
8.3.3.3	Channels Deleted by a DBC-REQ.....	244
8.3.3.4	UCD Changes Burst Profiles Resulting in New Value for P_{hi}	244
8.3.3.5	Power Offset in RNG-RSP Causing Dynamic Range Window Violation.....	244
8.4	Partial Service.....	244
9	Data Forwarding.....	245
9.1	General Forwarding Requirements.....	245
9.1.1	CMTS Forwarding Rules.....	246
9.1.1.1	General CMTS Forwarding.....	246
9.1.1.2	DSID Labeling.....	247
9.1.2	CM Address Acquisition, Filtering and Forwarding Rules.....	247
9.1.2.1	MAC Address Acquisition.....	248
9.1.2.2	CM Filtering Rules.....	248
9.1.2.3	CM Forwarding Rules.....	249
9.1.2.3.1	CM Pre-Operational Forwarding Behavior.....	249
9.1.2.3.2	CM Operational Forwarding Behavior.....	249
9.2	Multicast Forwarding.....	251
9.2.1	Introduction.....	251
9.2.2	Downstream Multicast Forwarding.....	252
9.2.2.1	Examples of Downstream Multicast Forwarding using DSIDs.....	253
9.2.2.2	Labeling Multicast Packets with DSIDs.....	255
9.2.2.2.1	Mixed CM environment.....	256
9.2.2.2.2	Pre-Registration DSID.....	256
9.2.2.2.3	Upstream Multicast Traffic from a Multicast Client.....	256
9.2.2.3	Communicating DSIDs and group forwarding attributes to a CM.....	256
9.2.2.4	DSID based Filtering and Forwarding by a Cable Modem.....	257
9.2.2.5	Individually Directed Multicast.....	258
9.2.3	Downstream Multicast Traffic Encryption.....	258
9.2.3.1	Multicast Encryption Overview.....	258
9.2.3.2	Dynamic Multicast Encryption.....	259
9.2.3.3	DSIDs and SAIDs.....	259
9.2.3.4	Pre-Registration Multicast Encryption.....	259
9.2.4	Static Multicast Session Encodings.....	260
9.2.5	IGMP and MLD Support.....	260
9.2.5.1	Motivation behind taking CM out of IGMP Control Plane.....	260
9.2.5.2	IP multicast service model support.....	260
9.2.5.3	IGMP and MLD membership handling.....	261
9.2.5.4	IGMPv2/MLDv1 Leave Processing.....	262
9.2.5.5	IGMP and MLD version and query support.....	262
9.2.5.6	Separation of Query Domains.....	262
9.2.6	Encrypted Multicast Downstream Forwarding Example.....	263

9.2.7	IP Multicast Join Authorization	266
9.2.7.1	Maximum Multicast Sessions	266
9.2.7.2	Session Rules	267
9.2.7.2.1	IP Multicast Profiles	267
9.2.7.2.2	Static IP Multicast Join Authorization Rules.....	268
9.2.7.3	CM Configuration File.....	268
9.2.7.3.1	IP Multicast Profile Name Subtype	268
9.2.7.3.2	Static IP Multicast Session Rule Subtype.....	268
9.2.7.4	Matching Session Rules	268
9.2.7.5	IP Multicast Profile Changes.....	269
10	Cable Modem - CMTS Interaction.....	269
10.1	CMTS Initialization.....	269
10.2	Cable Modem Initialization and Reinitialization.....	270
10.2.1	Scan for Downstream Channel	270
10.2.2	Continue Downstream Scanning.....	271
10.2.3	Service Group Discovery and Initial Ranging	271
10.2.3.1	Read MAC Domain Descriptor (MDD).....	273
10.2.3.2	MDDs Not Found on Primary Downstream.....	274
10.2.3.3	Determination of MD-DS-SG	275
10.2.3.4	Ranging Holdoff	277
10.2.3.5	Determination of MD-US-SG	279
10.2.3.5.1	Bonded Initial Ranging.....	280
10.2.3.5.2	Continue US Ambiguity Initial Ranging	282
10.2.3.6	Obtain Upstream Parameters / Try Next Upstream (DOCSIS 2.0 Initialization).....	284
10.2.3.6.1	Message Flows During Scanning and Upstream Parameter Acquisition.....	285
10.2.3.7	Ranging and Automatic Adjustments.....	286
10.2.3.7.1	Adjust Transmit Parameters	290
10.2.3.8	CMTS Determination of Cable Modem Service Group and Initial Ranging	291
10.2.4	Authentication.....	293
10.2.5	Establishing IP Connectivity.....	293
10.2.5.1	Establish IPv4 Network Connectivity	301
10.2.5.1.1	DHCPv4 Fields Used by the CM	302
10.2.5.1.2	Use of T1 and T2 Timers.....	303
10.2.5.1.3	CMTS Requirements	303
10.2.5.2	Establish IPv6 Network Connectivity	304
10.2.5.2.1	Obtain Link-Local Address	305
10.2.5.2.2	Obtain default routers	305
10.2.5.2.3	Obtain IPv6 management address and other configuration parameters.....	305
10.2.5.2.4	Use of T1 and T2 Timers.....	306
10.2.5.2.5	CMTS Requirements	307
10.2.5.3	Alternate Provisioning Mode (APM) Operation	307
10.2.5.4	Dual-stack Provisioning Mode (DPM).....	308
10.2.5.5	Establish Time of Day.....	308
10.2.5.6	Transfer Operational Parameters.....	309
10.2.5.7	Configuration File Processing.....	310
10.2.5.8	Post-registration Failures to Renew IP Addresses.....	311
10.2.6	Registration with the CMTS	311
10.2.6.1	Cable Modem Requirements	311
10.2.6.2	CMTS Requirements.....	319
10.2.6.2.1	Channel Assignment During Registration	325
10.2.7	Baseline Privacy Initialization	327
10.2.8	Service IDs During CM Initialization	327
10.3	Periodic Maintenance	328
10.4	Fault Detection and Recovery	330
10.4.1	CM Downstream Channel Interruptions	331
10.4.2	MAC Layer Error-Handling	332
10.4.2.1	Error Recovery During Pre-3.0 DOCSIS Fragmentation.....	333
10.4.2.2	Error Recovery During Segmentation with Segment Headers On	333
10.4.3	CM Status Report	334
10.4.3.1	Event Codes	337
10.5	DOCSIS Path Verification	340

10.5.1	DPV Overview.....	340
10.5.2	DPV Reference Points	340
10.5.3	DPV Math.....	342
10.5.4	DPV Per Path Operation.....	342
10.5.4.1	DPV Ping	343
10.5.5	DPV Per Packet Operation	343
11	Dynamic Operations.....	344
11.1	Upstream Channel Descriptor Changes.....	344
11.2	Dynamic Service Flow Changes	345
11.2.1	Dynamic Service Flow State Transitions.....	346
11.2.2	Dynamic Service Addition.....	354
11.2.2.1	CM Initiated Dynamic Service Addition.....	354
11.2.2.2	CMTS Initiated Dynamic Service Addition.....	355
11.2.2.3	Dynamic Service Addition State Transition Diagrams	356
11.2.3	Dynamic Service Change.....	364
11.2.3.1	CM-Initiated Dynamic Service Change	365
11.2.3.2	CMTS-Initiated Dynamic Service Change.....	365
11.2.3.3	Dynamic Service Change State Transition Diagrams	367
11.2.4	Dynamic Service Deletion	375
11.2.4.1	CM Initiated Dynamic Service Deletion	375
11.2.4.2	CMTS Initiated Dynamic Service Deletion	375
11.2.4.3	Dynamic Service Deletion State Transition Diagrams.....	376
11.3	Pre-3.0 DOCSIS Upstream Channel Changes.....	380
11.4	Dynamic Downstream and/or Upstream Channel Changes	383
11.4.1	DCC General Operation.....	383
11.4.1.1	Derivation of T15 Timer	385
11.4.1.2	Initialization Technique	386
11.4.1.2.1	Initialization Technique Zero (0).....	386
11.4.1.2.2	Initialization Technique One (1).....	387
11.4.1.2.3	Initialization Technique Two (2).....	387
11.4.1.2.4	Initialization Technique Three (3).....	387
11.4.1.2.5	Initialization Technique Four (4).....	387
11.4.2	DCC Exception Conditions	388
11.4.3	DCC State Transition Diagrams	389
11.4.4	DCC Performance.....	396
11.5	Dynamic Bonding Change (DBC).....	397
11.5.1	DBC General Operation.....	397
11.5.1.1	Changes to the Receive Channel Set.....	398
11.5.1.2	Changes to a DSID.....	399
11.5.1.2.1	Changes to Resequencing Encodings	399
11.5.1.2.2	Changes to Multicast Encodings	400
11.5.1.3	Changes to the Security Association for encrypting downstream traffic	402
11.5.1.4	Changes to the Transmit Channel Set	402
11.5.1.4.1	Impact of TCS Changes on Periodic Ranging	403
11.5.1.4.2	Exception Conditions for TCS Changes.....	403
11.5.1.5	Changes to the Service Flow SID Cluster Assignments.....	404
11.5.1.5.1	Bandwidth Sufficiency	405
11.5.1.6	Initialization Technique	405
11.5.1.6.1	Initialization Technique One (1).....	405
11.5.1.6.2	Initialization Technique Two (2).....	406
11.5.1.6.3	Initialization Technique Three (3).....	406
11.5.1.6.4	Initialization Technique Four (4).....	406
11.5.1.7	Fragmentation of DBC-REQ Messages	407
11.5.2	Exception Conditions.....	407
11.5.3	DBC State Transition Diagrams	408
11.5.3.1	CMTS DBC State Transition Diagrams.....	408
11.5.3.2	CM DBC State Transition Diagrams	413
11.6	Autonomous Load Balancing.....	418
11.6.1	Load Balancing Groups	419
11.6.1.1	General Load Balancing Groups	419
11.6.1.2	Restricted Load Balancing Groups.....	420

11.6.2	CMTS Load Balancing Operation	420
11.6.3	Multiple Channel Load Balancing	421
11.6.4	Initialization Techniques.....	421
11.6.5	Load Balancing Policies	421
11.6.6	Load Balancing Priorities	422
11.6.7	Load Balancing and Multicast	422
11.6.8	Externally-Directed Load Balancing	423
12	Supporting Future New Cable Modem Capabilities	423
12.1	Downloading Cable Modem Operating Software	423
12.2	Future Capabilities	424
Annex A (normative): Well_known_Addresses.....		425
A.1	Addresses	425
A.1.1	General MAC Addresses.....	425
A.1.2	Well-known IPv6 Addresses	425
A.2	MAC Service IDs	425
A.2.1	All CMs and No CM Service IDs.....	425
A.2.2	Well-Known Multicast Service IDs	426
A.2.3	Priority Request Service IDs	426
A.3	MPEG PID	426
Annex B (normative): Parameters and Constants		427
Annex C (normative): Common TLV Encodings.....		430
C.1	Encodings for Configuration and MAC-Layer Messaging	431
C.1.1	Configuration File and Registration Settings	431
C.1.1.1	Downstream Frequency Configuration Setting.....	431
C.1.1.2	Upstream Channel ID Configuration Setting	432
C.1.1.3	Network Access Control Object	432
C.1.1.4	DOCSIS 1.0 Class of Service Configuration Setting.....	432
C.1.1.4.1	Class ID.....	433
C.1.1.4.2	Maximum Downstream Rate Configuration Setting	433
C.1.1.4.3	Maximum Upstream Rate Configuration Setting.....	433
C.1.1.4.4	Upstream Channel Priority Configuration Setting	434
C.1.1.4.5	Guaranteed Minimum Upstream Channel Data Rate Configuration Setting	434
C.1.1.4.6	Maximum Upstream Channel Transmit Burst Configuration Setting.....	434
C.1.1.4.7	Class-of-Service Privacy Enable	434
C.1.1.5	CM Message Integrity Check (MIC) Configuration Setting.....	435
C.1.1.6	CMTS Message Integrity Check (MIC) Configuration Setting	435
C.1.1.7	Maximum Number of CPEs	435
C.1.1.8	TFTP Server Timestamp.....	435
C.1.1.9	TFTP Server Provisioned Modem IPv4 Address.....	435
C.1.1.10	TFTP Server Provisioned Modem IPv6 Address.....	436
C.1.1.11	Upstream Packet Classification Configuration Setting	436
C.1.1.12	Downstream Packet Classification Configuration Setting	436
C.1.1.13	Upstream Service Flow Encodings	436
C.1.1.14	Downstream Service Flow Encodings	436
C.1.1.15	Payload Header Suppression.....	436
C.1.1.16	Maximum Number of Classifiers.....	436
C.1.1.17	Privacy Enable	437
C.1.1.18	DOCSIS Extension Field	437
C.1.1.18.1	General Extension Information	437
C.1.1.18.1.1	CM Load Balancing Policy ID	438
C.1.1.18.1.2	CM Load Balancing Priority	438
C.1.1.18.1.3	CM Load Balancing Group ID	438
C.1.1.18.1.4	CM Ranging Class ID Extension.....	438
C.1.1.18.1.5	L2VPN Encoding	438
C.1.1.18.1.6	Extended CMTS MIC Configuration Setting	439
C.1.1.18.1.7	Source Address Verification (SAV) Authorization Encoding.....	440

C.1.1.18.1.8	Cable Modem Attribute Masks.....	441
C.1.1.18.1.9	IP Multicast Join Authorization Encoding	442
C.1.1.18.1.10	Service Type Identifier	444
C.1.1.18.2	Vendor-Specific Information	444
C.1.1.19	Subscriber Management TLVs	445
C.1.1.19.1	Subscriber Management Control.....	445
C.1.1.19.2	Subscriber Management CPE IPv4 List.....	445
C.1.1.19.3	Subscriber Management CPE IPv6 Prefix List	445
C.1.1.19.4	Subscriber Management Filter Groups.....	445
C.1.1.19.5	Subscriber Management Control Max CPE IPv6 Addresses	446
C.1.1.19.6	Subscriber Management CPE IPv6 List.....	446
C.1.1.20	Enable 2.0 Mode.....	446
C.1.1.21	Enable Test Modes.....	446
C.1.1.22	Downstream Channel List	447
C.1.1.22.1	Single Downstream Channel.....	447
C.1.1.22.1.1	Single Downstream Channel Timeout.....	448
C.1.1.22.1.2	Single Downstream Channel Frequency	448
C.1.1.22.2	Downstream Frequency Range	448
C.1.1.22.2.1	Downstream Frequency Range Timeout	448
C.1.1.22.2.2	Downstream Frequency Range Start	448
C.1.1.22.2.3	Downstream Frequency Range End	449
C.1.1.22.2.4	Downstream Frequency Range Step Size.....	449
C.1.1.22.3	Default Scanning.....	449
C.1.1.22.4	Examples Illustrating Usage of the Downstream Channel List.....	449
C.1.1.23	Static Multicast MAC Address	450
C.1.1.24	Downstream Unencrypted Traffic (DUT) Filtering Encoding.....	450
C.1.1.25	Channel Assignment Configuration Settings	451
C.1.1.25.1	Transmit Channel Assignment Configuration Setting.....	451
C.1.1.25.2	Receive Channel Assignment Configuration Setting.....	451
C.1.1.26	Upstream Drop Classifier Group ID	451
C.1.1.27	CMTS Static Multicast Session Encoding	451
C.1.1.27.1	Static Multicast Group Encoding	452
C.1.1.27.2	Static Multicast Source Encoding	452
C.1.1.27.3	Static Multicast CMIM Encoding	452
C.1.2	Configuration-File-Specific Settings.....	452
C.1.2.1	End-of-Data Marker.....	452
C.1.2.2	Pad Configuration Setting.....	452
C.1.2.3	Software Upgrade Filename	453
C.1.2.4	SNMP Write-Access Control.....	453
C.1.2.5	SNMP MIB Object	453
C.1.2.6	CPE Ethernet MAC Address	454
C.1.2.7	Software Upgrade IPv4 TFTP Server	454
C.1.2.8	Software Upgrade IPv6 TFTP Server	454
C.1.2.9	SnmpV3 Kickstart Value	454
C.1.2.9.1	SnmpV3 Kickstart Security Name	454
C.1.2.9.2	SnmpV3 Kickstart Manager Public Number.....	455
C.1.2.10	Manufacturer Code Verification Certificate	455
C.1.2.11	Co-signer Code Verification Certificate	455
C.1.2.12	SNMPv3 Notification Receiver	455
C.1.2.12.1	SNMPv3 Notification Receiver IPv4 Address	455
C.1.2.12.2	SNMPv3 Notification Receiver UDP Port Number.....	456
C.1.2.12.3	SNMPv3 Notification Receiver Trap Type.....	456
C.1.2.12.4	SNMPv3 Notification Receiver Timeout	456
C.1.2.12.5	SNMPv3 Notification Receiver Retries	456
C.1.2.12.6	SNMPv3 Notification Receiver Filtering Parameters	456
C.1.2.12.7	SNMPv3 Notification Receiver Security Name.....	456
C.1.2.12.8	SNMPv3 Notification Receiver IPv6 Address	457
C.1.2.13	SNMPv1v2c Coexistence Configuration.....	457
C.1.2.13.1	SNMPv1v2c Community Name.....	457
C.1.2.13.2	SNMPv1v2c Transport Address Access	457
C.1.2.13.2.1	SNMPv1v2c Transport Address.....	457
C.1.2.13.2.2	SNMPv1v2c Transport Address Mask	458

C.1.2.13.3	SNMPv1v2c Access View Type	458
C.1.2.13.4	SNMPv1v2c Access View Name	458
C.1.2.14	SNMPv3 Access View Configuration	458
C.1.2.14.1	SNMPv3 Access View Name	459
C.1.2.14.2	SNMPv3 Access View Subtree	459
C.1.2.14.3	SNMPv3 Access View Mask	459
C.1.2.14.4	SNMPv3 Access View Type	459
C.1.2.15	SNMP CPE Access Control	459
C.1.2.16	Management Event Control Encoding	460
C.1.3	Registration-Request/Response-Specific Encodings	460
C.1.3.1	Modem Capabilities Encoding	460
C.1.3.1.1	Concatenation Support	460
C.1.3.1.2	DOCSIS Version	460
C.1.3.1.3	Fragmentation Support	461
C.1.3.1.4	Payload Header Suppression Support	461
C.1.3.1.5	IGMP Support	461
C.1.3.1.6	Privacy Support	461
C.1.3.1.7	Downstream SAID Support	461
C.1.3.1.8	Upstream Service Flow Support	461
C.1.3.1.9	Optional Filtering Support	462
C.1.3.1.10	Transmit Pre-Equalizer Taps per Modulation Interval	462
C.1.3.1.11	Number of Transmit Equalizer Taps	462
C.1.3.1.12	DCC Support	462
C.1.3.1.13	IP Filters Support	463
C.1.3.1.14	LLC Filters Support	463
C.1.3.1.15	Expanded Unicast SID Space	463
C.1.3.1.16	Ranging Hold-Off Support	463
C.1.3.1.17	L2VPN Capability	464
C.1.3.1.18	L2VPN eSAFE Host Capability	464
C.1.3.1.19	Downstream Unencrypted Traffic (DUT) Filtering	464
C.1.3.1.20	Upstream Frequency Range Support	464
C.1.3.1.21	Upstream Symbol Rate Support	464
C.1.3.1.22	Selectable Active Code Mode 2 Support	465
C.1.3.1.23	Code Hopping Mode 2 Support	465
C.1.3.1.24	Multiple Transmit Channel Support	465
C.1.3.1.25	5,12 Msps Upstream Transmit Channel Support	466
C.1.3.1.26	2.56 Msps Upstream Transmit Channel Support	466
C.1.3.1.27	Total SID Cluster Support	466
C.1.3.1.28	SID Clusters per Service Flow Support	466
C.1.3.1.29	Multiple Receive Channel Support	466
C.1.3.1.30	Total Downstream Service ID (DSID) Support	467
C.1.3.1.31	Resequencing Downstream Service ID (DSID) Support	467
C.1.3.1.32	Multicast Downstream Service ID (DSID) Support	467
C.1.3.1.33	Multicast DSID Forwarding	467
C.1.3.1.34	Frame Control Type Forwarding Capability	468
C.1.3.1.35	DPV Capability	468
C.1.3.1.36	Unsolicited Grant Service/Upstream Service Flow Support	468
C.1.3.1.37	MAP and UCD Receipt Support	468
C.1.3.1.38	Upstream Drop Classifier Support	469
C.1.3.1.39	IPv6 Support	469
C.1.3.1.40	Extended Upstream Transmit Power Capability	469
C.1.3.2	Vendor ID Encoding	470
C.1.3.3	Modem IP Address	470
C.1.3.4	Service(s) Not Available Response	470
C.1.3.5	Vendor-Specific Capabilities	470
C.1.3.6	CM Initialization Reason	471
C.1.4	Dynamic-Message-Specific Encodings	471
C.1.4.1	HMAC-Digest	471
C.1.4.2	Authorization Block	472
C.1.4.3	Key Sequence Number	472
C.1.5	Registration, Dynamic Service and Dynamic Bonding Settings	472
C.1.5.1	Transmit Channel Configuration (TCC)	472