

Data-Over-Cable Service Interface Specifications Modular Headend Architecture

Downstream External PHY Interface Specification

CM-SP-DEPI-I08-100611

ISSUED

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Work in Progress	An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.
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1 SCOPE

1.1 Scope and Purpose

This specification is part of the DOCSIS® family of specifications developed by Cable Television Laboratories (CableLabs), and in particular, is part of a series of specifications that define a Modular Cable Modem Termination System (M-CMTS™) architecture for head-end components that comply with DOCSIS. This specification was developed by CableLabs for the benefit of the cable industry, and includes contributions by operators and vendors from North America, Europe, and other regions.

The DOCSIS Specifications [RFI2.0] define the requirements for the two fundamental components that comprise a high-speed data-over-cable system: the cable modem (CM) and the cable modem termination system (CMTS). The M-CMTS architecture was designed as an extension to the DOCSIS Specifications to allow for flexibility and independent scaling of certain CMTS functions, and to allow operators to more efficiently use available network resources.

One of the key elements of the M-CMTS architecture is the separation of the downstream physical layer QAM modulation and up-conversion functions from the CMTS, and the placement of that functionality into an "Edge-QAM" (EQAM) device. This separation allows for the development of EQAM products that support both video and DOCSIS, which in turn allows operators to use the same network resources to support multiple types of services such as data, voice, and video.

This document defines an interface known as the Downstream External PHY Interface (DEPI) and associated protocol requirements for the transport of downstream user data between the "M-CMTS Core" and the EQAM. It describes the characteristics of the DEPI interface, provides requirements that must be met by the M-CMTS Core and the EQAM, and also describes various aspects of technical issues that are involved in the implementation and deployment of a DOCSIS system using the M-CMTS architecture.

This specification does not address any traditional MPEG based video requirements. Those requirements are considered out of scope for this document. Any references made to video transport by the EQAM in this specification shall be considered informative.

1.2 Modular CMTS Interface Documents

A list of the documents in the Modular CMTS Interface Specifications family is provided below. For updates, please refer to <http://www.cablemodem.com/specifications/>.

Designation	Title
CM-SP-DEPI	Downstream External PHY Interface
CM-SP-DTI	DOCSIS Timing Interface
CM-SP-ERMI	Edge Resource Manager Interface
CM-SP-M-OSSI	M-CMTS Operations Support System Interface

1.3 Requirements and Conventions

In this specification the following convention applies any time a bit field is displayed in a figure. The bit field should be interpreted by reading the figure from left to right, then from top to bottom, with the MSB being the first bit so read and the LSB being the last bit so read.

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. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this specification are therefore encouraged to investigate the possibility of applying the most recent edition of the standards and other references listed below.

[DRFI]	DOCSIS Downstream Radio Frequency Interface, CM-SP-DRFI-I10-100611, June 11 2010, Cable Television Laboratories, Inc.
[DTI]	DOCSIS Timing Interface, CM-SP-DTI-I05-081209, December 9, 2008, Cable Television Laboratories, Inc.
[ERMI]	DOCSIS Edge Resource Manager Interface, CM-SP-ERMI-I03-081107, November 7, 2008, Cable Television Laboratories, Inc.
[IANA-PORTS]	IANA, Port Numbers, June 2004.
[IEEE-802.1Q]	IEEE Std 802.1Q™-2003, Virtual Bridged Local Area Networks, May 2003.
[IEEE-802.3]	IEEE Std 802.3™-2002, Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications, March 2002.
[ISO 13818]	ISO/IEC 13818-1, INFORMATION TECHNOLOGY - GENERIC CODING OF MOVING PICTURES AND ASSOCIATED AUDIO: SYSTEMS Recommendation H.222.0, February 2000.
[ITU-T J.83]	ITU-T Recommendation J.83 (4/97), Digital multi-programme systems for television sound and data services for cable distribution.
[ITU-T Y.1541]	ITU-T Recommendation Y.1541 (05/2002), Internet protocol aspects – Quality of service and network performance.
[M-OSSI]	DOCSIS M-CMTS Operations Support Interface, CM-SP-M-OSSI-I08-081209, December 9, 2008, Cable Television Laboratories, Inc.
[RFC 308]	IETF RFC 3308, Layer Two Tunneling Protocol (L2TP) Differentiated Services Extension, November 2002.
[RFC 791]	IETF RFC 791, Internet Protocol-DARPA, September 1981.
[RFC 1191]	IETF RFC 1191, MTU Path Discovery, November 1990.
[RFC 1981]	IETF RFC 1981, Path MTU Discovery for IP version 6, August 1996. ¹
[RFC 2597]	IETF RFC 2597, Assured Forwarding PHB Group, June 1999.
[RFC 2983]	IETF RFC 2983, Differentiated Services and Tunnels, October 2000.
[RFC 3246]	IETF RFC 3246, An Expedited Forwarding PHB (Per-Hop Behavior), March 2002.
[RFC 3260]	IETF RFC 3260, New Terminology and Clarifications for Diffserv, April 2002.
[RFC 3931]	IETF RFC 3931, Layer Two Tunneling Protocol - Version 3 (L2TPv3), March 2005.
[RFC 768]	IETF RFC 768, User Datagram Protocol, August 1980.
[RFI2.0]	DOCSIS Radio Frequency Interface Specification, CM-SP-RFIV2.0-C02-090422, April 22, 2009, Cable Television Laboratories, Inc.

¹ DEPI-N-06.0305-2, 11/26/06, PO.

2.2 Informative References

This document uses the following informative references:

- [IANA-L2TP] IANA, Layer Two Tunneling Protocol (L2TP) Parameters.²
- [ISO8802-2] ISO/IEC 8802-2: 1994 (IEEE Std 802.2: 1994) - Information technology – Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 2: Logical link control.
- [RFC 3140] IETF RFC 3140, Per Hop Behavior Identification Codes, June 2001.³
- [RFC 5085] IETF RFC 5085, Pseudowire Virtual Circuit Connectivity Verification (VCCV): A Control Channel for Pseudowires, T.Nadeau, C. Pignataro, December 2007.

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>
- The Institute of Electrical and Electronics Engineers, Inc, Internet: <http://standards.ieee.org>
- Internet Assigned Numbers Authority, IANA, Internet: <http://www.iana.org>
- European Telecommunications Standards Institute, ETSI, <http://www.etsi.org>
- Internet Engineering Task Force (IETF) Secretariat, 48377 Fremont Blvd., Suite 117, Fremont, California 94538, USA, Phone: +1-510-492-4080, Fax: +1-510-492-4001. <http://www.ietf.org>.
- International Telecommunication Union (ITU), Phone +41 22 730 5111 (ITU Switchboard), Fax +41 22 733 7256, <http://www.itu.int/>
- International Organization for Standardization (ISO), Tel.: +41 22 749 02 22, Fax: +41 22 749 01 55, www.standardsinfo.net

² L2TP added per DEPI-N-0307-2, 11/26/06, PO.

³ RFC3410 added per DEPI-N-0347-2, 12/3/06, PO.

3 TERMS AND DEFINITIONS

This specification uses the following terms:⁴

Bonded Channels	A logical channel comprising multiple individual channels.
Cable Modem (CM)	A modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system.
Converged Interconnect Network	The network (generally gigabit Ethernet) that connects an M-CMTS Core to an EQAM.
Customer Premises Equipment (CPE)	Equipment at the end user's premises; may be provided by the service provider.
Data Rate	Throughput, data transmitted in units of time usually in bits per second (bps).
Decibels (dB)	Ratio of two power levels expressed mathematically as $dB = 10\log_{10}(P_{OUT}/P_{IN})$.
Decibel-Millivolt (dBmV)	Unit of RF power expressed in decibels relative to 1 millivolt, where $dBmV = 20\log_{10}(\text{value in mV}/1 \text{ mV})$.
Downstream (DS)	<ol style="list-style-type: none"> 1. Transmissions from CMTS to CM. This includes transmission from the M-CMTS Core to the EQAM, as well as the RF transmissions from the EQAM to the CM. 2. RF spectrum used to transmit signals from a cable operator's headend or hub site to subscriber locations.
Edge QAM modulator (EQAM)	A head end or hub device that receives packets of digital video or data. It re-packetizes the video or data into an MPEG transport stream and digitally modulates the digital transport stream onto a downstream RF carrier using quadrature amplitude modulation (QAM).
Flow	A stream of packets in DEPI used to transport data of a certain priority from the M-CMTS Core to a particular QAM channel of the EQAM. In PSP operation, there can exist several flows per QAM channel.
Gbps	Gigabits per second
Gigahertz (GHz)	A unit of frequency; 1,000,000,000 or 10^9 Hz.
GigE (GE)	Gigabit Ethernet (1 Gbps)
Hertz (Hz)	A unit of frequency; formerly cycles per second.
Hybrid Fiber/Coax (HFC) System	A broadband bidirectional shared-media transmission system using optical fiber trunks between the head-end and the fiber nodes, and coaxial cable distribution from the fiber nodes to the customer locations.
Institute of Electrical and Electronic Engineers (IEEE)	A voluntary organization which, among other things, sponsors standards committees and is accredited by the American National Standards Institute (ANSI).
Internet Engineering Task Force (IETF)	A body responsible for, among other things, developing standards used in the Internet.
Internet Protocol (IP)	An Internet network-layer protocol
kilohertz (kHz)	Unit of frequency; 1,000 or 10^3 Hz; formerly kilocycles per second
L2SS	Layer 2 Specific Sublayer. DEPI is a L2SS of L2TPv3. ⁵

⁴ Added new term and definition per DEPI-N-05.0256-4 on 11/18/05.

⁵ L2SS def added per DEPI-N-0307-2, 11/26/06, PO.

L2TP Access Concentrator (LAC)	If an L2TP Control Connection Endpoint (LCCE) is being used to cross-connect an L2TP session directly to a data link, we refer to it as an L2TP Access Concentrator (LAC). An LCCE may act as both an L2TP Network Server (LNS) for some sessions and an LAC for others, so these terms must only be used within the context of a given set of sessions unless the LCCE is, in fact, single purpose for a given topology.
L2TP Attribute Value Pair (AVP)	The L2TP variable-length concatenation of a unique Attribute (represented by an integer), a length field, and a Value containing the actual value identified by the attribute.
L2TP Control Connection	An L2TP control connection is a reliable control channel that is used to establish, maintain, and release individual L2TP sessions, as well as the control connection itself.
L2TP Control Connection Endpoint (LCCE)	An L2TP node that exists at either end of an L2TP control connection. May also be referred to as an LAC or LNS, depending on whether tunneled frames are processed at the data link (LAC) or network layer (LNS).
L2TP Control Connection ID	The Control Connection ID field contains the identifier for the control connection, a 32-bit value. The Assigned Control Connection ID AVP, Attribute Type 61, contains the ID being assigned to this control connection by the sender. The Control Connection ID specified in the AVP must be included in the Control Connection ID field of all control packets sent to the peer for the lifetime of the control connection. Because a Control Connection ID value of 0 is used in this special manner, the zero value must not be sent as an Assigned Control Connection ID value.
L2TP Control Message	An L2TP message used by the control connection.
L2TP Data Message	L2TP message used by the data channel
L2TP Endpoint	A node that acts as one side of an L2TP tunnel
L2TP Network Server (LNS)	If a given L2TP session is terminated at the L2TP node and the encapsulated network layer (L3) packet processed on a virtual interface, we refer to this L2TP node as an L2TP Network Server (LNS). A given LCCE may act as both an LNS for some sessions and an LAC for others, so these terms must only be used within the context of a given set of sessions unless the LCCE is in fact single purpose for a given topology.
L2TP Pseudowire (PW)	An emulated circuit as it traverses a packet-switched network. There is one Pseudowire per L2TP Session.
L2TP Pseudowire Type	The payload type being carried within an L2TP session. Examples include PPP, Ethernet, and Frame Relay.
L2TP Session	An L2TP session is the entity that is created between two LCCEs in order to exchange parameters for and maintain an emulated L2 connection. Multiple sessions may be associated with a single Control Connection.
L2TP Session ID	A 32-bit field containing a non-zero identifier for a session. L2TP sessions are named by identifiers that have local significance only. That is, the same logical session will be given different Session IDs by each end of the control connection for the life of the session. When the L2TP control connection is used for session establishment, session IDs are selected and exchanged as Local Session ID AVPs during the creation of a session. The Session ID alone provides the necessary context for all further packet processing, including the presence, size, and value of the Cookie, the type of L2-Specific Sublayer, and the type of payload being tunneled.
MAC Domain	A grouping of layer 2 devices that can communicate with each other without using bridging or routing. In DOCSIS is the group of CMs that are using upstream and downstream channels linked together through a MAC forwarding entity.

Maximum Transmission Unit (MTU)	The layer 3 payload of a layer 2 frame.
Mbps	Megabits per second
Media Access Control (MAC)	Used to refer to the layer 2 element of the system which would include DOCSIS framing and signaling.
Megahertz (MHz)	A unit of frequency; 1,000,000 or 10^6 Hz; formerly megacycles per second
Microsecond (μs)	10^{-6} second
Millisecond (ms)	10^{-3} second
Modulation Error Ratio (MER)	The ratio of the average symbol power to average error power
Multiple System Operator (MSO)	A corporate entity that owns and/or operates more than one cable system.
Nanosecond (ns)	10^{-9} second
Physical Media Dependent (PMD) Sublayer	A sublayer of the Physical layer which is concerned with transmitting bits or groups of bits over particular types of transmission link between open systems and which entails electrical, mechanical, and handshaking procedures.
QAM channel (QAM ch)	Analog RF channel that uses quadrature amplitude modulation (QAM) to convey information
Quadrature Amplitude Modulation (QAM)	A modulation technique in which an analog signal's amplitude and phase vary to convey information, such as digital data.
Radio Frequency (RF)	In cable television systems, this refers to electromagnetic signals in the range 5 to 1000 MHz.
Radio Frequency Interface (RFI)	Term encompassing the downstream and the upstream radio frequency interfaces.
Request For Comments (RFC)	A technical policy document of the IETF; these documents can be accessed on the World Wide Web at http://www.rfc-editor.org/ .
Session	An L2TP data plane connection from the M-CMTS Core to the QAM channel. There must be one session per QAM Channel. There is one DEPI pseudowire type per session. There may be one MPT flow or one or more PSP flows per session. Multiple sessions may be bound to a single control connection.
StopCCN	L2TPv3 Stop-Control-Connection-Notification message
Upconverter	A device used to change the frequency range of an analog signal, usually converting from a local oscillator frequency to an RF transmission frequency.
Upstream (US)	<ol style="list-style-type: none"> 1. Transmissions from CM to CMTS. This includes transmission from the EQAM to M-CMTS Core as well as the RF transmissions from the CM to the EQAM. 2. RF spectrum used to transmit signals from a subscriber location to a cable operator's headend or hub site.
Upstream Channel Descriptor (UCD)	The MAC Management Message used to communicate the characteristics of the upstream physical layer to the cable modems.
Video on Demand (VoD) System	System that enables individuals to select and watch video content over a network through an interactive television system.

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations:⁶

ACK	L2TPv3 Explicit Acknowledgement message
AVP	L2TPv3 Attribute Value Pair
CDN	L2TPv3 Call-Disconnect-Notify message
CIN	Converged Interconnect Network
CLI	Command Line Interface
CM	Cable Modem
CMCI	Cable Modem CPE Interface
CMTS	Cable Modem Termination System
CPE	Customer Premises Equipment
CRC	Cyclic Redundancy Check
CRC16	CRC of length 16
CSMA	Carrier Sense Multiple Access
dB	Decibels
dBmV	Decibel-Millivolt
DEPI	Downstream External-PHY Interface
DOCSIS	Data-Over-Cable Service Interface Specifications
DOCSIS-MPT (D-MPT)	DOCSIS MPT Mode
DRFI	Downstream Radio Frequency Interface
DS	Downstream
DSCP	Differentiated Services Code Point
DTI	DOCSIS Timing Interface
DTS	DOCSIS Time Stamp, 32-bit
EQAM	Edge QAM
ERM	Edge Resource Manager
ERMI	Edge Resource Manager Interface
ETSI	European Telecommunications Standards Institute
FQDN	Fully Qualified Domain Name
Gbps	Gigabits per second
GHz	Gigahertz
GE	Gigabit Ethernet (Gig E)
Hz	Hertz
HELLO	L2TPv3 Hello message
HFC	Hybrid Fiber/Coax
ICCN	L2TPv3 Incoming-Call-Connected message
ICRP	L2TPv3 Incoming-Call-Reply message

⁶ Added new abbreviation per DEPI-N-05.0256-4 on 11/18/05; deleted abbreviation per DEPI-N-05.0257-2 on 11/21/05.

ICRQ	L2TPv3 Incoming-Call-Request message
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv4	Internet Protocol version 4
ISO	International Standards Organization
ITU	International Telecommunications Union
ITU-T	Telecommunication Standardization Sector of the International Telecommunication Union
kbps	Kilobits per second
kHz	Kilohertz
L2TP	Layer 2 Transport Protocol
L2TPv3	Layer 2 Transport Protocol – version 3
L3	Layer 3
LAC	L2TP Access Concentrator
LCCE	L2TP Control Connection Endpoint
LNS	L2TP Network Server
LSB	Least Significant Bit
MAC	Media Access Control
Mbps	Megabits per second
M-CMTS	Modular Cable Modem Termination System
MER	Modulation Error Ratio
MHz	Megahertz
MIB	Management Information Base
M/N	Relationship of integer numbers M,N that represents the ratio of the downstream symbol clock rate to the DOCSIS master clock rate
MPEG	Moving Picture Experts Group
MPEG-TS	Moving Picture Experts Group Transport Stream
MPT	MPEG-TS mode of DEPI
MPTS	Multi Program Transport Stream
ms	Millisecond
MSO	Multiple System Operator
MSB	Most Significant Bit
MTU	Maximum Transmission Unit
ns	Nanosecond
OSSI	Operations System Support Interface
PCR	Program Clock Reference. A time stamp in the Video Transport Stream from which decoder timing is derived.
PHY	Physical Layer
PID	Packet Identifier; PID (system): A unique integer value used to identify elementary streams of a program in a single or multi-program Transport Stream as described in 2.4.3 of ITU-T Rec. H.222.0 [ISO 13818]
PMD	Physical Media Dependent Sublayer

PPP	Point-to-Point Protocol
PSI	Program Specific Information
PSP	Packet-Streaming-Protocol
PW	Pseudowire
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
RFI	Radio Frequency Interface
RFC	Request For Comments
SCCRN	L2TPv3 Start-Control-Connection-Connected message
SCCRP	L2TPv3 Start-Control-Connection-Reply message
SCCRQ	L2TPv3 Start-Control-Connection-Request message
S-CDMA	Synchronous Code Division Multiple Access
SLI	L2TPv3 Set Link Info message
SPTS	Single Program Transport Stream
StopCCN	L2TPv3 Stop-Control-Connection-Notification message
TSID	MPEG2 Transport Stream ID
UCD	Upstream Channel Descriptor
UDP	User Datagram Protocol
US	Upstream
VOD	Video On Demand

5 TECHNICAL OVERVIEW

This section is informative.

5.1 System Architecture

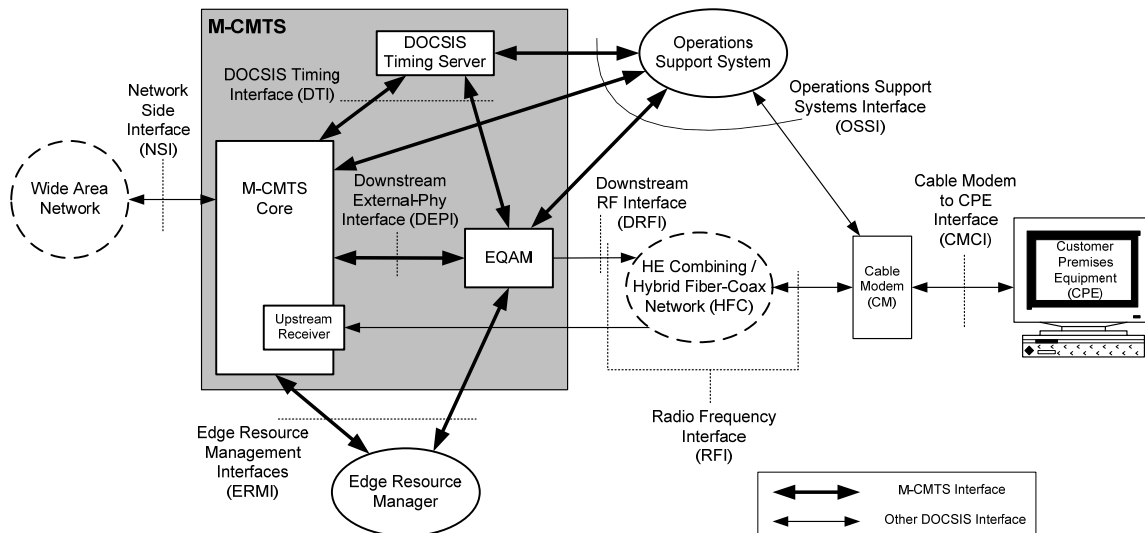


Figure 5-1 - Modular CMTS Reference Architecture

In the M-CMTS architecture, a device referred to as the M-CMTS Core contains the DOCSIS MAC. This includes all signaling functions, downstream bandwidth scheduling, and DOCSIS framing. The EQAM box contains mainly PHY related circuitry, such as QAM modulators, and tunneling logic, to connect to the M-CMTS Core.

5.1.1 Reference Architecture

The reference architecture for a Modular CMTS system is shown in Figure 5-1. This architecture contains several pieces of equipment along with interfaces between those pieces of equipment. This section will briefly introduce each device and interface.

The Edge QAM device, or EQAM for short, has its origins in the VOD environment. It is a chassis that typically has one or more gigabit Ethernet coming in and multiple QAM modulators and RF upconverters on the output. This EQAM is being adapted for use in a Modular CMTS environment. The individual outputs of these devices are often referenced to as QAM Channel rather than the full "QAM Modulator and RF Upconverter".

The M-CMTS Core contains everything a traditional CMTS does, except for functions performed in the EQAM. The M-CMTS Core contains the downstream MAC and all the initialization and operational DOCSIS related software.

This diagram currently shows the Upstream Receivers of DOCSIS upstreams located internally to the M-CMTS Core. However, there is nothing preventing an implementation of a Modular CMTS from using external upstream receivers. In the future, upstream receivers may be external to the M-CMTS Core.

The DOCSIS Timing Interface (DTI) Server provides a common frequency of 10.24 MHz and a DOCSIS timestamp to other M-CMTS elements

DEPI, the Downstream External PHY Interface, is the interface between the M-CMTS Core and the EQAM. More specifically, it is an IP Tunnel between the MAC and PHY in a Modular CMTS system which contains both a data path for DOCSIS frames, and a control path for setting up, maintaining, and tearing down sessions.

DRFI, or Downstream Radio Frequency Interface, is intended to capture all the current and future RF requirements for the downstream direction for both integrated DOCSIS CMTS systems, Modular DOCSIS CMTS systems, and VOD EQAM systems.

DTI, or DOCSIS Timing Interface, is a point-to-point interface from the DTI Server to other M-CMTS elements. The DTI Specification [DTI] defines DTI Server and DTI Client behaviors and protocols. The DTI Server is the Timing Signal Generator while each M-CMTS Core and EQAM has a DTI Client. The DTI Server distributes a 10.24 MHz frequency and a DOCSIS timestamp over unshielded twisted pair (UTP). The DTI protocol automatically compensates for cable length and ensures that all M-CMTS elements have the same sense of time and frequency.

ERMI, or Edge Resource Manager Interface [ERMI], involves three interfaces: a registration interface between an EQAM and ERM (Edge Resource Manager), a control interface between an EQAM and an ERM, and a control interface between an M-CMTS Core and an ERM. The first interface is used to register and unregister EQAM resources (i.e., QAM channels) with an ERM. The second interface is used by an ERM to request QAM channel resources from an EQAM, and by an EQAM to deliver resources to an ERM. The third interface is used by the M-CMTS Core to request specific QAM channel resources from the ERM, and by the ERM to respond to such requests with the location of QAM channel resources.

MOSSI, or Modular CMTS Operations Support System Interface [M-OSSI], provides the management interface to each system component. This interface is an extension of the OSSI defined in the DOCSIS specifications for monitoring a management of CMTS functions. This interface could be used, in place of an ERM and the ERMI, to statically configure and associate QAM channel resources with M-CMTS Cores. This interface allows for the modification of a QAM channel's physical layer parameter by either the M-CMTS Core or the EQAM, and provides a mechanism by which the operator can "lock" certain parameters at the EQAM so that they can only be modified there. This document defines the mechanism to communicate these parameter settings to the other side.

NSI, or the Network Side Interface, is unchanged, and is the physical interface the CMTS uses to connect to the backbone network. Today, this is typically 100 Mbps or 1 Gbps Ethernet.

CMCI, or Cable Modem to Customer Premise Equipment Interface, is also unchanged, and is typically 10/100 Mbps Ethernet or USB.

5.1.2 DEPI Operation

DEPI is an IP Tunnel that exists between the DOCSIS MAC in the M-CMTS Core and the DOCSIS PHY that exists in the EQAM. DEPI's job is to take either formatted DOCSIS frames or MPEG packets and transport them through a layer 2 or layer 3 network and deliver them to the EQAM for transmission.

The base protocol that is used for the DEPI is the Layer 2 Tunneling Protocol Version 3, or L2TPv3 for short [RFC 3931]. L2TPv3 is an IETF protocol that is a generic protocol for creating a pseudowire. A pseudowire is a mechanism to transparently transport a layer 2 protocol over a layer 3 network. Examples of protocols supported by L2TPv3 include ATM, HDLC, Ethernet, Frame Relay, PPP, etc.

Section 8.1 "L2TPv3 Transport Packet Format" shows the format of an L2TPv3 data packet. Each data packet contains a 32-bit session ID which is associated with a single QAM Channel. The UDP header is optional in the L2TPv3 protocol.⁷

L2TPv3 then permits a sub-header to exist whose definition is specific to the payload being carried. The control channel allows for signaling messages to be sent between the M-CMTS Core and EQAM. Typical control messages will set up a "control connection" between the M-CMTS Core and EQAM, and then set up multiple data sessions (one for each downstream QAM channel). Each session can be marked with different DiffServ Code Points (DSCPs) and support different encapsulation protocols.

There are two basic tunneling techniques defined by DEPI. The first technique, known as D-MPT mode, transports multiple 188-byte MPEG-TS packets by placing them into the L2TPv3 payload with a unique sub-header which contains a sequence number so packet drops can be detected. The encapsulation of DOCSIS Frames into MPEG-TS packets is performed in the M-CMTS Core. The second technique, known as the Packet Streaming Protocol (PSP),

⁷ Revised this paragraph per DEPI-N-05.0243-1 on 10/27/05; last 2 sentences deleted per DEPI-N-06.0311-2, 11/26/06, PO.

transports DOCSIS Frames in the L2TPv3 payload. The DOCSIS Frames are then encapsulated in MPEG-TS packets within the EQAM. PSP mode allows DOCSIS frames to be both concatenated, to increase network performance, and fragmented, in case the tunneled packets exceed the network MTU size.

One of the technical considerations of the Modular CMTS architecture is its impact on the round trip request-grant delay time. The request-grant delay time is the time from when a CM requests bandwidth using an uncontended bandwidth request (REQ) to when it receives a MAP message with the granted transmit opportunity in it.

To prevent the MAP from being slowed down by other traffic in the CIN, the DOCSIS traffic (or a subset containing the MAP messages) may be sent in an independent L2TPv3 flow that has a unique DSCP. The value of the marked DSCP value should be consistent with a configured "per hop behavior (PHB)" that will provide MAP messages with the highest priority and lowest latency across the CIN to the EQAM.⁸

5.1.3 EQAM Operation

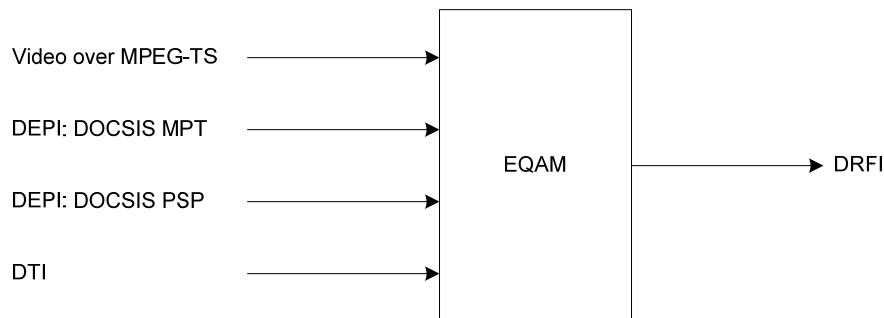


Figure 5-2 - EQAM Block Diagram

Figure 5-2 shows a high level block diagram of an EQAM that is capable of handling either Video MPEG traffic or DOCSIS traffic. The expression "D-MPT" is an acronym for DOCSIS MPEG Transport.

The first interface that is shown is the VOD transport. VOD SPTS or MPTS streams are received with a format of MPEG packets over UDP/IP. The video processing functions generally include de-jittering, re-multiplexing PID remapping, MPEG-2 PSI insertion, and PCR timestamp correction. These functions are not defined in this specification.

The next set of interfaces are the DEPI interfaces.

The first interface defined is D-MPT. This is a mode where the EQAM must search the incoming D-MPT frames for DOCSIS SYNC messages and correct the timestamp value in these messages based upon the EQAM's internal DOCSIS timestamp, which has been derived from DTI. The resulting D-MPT frames are then copied to the QAM channel without further interpretation or modification. This mode is intended for DOCSIS frames where the MAP is embedded into the stream and network latency or jitter is not a concern.

Because D-MPT mode encapsulates all DOCSIS traffic into a single DEPI flow, it does not allow for QoS differentiation among various types of traffic either across the CIN or within the EQAM. For example, acceleration of MAPs relative to other DOCSIS data is not possible when D-MPT mode is used. This may still give acceptable performance when the delay and jitter introduced onto DEPI packets by the CIN and EQAM are determined by the operator to be sufficiently low.

Certain network conditions and/or architectures may reduce network delay and/or jitter and make it more likely that DOCSIS MPT mode will give acceptable system performance. Some examples are:

- networks with a very small number of hops (e.g., 1 or 2 hops)⁹

⁸ Revised this section per DEPI-N-06.0300-2 11/22/06, PO.

⁹ DEPI-N-06.0300-2 11/22/06, PO.

- networks which are largely shared with video traffic from VOD servers to EQAMs, on which most of the traffic is video and it is acceptable to prioritize all DEPI traffic on the network above all VOD traffic
- networks which are lightly loaded so that delays due to congestion are highly unlikely

Such conditions may exist on today's CINs. They may be less likely to occur as deployments become denser and total IP traffic increases. Evaluation of network conditions and decisions about acceptable performance levels with DOCSIS MPT mode are in the realm of operator discretion.

The next interface is DOCSIS PSP. This interface transports DOCSIS Data and MAPs in separate flows which are streamed together in a uniform byte stream by the M-CMTS Core. The PSP re-assembly engine removes this overhead and recovers the DOCSIS Frames. The PSP scheduler then allows MAPs to be placed in order, ahead of data and SYNC messages. In PSP mode, the EQAM generates all SYNC messages as detailed in Section 6.1.1. The output is then delivered to a transmission convergence layer which converts the results to a DOCSIS MPEG stream.

The last interface is the DTI interface which provides a common frequency and DOCSIS timestamp. The reference is used to synchronize the downstream symbol rate and DOCSIS timestamp for use with DOCSIS cable modems. The timestamp is used for the DOCSIS SYNC correction.

The output from the EQAM consists of a stream of MPEG frames which carry video and/or DOCSIS data, and are modulated onto an RF carrier in accordance with the DRFI specification [DRFI].

5.2 Bonding Services Model

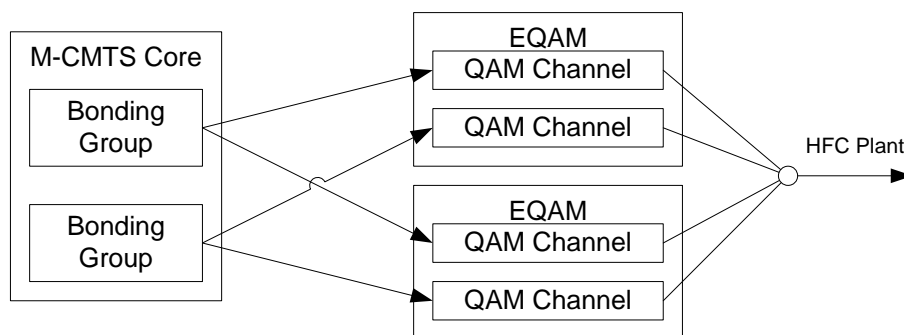


Figure 5-3 - Bonding Services Model

Downstream Channel Bonding refers to the forwarding of a stream of DOCSIS frames across multiple QAM carriers.

In the Modular CMTS architecture, the Downstream Channel Bonding is implemented in the M-CMTS Core. At the M-CMTS Core, packets from the IP backbone are placed in a DOCSIS frame. That DOCSIS frame is then sent to one of several QAM channels in a Bonding Group. The frame may be transported using D-MPT or PSP.

In this system, the EQAM is unaware that it is doing bonding. It is also unaware of any of the details of the Bonding protocol.

5.3 Multiple Services Model

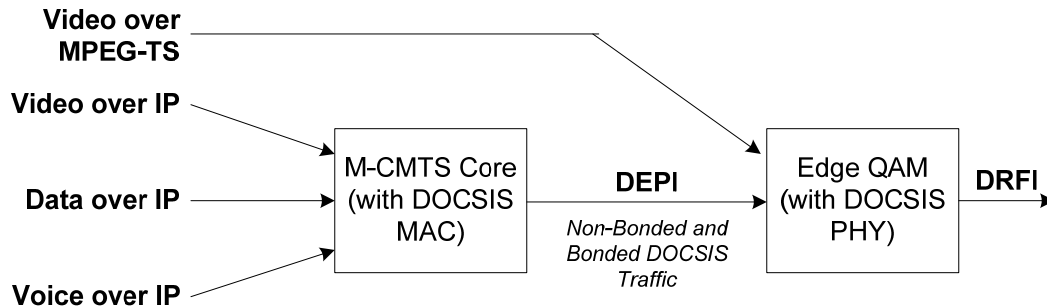


Figure 5-4 - Multi-Service Mode

The Modular CMTS (M-CMTS) architecture reflects an effort to merge the video-on-demand (VOD) and high-speed-data (HSD) applications. This effort is made in anticipation of achieving higher efficiencies than are possible with two separate transmission networks feeding into the cable plant. In particular, the M-CMTS effort has repartitioned the traditional CMTS architecture so that the transmission technology which is common to both the VOD environment and the HSD environment will be able to share the same EQAM devices.

In a video delivery system, the EQAM is used to deliver video streams in MPEG-TS format to set top boxes at the subscribers' premises. This functionality will continue to be used in the future and operates independently of other processing which is described here. The M-CMTS architecture adds new interfaces which are unique to HSD service. These interfaces support both traditional DOCSIS and multi-channel (bonded) DOCSIS payloads as received from the M-CMTS Core device.

The M-CMTS Core provides the gateway functionality between the IP-based core network and the CIN. As such, the M-CMTS Core provides support for a multitude of services – including, but not limited to video over IP, voice-over-IP (VoIP), email, gaming, video telephony, etc.

6 DEPI ARCHITECTURE

This section is normative.

6.1 DEPI Data Path¹⁰

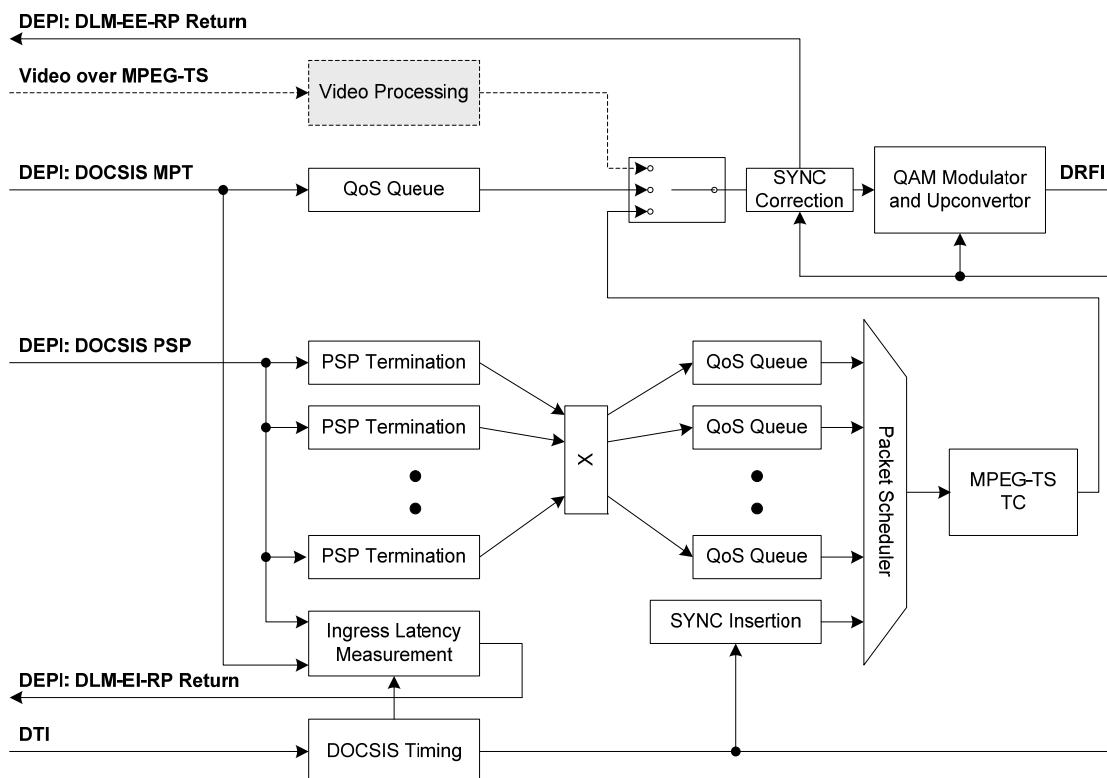


Figure 6-1 - Downstream EQAM Block Diagram

A simplified logical block diagram of the internal data path of the EQAM is shown in Figure 6-1.

It is recognized, but not specified by this document, that the EQAM may receive non-DOCSIS MPEG elementary streams which have been encapsulated in MPEG packets and placed in a UDP datagram. This specification does not define requirements for transport of this type of traditional MPEG video. However, it is recognized that M-CMTS EQAM implementations may (and likely will) be capable of transporting traditional MPEG video (either interleaved with DOCSIS traffic on a single QAM channel, or on separate QAM channels within the same EQAM chassis).

The M-CMTS Core MUST support PSP mode, D-MPT mode, or both. The EQAM MUST support PSP mode, D-MPT mode, or both.

Within a session, the M-CMTS Core MUST support either one priority level of D-MPT or at least two priority levels of PSP, where each priority level would have a different DSCP. The M-CMTS Core MUST provide a mechanism to map DOCSIS traffic to the multiple priority levels of PSP. The M-CMTS Core MUST NOT attempt to establish a session which includes both PSP and D-MPT flows.

Within a session, the EQAM MUST support either one priority level of D-MPT or at least two priority levels of PSP, where each priority level would have a different DSCP. The EQAM is not intended to simultaneously support D-MPT and PSP within a single session, and MUST reject any attempt to establish such a session. Each priority

¹⁰ Revised the title of this section per DEPI-N-05.0259-3 on 11/11/05.

level for each DEPI type, maps to one or more DEPI flows. The EQAM MUST support the establishment of a single DEPI flow per priority level. The EQAM MAY support the establishment of more than one DEPI flow per priority level. The mapping of individual flows to priority levels (QoS Queues) is vendor-specific (see Figure 7–3). The mapping of flows will be done through the local EQAM Command Line Interface (CLI) configuration.

For both D-MPT and PSP modes, the EQAM MUST insert null MPEG packets when it has no data to send. The EQAM SHOULD NOT insert a null MPEG packet if it has data to send. Note that MPEG null insertion should take place prior to the correction of the DOCSIS SYNC message (refer to Section 6.1.1).

6.1.1 DOCSIS D-MPT Data Path

The DEPI DOCSIS D-MPT flows contain DOCSIS frames using the format as described in Section 8.2. All DOCSIS frames, including packet based frames and MAC management based frames, are included within the one D-MPT flow. The EQAM searches the D-MPT payload for any DOCSIS SYNC messages and performs SYNC corrections as described in Section 6.1.3.2. It then forwards the D-MPT packet to the RF interface.

The intent of D-MPT mode is that MPEG packets can be received by the EQAM and forwarded directly to the RF interface without having to terminate and regenerate the MPEG framing. The only manipulation of the D-MPT payload is the SYNC correction.

6.1.2 PSP Data Path

The Packet Stream Protocol (PSP) is a layer-3 convergence layer protocol, which allows packets to be consecutively streamed together and fragmented at arbitrary boundaries. The intent of the PSP mode is to facilitate Quality of Service. This mode is to be used for transporting traditional DOCSIS data and signaling messages which use one or more DSCP values. For example, in order to reduce Request-Grant latency, MAP MAC management messages may be sent using a different DSCP on a different PSP flow than the rest of the DOCSIS channel. Refer to Section 6.2.1 for more information. The EQAM MUST support a minimum of two PSP receivers per QAM modulator. The intent of two receivers is to permit the implementation of a higher latency PSP flow and a lower latency PSP flow.

Each PSP flow is terminated, and the DOCSIS Frames within the flow are extracted. The DOCSIS frames are placed into corresponding output QoS queues. The output of the QoS queues go to a Packet Scheduler, which decides which queue is to be serviced based upon the PHB (negotiated between the M-CMTS Core and EQAM) of the PSP flow, which carried the DOCSIS frames. The Packet Scheduler is also responsible for inserting DOCSIS SYNC messages within the time interval specified by the DOCSIS SYNC Control AVP (see Figure 7–31). The Packet Scheduler SHOULD support a strict priority scheduler. The Packet Scheduler MAY support other queue scheduling disciplines.

The phrase "packet scheduler" is a general term that describes a method of applying priorities to different queues as packets are moved from different input queues to the output queue. An example of a typical Packet Scheduling algorithm would be Weighted Fair Queuing (WFQ) where some streams are given priority over other streams, but only up to some limit. This should not be confused with the more complex DOCSIS upstream scheduler, which deals with requests and grants.

The output of the Packet Scheduler goes to a Transmission Convergence engine which places the DOCSIS frames into MPEG packets according to the requirements in [DRFI]. This includes the insertion of stuffing bytes and the DOCSIS SYNC message as described by Section 6.1.3. The output of Transmission Convergence (TC) engine is sent to the RF Interface.

PSP mode primarily provides acceleration of MAPs through the network, in an attempt to reduce Request Grant latency. The PSP mode is most useful when all or most traffic has migrated to DOCSIS, and therefore, marking MAPs with higher QoS, when compared to other DOCSIS traffic that is needed in order to provide lower latency for MAPs, when traversing a fully subscribed network. Therefore, PSP has value in the long term and is included to address the case where most or all traffic is carried to the home via DOCSIS.

6.1.3 DOCSIS SYNC Message¹¹

6.1.3.1 SYNC Message Format¹²

The DOCSIS Time Synchronization (SYNC) MAC message is transmitted by a Modular CMTS system at a periodic interval to establish MAC sublayer timing in cable modems. This message **MUST** use an FC field with FC_TYPE = MAC Specific Header and FC_PARM = Timing MAC Header. This **MUST** be followed by a Packet PDU in the format shown in Figure 6–2.

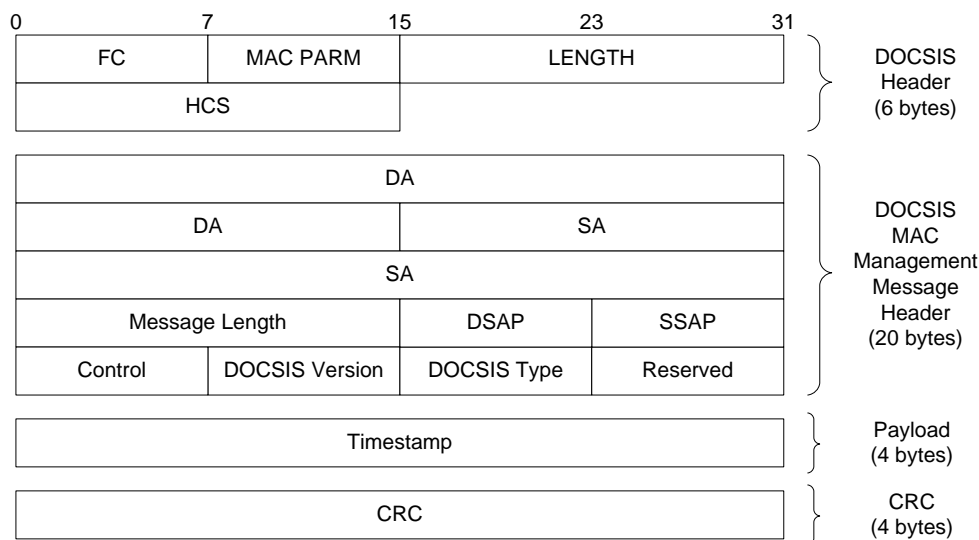


Figure 6–2 - Format of a DOCSIS SYNC MAC Message

The fields **MUST** be as defined below:

FC, MAC PARM, LEN, HCS: Common MAC frame header with FC_PARM field to indicate a timing header – refer to [RFI2.0] for details.¹³

Destination Address (DA): Set to the DOCSIS MAC multicast address of 01-E0-2F-00-00-01.

Source Address (SA): The MAC address of the M-CMTS Core. In PSP Mode, the EQAM learns the appropriate M-CMTS Core MAC address via explicit signaling during L2TPv3 session setup.

Msg Length: Length of the MAC message from DSAP to the end of the payload.

DSAP: The LLC null destination SAP (00) as defined by [ISO8802-2].

SSAP: The LLC null source SAP (00) as defined by [ISO8802-2].

Control: Unnumbered information frame (03) as defined by [ISO8802-2].

DOCSIS Version: Set to 1.

DOCSIS Type: Set to 1 to indicate a SYNC message.

CMTS Timestamp: The count state of an incrementing 32-bit binary counter clocked with the 10.24 MHz master clock derived from [DTI].

The CMTS timestamp represents the count state at the instant that the first byte (or a fixed time offset from the first byte) of the Time Synchronization MAC Management Message is transferred from the Downstream Transmission Convergence Sublayer, to the Downstream Physical Media Dependent Sublayer, as described in [DRFI].

¹¹ Removed Timestamp Jitter from spec per DEPI-N-06.0332-1 by GO on 1/15/07.

¹² Revised this section title per DEPI-N-05.0259-3 on 11/11/05.

¹³ Revised this statement per DEPI-N-05.0246-3 on 10/28/05.

6.1.3.2 Correction and Insertion¹⁴

The EQAM MUST derive a local DOCSIS timestamp from the DTI Client, specified in [DTI]. In the D-MPT mode, the EQAM must be capable of correcting all embedded SYNC messages in the DOCSIS stream. For the DOCSIS PSP mode, the EQAM MUST be capable of inserting DOCSIS SYNC messages based upon its internal timestamp into the downstream MPEG-TS stream. In PSP Mode, the EQAM MUST insert the SYNC message starting at the 6th byte of the MPEG-TS frame (the fifth byte would be the MPEG pointer_field). When referencing a timebase to use for SYNC timestamp insertion or correction, the EQAM MUST utilize a timebase that is delayed by no less than 0 and no more than 100 clock cycles (approximately 10 μ s) of the master clock (10.24 MHz) compared to the time communicated via the DTI Client Test Port output.

This time difference between the time communicated via the DTI Client Test Port output and the time reference applied by an EQAM is expected to be essentially constant. All timing and jitter requirements that exist in this specification and [DRFI] still apply. The requirements here do not preclude an EQAM from taking longer than 100 clock cycles to process the DTI conveyed time, but in that case, the EQAM would need to internally adjust the applied timebase such that it is delayed between zero and 100 clock cycles from the DTI conveyed timebase.

When using the D-MPT mode, the M-CMTS Core MUST generate SYNC messages and include them in the D-MPT payload. The M-CMTS Core MUST insert the SYNC message starting at the 6th byte of the MPEG-TS frame (the fifth byte would be the MPEG pointer_field). This is intended to simplify the EQAM implementation by allowing the EQAM to check only the payload_unit_start_indicator bit and the fifth and sixth byte (which together will contain 0x00C0) of the MPEG-TS packet to locate a DOCSIS SYNC message. Note that the CMTS Timestamp in the SYNC messages generated by the M-CMTS core is not required to accurately reflect the current timestamp received via a DTI Client in the M-CMTS Core. For example, it is permissible for the M-CMTS Core to use a value of zero for the CMTS Timestamp in all SYNC messages. When using the DOCSIS PSP mode, the M-CMTS Core MUST NOT generate SYNC messages as part of the PSP payload.

6.1.4 Latency and Skew Requirements

6.1.4.1 Latency

For PSP DEPI sessions, latency is defined as the absolute difference in time from when the last bit of a DEPI packet containing the last bit of a single DOCSIS MAC frame enters the EQAM DEPI port to the time that the first bit of the DOCSIS MAC frame exits the EQAM RFI port. For D-MPT DEPI sessions, latency is defined as the absolute difference in time from when the last bit of a DEPI packet enters the EQAM DEPI port to the time that the first bit of the first MPEG packet contained within said DEPI packet exits the EQAM RFI port. At the EQAM input, the last bit of the arriving DEPI packet is used because the EQAM's layer 2 interface (e.g., GigE Ethernet port) must receive the entire packet before the EQAM can begin processing. At the EQAM output, the first bit of the first MPEG packet (in D-MPT mode) or DOCSIS frame (in PSP mode) inside the DEPI packet is used to guarantee that the data complies with the definition of "isolated packets" (see next paragraph). If this were not done, the measurement could be corrupted by delays incurred due to queuing of data behind other packets destined for the same RF interface. The EQAM SHOULD allow enough buffer memory per QAM channel to buffer at least 20 ms worth of traffic across all L2TPv3 sessions destined for that QAM channel.

In PSP DEPI sessions, the multiple flows supported in the EQAM provide for prioritized access to the modulator. In the absence of higher priority traffic, and regardless of load of lower priority traffic, the EQAM MUST forward isolated packets in each DEPI flow with a latency of less than 500us plus the delay of the interleaver. Isolated packets are spaced such that, at the nominal downstream data rate, the EQAM would complete transmission of the current packet before the arrival of the next packet.

6.1.4.2 Skew

Skew is defined as the difference between the maximum latency and the minimum latency through the EQAM, as measured from two reference bits on the network interface to the same bits on two separate RF outputs. Skew is to be measured with the PHY parameters set equal on the QAM Channels under measurement.

¹⁴ Revised this section per DEPI-N-05.0258-1 on 11/10/05.

The skew between any two bonded QAM Channels within an EQAM MUST be less than 500 usec. The skew requirements for the EQAM are implicitly met when the EQAM meets the latency requirements set out above in Section 6.1.4.1. This requirement is intended for the transmission of skew sensitive traffic such as bonded traffic.

6.2 Networking Considerations

6.2.1 Per Hop Behavior Usage

The IETF has defined a number of Per Hop Behaviors (PHBs) to be used for offering network-based QoS.

DEPI supports use of the 6-bit Expedited Forwarding (EF) PHB as described in [RFC 3246], Assured Forwarding (AF) PHBs as described in [RFC 2597], and best effort forwarding as described in [RFC 2597]. DEPI negotiates six-bit Per-Hop Behavior Identifiers (PHBIDs) between the M-CMTS Core and the EQAM. Note: the term PHBID, as defined in this specification, while consistent with the purpose of PHBIDs defined in [RFC 3140], does not conform to the format of PHBIDs defined in [RFC 3140]. The term "PHBID" in this specification is equivalent to the term "recommended DSCP value" in [RFC 3140]. The M-CMTS Core MUST support the Expedited Forwarding PHBID for PSP mode. The M-CMTS Core MUST support the best effort PHBID for both DEPI modes. The EQAM MUST support the EF PHBID for PSP mode. The EQAM MUST support the best effort PHBID for both DEPI modes. NOTE: This specification does not preclude support for other PHBs not defined in Error! Not a valid bookmark self-reference..

Table 6–1 lists the PHBs explicitly supported by the DEPI specification.

NOTE: This specification does not preclude support for other PHBs not defined in Error! Not a valid bookmark self-reference..¹⁵

Table 6–1 - PHBs and recommended DSCP values

PHB	PHB ID(s) and recommended DSCP value(s)
EF	46
AF (multiple levels)	10, 12, 14, 18, 20, 22, 26, 28, 30, 34, 36, 38
Best effort	0

The DEPI interface supports multiple traffic types including DOCSIS MAC and DOCSIS data traffic. Within both traffic types, there may be different levels of priority. For PSP operation, the M-CMTS Core SHOULD provide a mechanism to map traffic of different priorities to DEPI flows with different PHB values. The M-CMTS Core SHOULD NOT use the same PHB across multiple DEPI flows within a session.

The CIN should provide the appropriate Per Hop Behavior for the differentiated traffic types. The level of granularity provided for differentiated traffic is determined by the network operator, but at a minimum, it would be expected that DOCSIS MAP messages and VoIP data traffic are prioritized over best effort data traffic.

The EQAM uses the PHB signaled in the establishment of the DEPI flow when scheduling multiple DEPI PSP flows onto one QAM Channel as described in Section 6.1.2.

6.2.2 DiffServ Code Point Usage

Differentiated Services (DiffServ) is a mechanism for tagging IP packets with defined PHBs. DiffServ uses the first 6 bits of the ToS Byte in DiffServ Field of the IP Header. The PHB values encoded into the DiffServ Field are referred to as DiffServ Code Points (DSCPs). The DSCP of the L2TPv3 packet SHOULD be assigned at the egress of the M-CMTS Core to provide Quality of Service for DEPI traffic within the CIN. The M-CMTS Core SHOULD use the DSCP values corresponding to the PHBs identified in NOTE: This specification does not preclude support for other PHBs not defined in Error! Not a valid bookmark self-reference..

Table 6–1. The DSCP MAY be used at the ingress of the EQAM. ¹⁶

The M-CMTS Core MUST tag all packets within a DEPI flow of an L2TPv3 session with the same DSCP.

¹⁵This paragraph modified, and following table added per DEPI-N-0300-2, 11/22/06 PO.

¹⁶ This paragraph modified per DEPI-N-06.0300-2, 11/22/06 PO.

DOCSIS frames encapsulated in L2TPv3 packets may contain IP packets which also have a DSCP assigned. The EQAM is not required to schedule packets based upon the original DSCP contained within the DOCSIS frame.

6.2.3 Packet Sequencing

For a stream of packets transmitted on a DEPI flow, the packet sequence number will be incremented by one for each packet sent, as described in Sections 8.2 and 8.3. If the EQAM detects a discontinuity in the packet sequence numbers indicating that one or more packets were dropped or delayed, an error is logged and the EQAM **SHOULD** transfer the current packet to the QAM Channel without waiting for the missing packets. If the EQAM detects a discontinuity in the packet sequence numbers indicating that one or more packets have arrived late, then those packets **SHOULD** be discarded. The EQAM **MUST NOT** forward packets which were skipped due to a discontinuity in the sequence numbers. Storing and re-ordering of packets so that they can be delivered to the QAM Channel in the correct sequence is not prohibited by these requirements and the EQAM **MAY** perform such re-ordering as long as the latency requirements of Section 6.1.4 are met.

6.2.4 Network MTU¹⁷

The network between the M-CMTS Core and the EQAM will have a certain Maximum Transmission Unit. If a maximum size DOCSIS frame were to be tunneled from the M-CMTS Core to the EQAM without fragmentation, the size of the resulting packet may be greater than the CIN can handle. Both the D-MPT and PSP modes avoid this issue by offering streaming and fragmentation. As such, IP fragmentation is not required. IP fragmentation is also undesirable because the EQAM may forward packets based upon the destination UDP port, and the UDP port is only available in the first IP fragment.

Determining the MTU to use for the L2TPv3 tunnel between the M-CMTS Core and the EQAM is a two step process. The first step is done as part of L2TPv3 session establishment (see Section 7) using the DEPI MTU AVPs. When the M-CMTS Core starts the session establishment with an ICRQ message it **MUST** supply the DEPI Local MTU AVP with a payload size that is the lesser of its receive capabilities and the receive capabilities defined by its lower layer. The receive capabilities of the M-CMTS Core are defined by its internal constraints, and any configured maximums. The receive capabilities defined by its lower layer is a calculation based on referencing the payload size constraints of the interface below which this tunnel is being created, as defined in Annex A.1. The M-CMTS Core **MUST** support an MTU size of at least 1500 bytes. The EQAM **MUST** send L2TPv3 frames with a payload size less than or equal to this maximum. If the EQAM cannot meet this criterion then it **MUST** fail session creation by generating a CDN message. The EQAM needs to consider the same criteria in calculating its MTU. The EQAM **MUST** support an MTU size of at least 1500 bytes, as calculated in Annex A.1. The EQAM **MUST** insert the DEPI Remote MTU AVP in the ICRP message with its MTU size. The M-CMTS Core **MUST** send L2TPv3 frames with a payload size less than or equal to this maximum. If the M-CMTS Core cannot meet this criterion then it **MUST** fail session creation by generating a CDN message.

The second step is to determine the MTU of the path between the M-CMTS Core and the EQAM. The M-CMTS Core **MUST** support a mechanism to prevent sending packets larger than the network MTU. This **SHOULD** be done using Path MTU Discovery, as described in [RFC 1191]. Annex A.3 gives a brief overview of the Path MTU discovery protocol. Alternatively, this **MAY** be done via a static configuration option. Both the M-CMTS Core and the EQAM **MUST** have a way to statically configure an MTU for each L2TPv3 session. To avoid IP fragmentation, the M-CMTS Core and the EQAM **MUST** set the Don't Fragment bit (DF) in the IPv4 header for all transmissions into the L2TPv3 pseudowire.

6.3 System Timing Considerations¹⁸

To ensure proper system operation, the M-CMTS Core **SHOULD** utilize a timebase that is delayed by no less than 0 and no more than 100 clock cycles (approximately 10 μ s) of the master clock (10.24 MHz) compared to the time communicated via the DTI Client Test Port output.

This time difference between the time communicated via the DTI Client Test Port output and the time reference applied by an M-CMTS Core is expected to be essentially constant. The requirements here do not preclude an M-

¹⁷ Revised this section per DEPI-N-05.0256-4 on 11/21/05.

¹⁸ Added a new section per DEPI-N-05.0258-1 on 11/11/05.

CMTS Core from taking longer than 100 clock cycles to process the DTI conveyed time, but in that case, the M-CMTS Core would need to internally adjust the applied timebase such that it is delayed between zero and 100 clock cycles from the DTI conveyed timebase.

7 DEPI CONTROL PLANE

NOTE: This section is normative.

The DEPI control plane is based upon L2TPv3 signaling. The intent of this specification is to follow the provisions of [RFC 3931]. This section includes some examples of how L2TPv3 signaling is used, and includes the extensions and interpretations of the [RFC 3931] specification as it applies to DOCSIS.

All requirements from [RFC 3931] **MUST** be met by both the M-CMTS Core and the EQAM unless this specification explicitly states that a particular requirement from [RFC 3931] is not required.

7.1 Topology

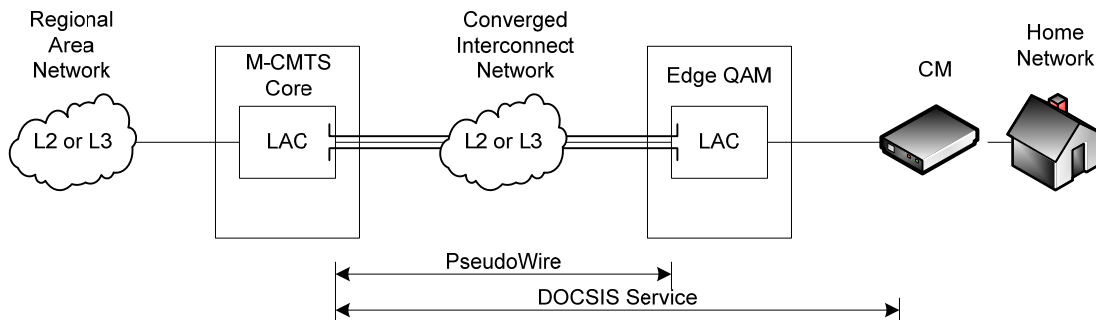


Figure 7-1 - L2TP Topology for Modular CMTS

Figure 7-1 shows how the Modular CMTS architecture maps to L2TP topology. In L2TPv3 nomenclature, the M-CMTS Core and the EQAM are known as a L2TP Access Concentrator (LAC). The M-CMTS Core and the EQAM are considered as peers and may also be referred to as L2TP nodes or as L2TP Control Connection Endpoints (LCCE). For the purposes defined in this document, each LCCE is identified on the network by a single IP address. The connections between two LCCEs are known as Pseudo-Wires (PW).

The L2TP supports both a data path and an inband control path. In L2TPv3 nomenclature, data messages are sent on the data channel, and control messages are sent on the control connection.

First a control connection is established between the two LCCEs, then a session is established. An L2TP session is established before L2TP begins to forward session frames for data. Multiple sessions may be bound to a single control connection.

7.2 Addressing¹⁹

The M-CMTS Core **SHOULD** use the IP Address of the EQAM and the TSID of the QAM Channel to uniquely identify a QAM Channel within an EQAM during initial configuration.

The M-CMTS Core **MUST** establish at most one control connection for each LCCE pair. This control connection will manage all sessions between the M-CMTS Core and the EQAM. If the UDP Header is used, the control connection **SHOULD** use UDP port 1701.

¹⁹ Revised per DEPI-N-10.0901-5 on 3/18/10 by JB.

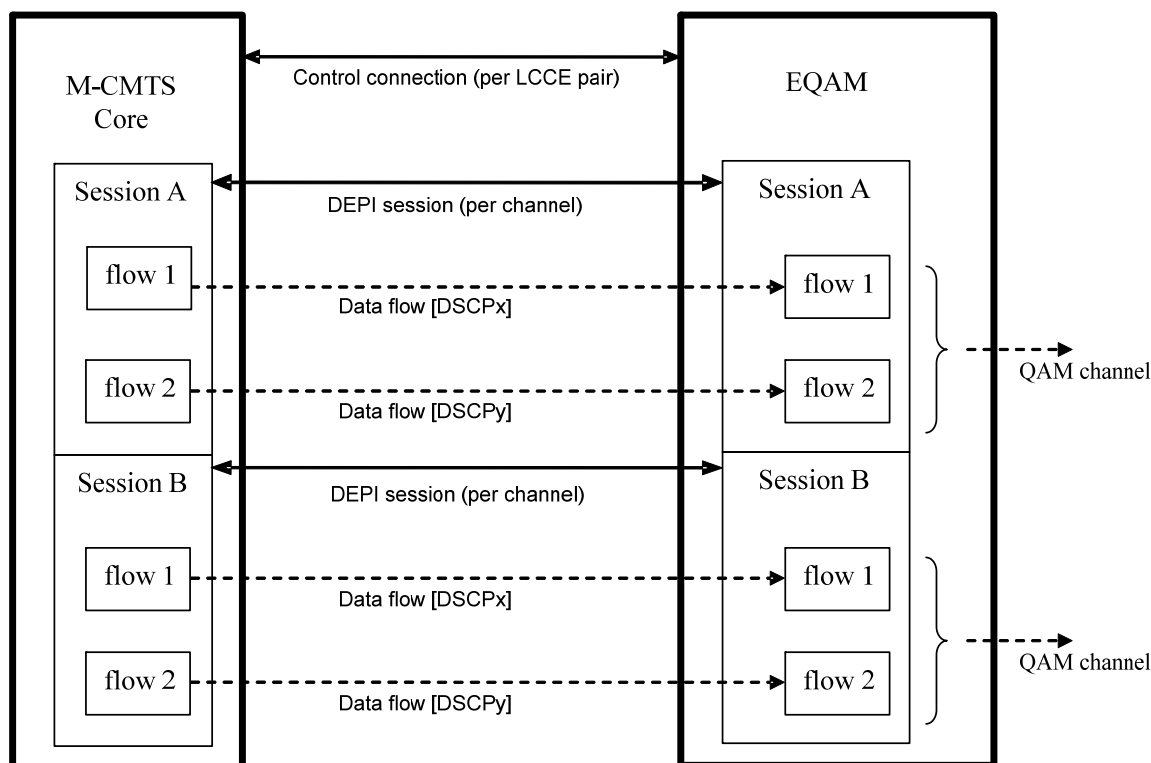


Figure 7-2 - DEPI Addressing Hierarchy

The M-CMTS Core **MUST** support the creation of a single session per QAM channel. The EQAM **MUST** support a single session per QAM channel. Each DEPI session uses one of the Pseudowire types described in Section 7.5.1.1. Per [RFC 3931], both the M-CMTS Core and the EQAM assign a unique L2TPv3 session ID for each session. The M-CMTS Core **MUST NOT** attempt to create a session to a QAM channel for which the M-CMTS Core already has an active session. Unless specifically configured otherwise, the EQAM **MUST** reject an attempt to establish a session to a QAM channel for which a session has already been established. The requirements listed above are modified when EQAM and the M-CMTS Core operate with DPR. For more information see Annex E.

The M-CMTS Core **MAY** create multiple PSP flows per session. Different EQAM implementations may support different numbers of PSP flows on any given DEPI session, which is described further in Section 6.1. During L2TPv3 session setup, the EQAM **MUST** assign each flow a unique flow ID. Reassembly, if applicable, is done per flow ID at the EQAM.

L2TPv3 permits the optional use of a UDP Port. L2TPv3 uses the same UDP port number for both the control connection and the data sessions. DEPI also permits the use of UDP ports, primarily for legacy applications. When UDP ports are used, DEPI differs from L2TPv3 in that DEPI permits the data sessions to have different UDP ports than the control connection. Further, DEPI allows each flow within a DEPI session to have a unique UDP port.²⁰

The EQAM **MAY** assign each flow a unique UDP Destination Port. The M-CMTS Core **MUST** address DEPI packets using the UDP Destination Port (if the UDP header is used), L2TPv3 Session ID, and flow ID assigned by the EQAM. This is shown in Figure 7-2 and in more detail in Figure 7-3.

²⁰ Para added per DEPI-N-06.0311-2, 11/26/06, PO.

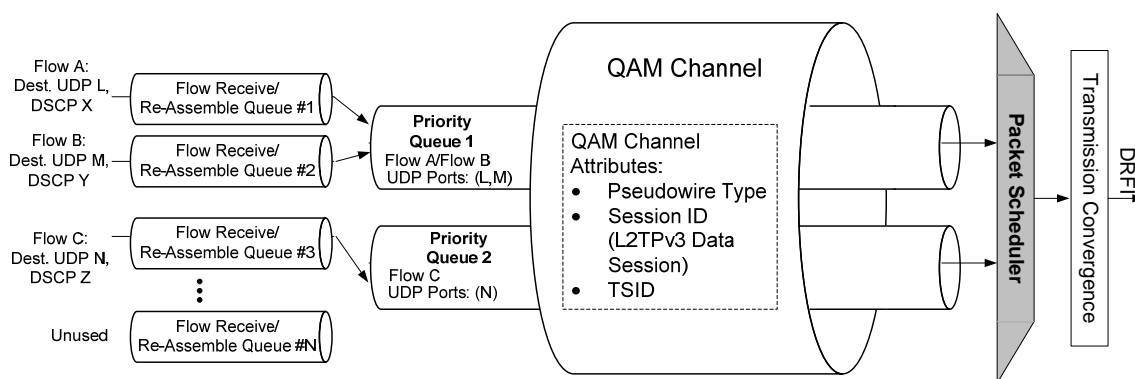


Figure 7-3 - DEPI Addressing Hierarchy

7.3 Control Message Format

The format of a DEPI Control Packet, as shown in Figure 7-4 and Figure 7-5, is based on [RFC 3931], with extensions for DOCSIS. The fields which are common with the DEPI Data Packet are described in Section 8.1. Fields which are used differently or are new are described below. Unless otherwise indicated, all values are shown in decimal notation.

The choice of using or not using a UDP header is done through system configuration and is not a negotiated DEPI parameter. The UDP version of DEPI is intended for systems which use the UDP port to map flows to a QAM Channel within an EQAM. The non-UDP version of DEPI is intended for systems which use the L2TPv3 Session ID to map flows to a QAM Channel within an EQAM.

The M-CMTS Core **MUST** support DEPI directly over IP. The M-CMTS **MAY** support DEPI over UDP. The EQAM **MUST** support DEPI directly over IP. The EQAM **MAY** support DEPI over UDP.²¹

²¹ Para modified per DEPI-N-06.0311-2, 11/26/06, PO.

7.3.1 Control Message with a UDP Header

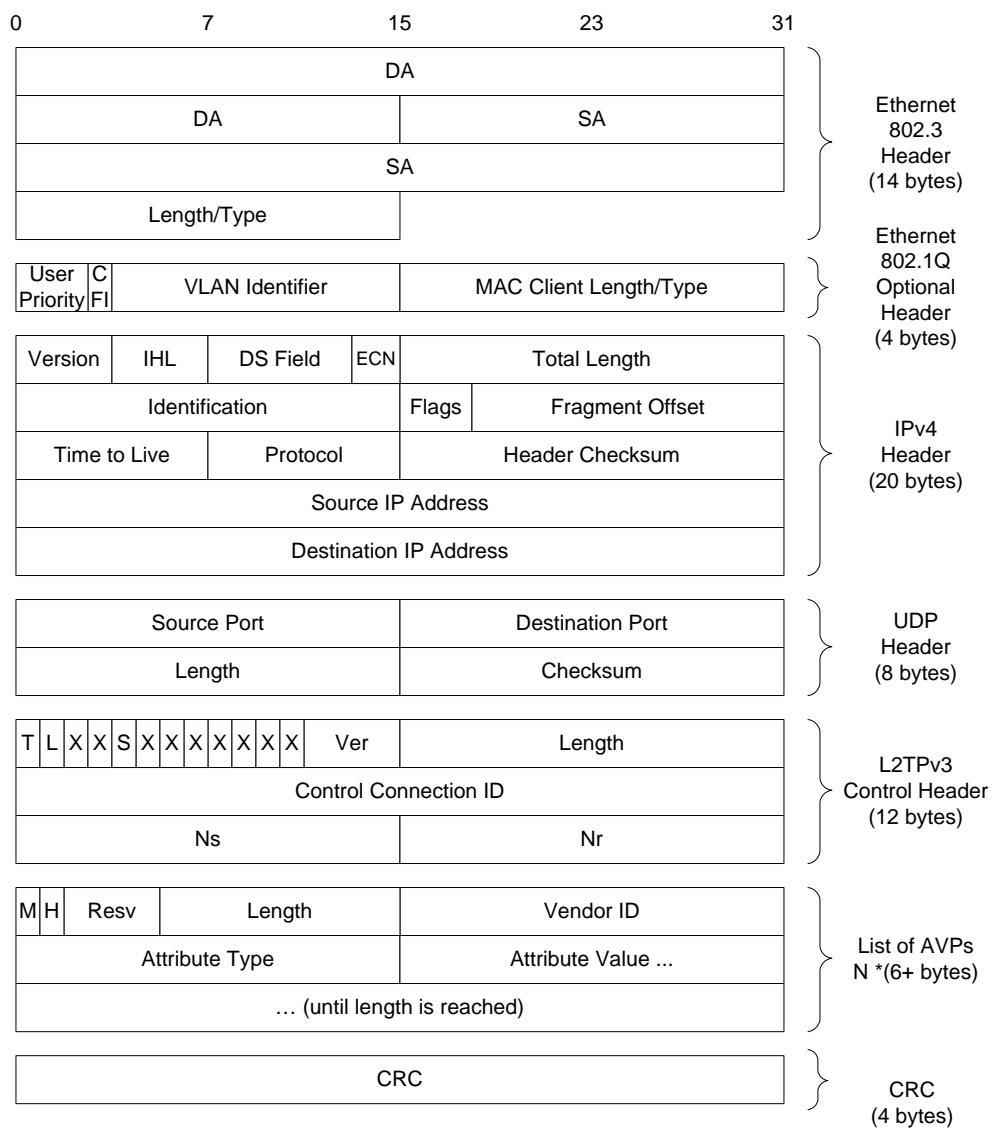


Figure 7–4 - DEPI Control Packet with UDP

7.3.2 Control Message without a UDP Header

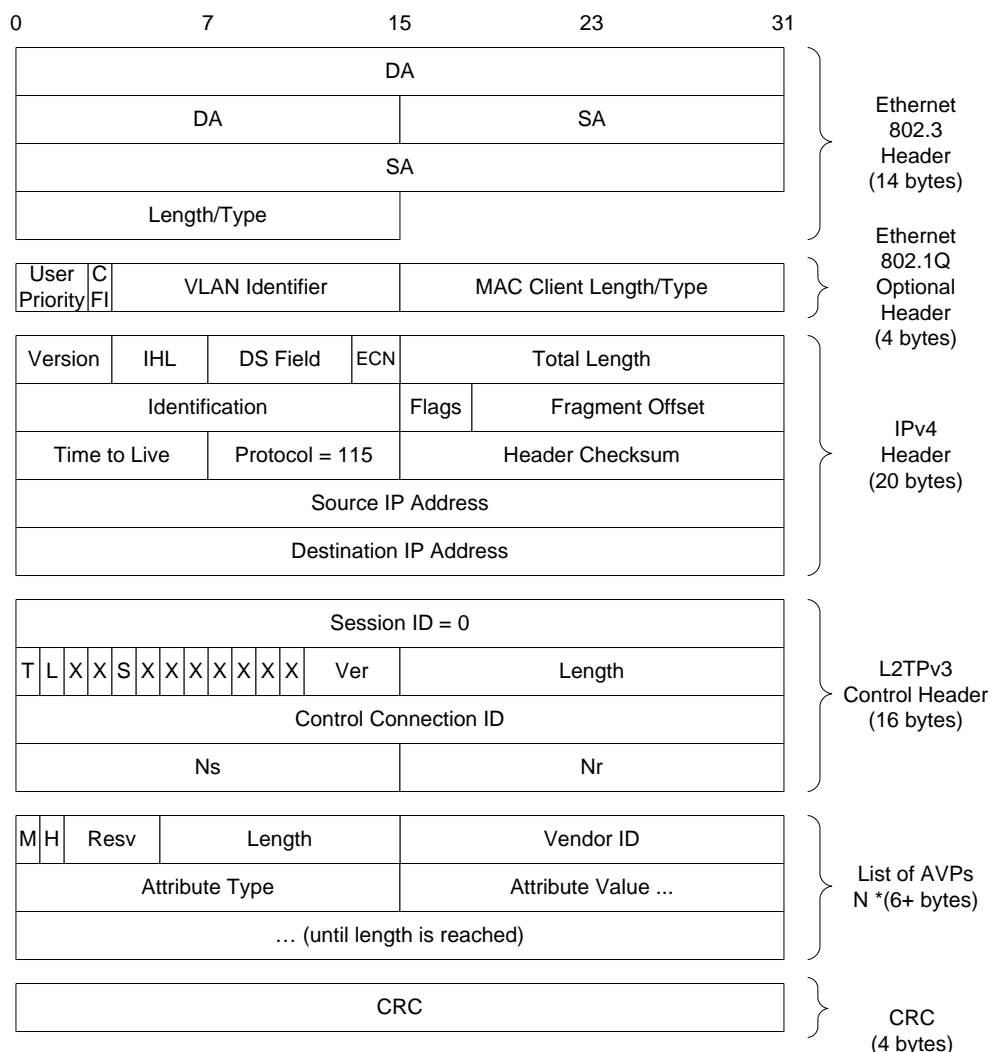


Figure 7-5 - DEPI Control Packet without UDP

7.3.3 Common Headers for Control and Data Messages

7.3.3.1 Ethernet 802.3 Header

The Ethernet header is defined by [IEEE-802.3]. The Ethernet Destination Address is an individual address. Operation with DEPI over Ethernet group addresses is not specified at this time. The Ethernet Destination Address may be locally or globally administered.

Upon transmission of this frame by the M-CMTS Core, the Ethernet Destination Address will be the Ethernet address of the EQAM or of the next hop router. Upon reception of this frame by the EQAM, the Ethernet Source Address will be the Ethernet address of the output port of the M-CMTS Core or of the previous hop router.

If the networking interface is Ethernet, the M-CMTS Core MUST support the Ethernet header. If the networking interface is Ethernet, the EQAM MUST support the Ethernet header. If another physical layer interface is used instead of Ethernet, then the Ethernet headers would be replaced with the header format pertaining to that physical layer.

7.3.3.2 Ethernet 802.1Q Header

The Ethernet 802.1Q header is defined by [IEEE-802.1Q]. The use of this header is optional and provides frame prioritization and VLAN support at layer 2. The M-CMTS Core **MUST** be able to support the Ethernet 802.1Q header. The M-CMTS Core **SHOULD** support mapping of 802.1Q user priority of tunneled packets based on the DSCP value of a tunnel's IP packet. The EQAM **SHOULD** support the Ethernet 802.1Q header.

7.3.3.3 IPv4 Header

The IP header is defined by [RFC 791]. The IP Source Address is an IP address belonging to the M-CMTS Core. Currently, the IP Destination Address is unicast and is an IP Address belonging to the EQAM. Operation with DEPI over IP Multicast is not specified at this time.

For implementation considerations and for coexistence with network policies that are not amenable to IP fragmentation, EQAMs are not required to perform IP reassembly. The M-CMTS Core **MUST NOT** use IP fragmentation. The M-CMTS Core **MUST** set the IP DF (don't fragment) bit.

The M-CMTS Core **MUST** support a configurable 6 bit Differentiated Service Code Point (DSCP) as defined by [RFC 2983] and [RFC 3260].

The M-CMTS Core **MUST** support the IPv4 header. The EQAM **MUST** support the IPv4 header.

7.3.3.4 UDP Header

The UDP header is defined by [RFC 768]. The value of the UDP Source Port and the UDP Destination Port is determined through the L2TPv3 control plane between the M-CMTS Core and the EQAM. This value **SHOULD** conform to [IANA-PORTS].

When L2TPv3 Control Message Authentication not in use and the UDP header is in use, both the EQAM and M-CMTS Core **MUST** support the generation of UDP checksums as defined in [RFC 768]. The sender **MUST NOT** set the UDP checksum to 0 for L2TPv3 control messages. The receiver **MUST** support validation of the UDP checksum field, as per [RFC 768].

When L2TPv3 Control Message Authentication is in use, the UDP checksum verification is redundant. Therefore, when L2TPv3 Control Message Authentication is in use and the UDP header is in use, the M-CMTS Core and EQAM **MAY** set the UDP checksum field to 0 on control packets when sending a packet, and M-CMTS Core and EQAM **MUST** ignore the UDP checksum field upon receiving a control packet with a UDP checksum of 0.²²

The M-CMTS Core **MUST** support the UDP header. The EQAM **MUST** support the UDP header.

7.3.3.5 CRC

The CRC is CRC-32 and is defined by [IEEE-802.3].

The M-CMTS Core **MUST** support the CRC field. The EQAM **MUST** support the CRC field.

7.3.4 Specific Headers for Control Messages

7.3.4.1 L2TPv3 Control Header

These fields are defined in [RFC 3931] and are repeated here for reference. The fields have the following significance:

- T** Type bit. The T bit **MUST** be set to 1, indicating that this is a control message.
- L** Length bit. The L bit **MUST** be set to 1, indicating that the Length field is present.
- S** Sequence bit. The S bit **MUST** be set to 1 indicating that sequence numbers (Ns and Nr) are present.
- X** Reserved bits. All reserved bits **MUST** be set to 0 on outgoing messages and ignored on incoming messages.

²² Previous para deleted, these 2 added per DEPI-N-06.0310-2, 11/26/06, PO.

Ver	Version. 4 bits. Set to 3.
Length	2 bytes. The Length field indicates the total length of the message in octets, always calculated from the start of the control message header itself, beginning with the T bit. It does not include the Session ID (shown in Figure 7–5) when present.
CCID	Control Connection Identifier. 4 bytes. Negotiated per control connection. ²³
Ns	Sending Sequence Number. 2 bytes. Indicates sending sequence of this control message.
Nr	Received Sequence Number. 2 bytes. Indicates next expected received sequence number.

7.3.4.2 Attribute Value Pairs (AVP)

There can be one or more attribute value pairs (AVPs) per DEPI control message. The fields have the following significance:

M	Mandatory bit. If this bit is set to a 1 and this AVP is rejected, the control connection or session setup in which the AVP is carried will be torn down, according to the procedures outlined in [RFC-L2TPv3]. ²⁴
H	Hidden bit. This bit is set to a 1 when the contents of the AVP message are encrypted and a 0 when the contents of the AVP message are not encrypted. Encryption of AVP messages is not required for DEPI.
Resv	Reserved. 4 bits. Set to all zeros on transmit. Ignored on receive.
Length	10 bits. Equal to the length of the attribute value field plus 6 bytes.
Vendor ID	2 bytes. For AVPs defined by [RFC 3931], this field is set to 0. For AVPs defined by this specification, this field is set to the IANA assigned CableLabs vendor ID of 4491 (0x118B). For AVPs defined outside the scope of this specification, this may be set to a vendor specific ID.
Attribute Type	2 bytes.
Attribute Value	N bytes.
Reserved	8 bits. If an AVP has a reserved field, the bits in this field should be set to 0 on transmit and ignored on the receive.

If an LCCE receives an AVP with a Vendor ID that it doesn't recognize, and the M bit is set to 0, the LCCE MUST silently discard the AVP.²⁵

7.4 Signaling

The supported L2TPv3 messages for the DEPI control plane are shown in Figure 7–1:

Table 7–1 - DEPI Control Messages

#	Mnemonic	Name
Control Connection Management		
1	SCCRQ	Start-Control-Connection-Request
2	SCCRP	Start-Control-Connection-Reply
3	SCCCN	Start-Control-Connection-Connected
4	StopCCN	Stop-Control-Connection-Notification
6	HELLO	Hello
20	ACK	Explicit Acknowledgement

²³ Revised this field statement per DEPI-N-05.0259-3 on 11/11/05.

²⁴ DEPI-N-0307-1, 11/22/06 PO.

²⁵ DEPI-N-0307-1, 11/22/06 PO.

#	Mnemonic	Name
Session Management		
10	ICRQ	Incoming-Call-Request
11	ICRP	Incoming-Call-Reply
12	ICCN	Incoming-Call-Connected
14	CDN	Call-Disconnect-Notify
16	SLI	Set Link Info

L2TPv3 outgoing call messages (OCRQ, OCRP, OCCN) and the WAN-Error-Notify (WEN) message are not required to be supported.

There is a reliable control message delivery mechanism that is accomplished either by sending an Explicit Acknowledgement (ACK) message after any of the control messages or by piggybacking an acknowledgment with the Nr and Ns fields in a later control message. If Control Messages are not acknowledged within the time Control Message Timeout (refer to Annex B), then the Control Message **MUST** be retransmitted up to the value of Control Message Retry Count (refer to Annex B). For example, the Control Message must be retransmitted a total of 10 times using an exponential back-off value starting at 1 second and growing to a maximum value of 8 seconds.

NOTE: There will be 7 intervals of 8 seconds in this scheme.

Control message authentication **MAY** be supported. If Control Message Authentication is supported, the methods described in [RFC 3931], section 5.4.1, should be followed.

The following flow diagrams show typical DEPI message exchanges along with the required AVPs from L2TPv3 and DEPI. Optional AVPs are not shown but may also be present.

7.4.1 Control Connection Signaling

7.4.1.1 Control Connection Setup

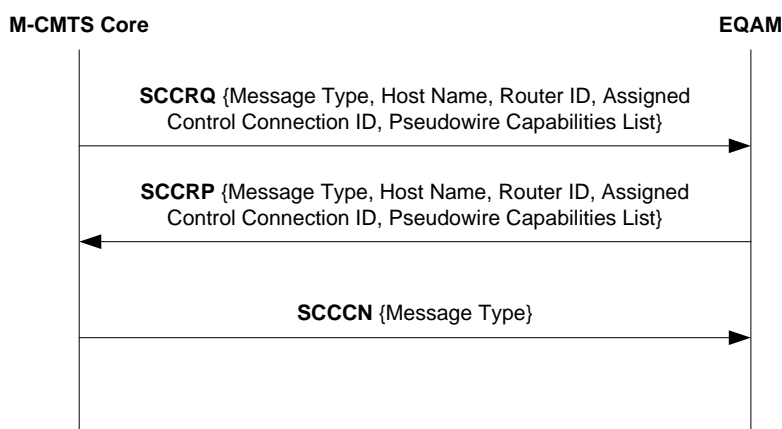


Figure 7-6 - DEPI Control Connection Setup

In order to tunnel DOCSIS frames over IP using L2TPv3, an L2TPv3 Control Connection is first established as described in [RFC 3931]. Establishment of the control connection involves an exchange of AVPs that identifies the peer and its capabilities. Each control connection has a Control Connection ID which is assigned by the recipient, and negotiated with Connection ID AVPs during the creation of a control connection.

The M-CMTS Core **MUST** support the ability to initiate control connection signaling (L2TPv3 caller). The EQAM **MUST** support the ability to receive incoming control connection requests from the M-CMTS Core (L2TPv3 callee). Establishment of control connections by the EQAM is not required for DEPI and is outside the scope of this specification.

7.4.1.2 Control Connection Teardown²⁶

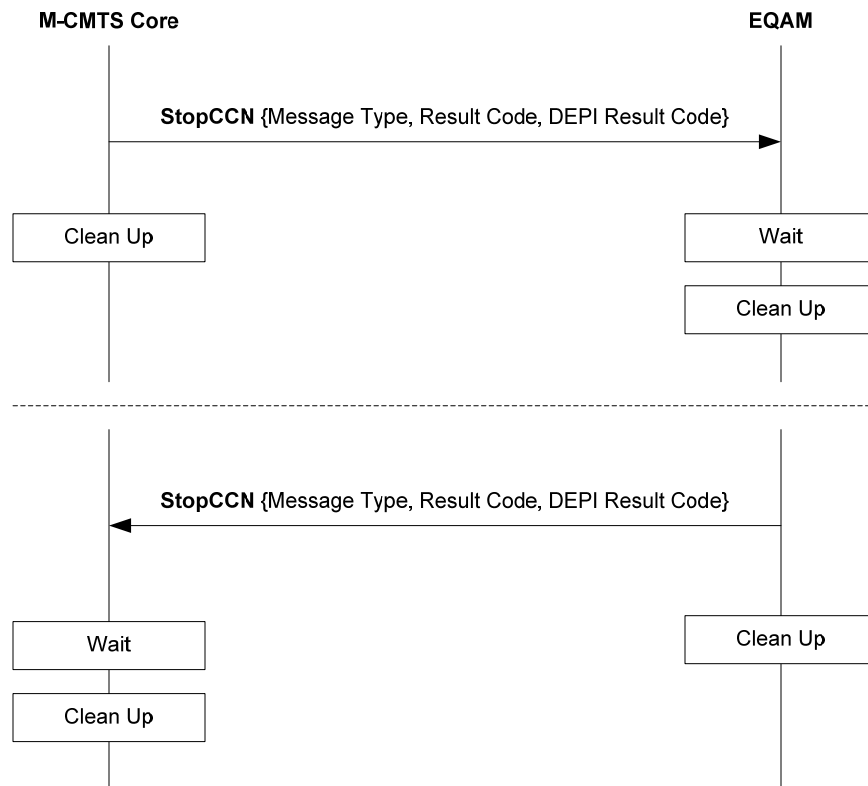


Figure 7–7 - DEPI Control Connection Teardown

Control connection teardown may be initiated by either LCCE and is accomplished by sending a single StopCCN control message. An implementation may shut down an entire control connection and all sessions associated with the control connection by sending the StopCCN. Thus, it is not necessary to clear each session individually when tearing down the whole control connection. The peer receiving the StopCCN message **MUST** maintain session and control state for a period of time equal to StopCCN Timeout (Annex B) after acknowledging the StopCCN. This provision is for managing lost acknowledgments.

In some cases, such as after a reboot, an LCCE may receive a Hello message for a Control Connection for which it is unaware. If the LCCE which received the Hello message with an unknown Connection ID, the LCCE **SHOULD** send a StopCCN message with the Connection ID set to 0, Result Code 2 - General error, and Error Code 1 - No control connection exists yet for this pair of LCCEs. If the LCCE receives a StopCCN message with a Control Connection ID set to 0, it **MUST** tear down all Control Connections with the other LCCE sending the StopCCN.

²⁶ Paragraph added per DEPI-N-09.0860-3 on 11/17/09 by JB.

7.4.1.3 Control Connection Keep-Alive

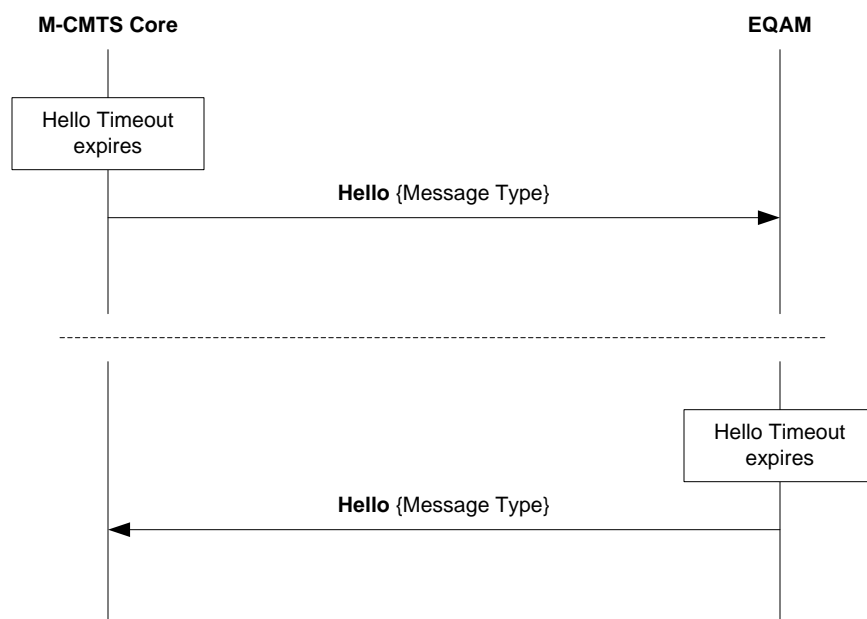


Figure 7–8 - DEPI Keep-alive

A periodic keep-alive for the control connection is implemented by sending a Hello message if a period of time known as the Hello Timeout (refer to Annex A) has passed without receiving any message (data or control) from the peer.

7.4.2 Session Signaling

7.4.2.1 Session Setup

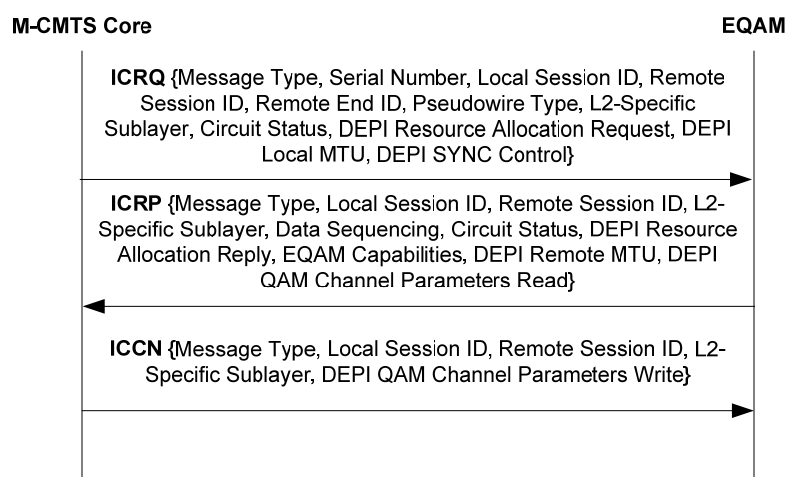


Figure 7–9 - DEPI Session Setup²⁷

²⁷ Revised this figure per DEPI-N-05.0246-3 on 10/27/05; revised figure and added preceding text per DEPI-N-05.0256-4 on 11/21/05; revised figure per DEPI-N-05.0257-2 on 11/21/05.

After successful control connection establishment, individual sessions may be created. Each session corresponds to a single data stream between the two LCCEs. In addition to the mandatory and optional AVPs in [RFC 3931], the following DEPI specific AVPs are used as part of the session setup.

ICRQ contains the Remote End ID AVP which contains the TSID of the QAM Channel for which the session is intended.

ICRP contains the Remote Session AVP which indicates the session ID that the EQAM wants to use. ICRP also contains a suite of QAM Channel AVPs (refer to Section 7.5.2) which indicate the EQAM's current configuration, which parameters can be changed, EQAM capabilities, and assigned values such as the UDP port values. If these values are not acceptable to the M-CMTS Core, the M-CMTS Core will return a CDN message with the appropriate error code.

ICCN contains the parameters that the M-CMTS Core wants to change. If these parameters are acceptable to the EQAM, the EQAM will return an ACK (either explicit or implicit). If these parameters are not acceptable to the EQAM, the EQAM will return a CDN message with the appropriate error code.

The receipt and processing of the ICCN triggers the initiation of data forwarding within the EQAM for the session. The EQAM **MUST NOT** transmit data on the QAM channel until the session is configured according to the parameters in the ICCN message. The EQAM **SHOULD NOT** buffer data while the session is being configured.

Since the ICCN message may contain AVP parameters that could reconfigure the QAM Channel and disrupt data transmission, the EQAM **SHOULD** set the Circuit Status AVP in the ICRP message to the down state. After the ICCN is received and when the QAM Channel is operational, then the EQAM **SHOULD** send an SLI message to the M-CMTS Core with the Circuit Status AVP set to the up state (refer to 7.5.1.5).

The M-CMTS Core **MAY** also set its circuit status to the down state in the ICRQ message, and then set its circuit status to the up state in the ICCN message or a follow-on SLI message.²⁸

The M-CMTS Core **MUST** support the ability to generate session establishment signaling. The EQAM **MUST** support the ability to receive incoming session establishment requests from the M-CMTS Core. Establishment of L2TP sessions by the EQAM is outside the scope of this specification.

²⁸ Previous para modified, these 2 paras. added per DEPI-N-06.0306-1, 11/26/06, PO.

7.4.2.2 Session Teardown

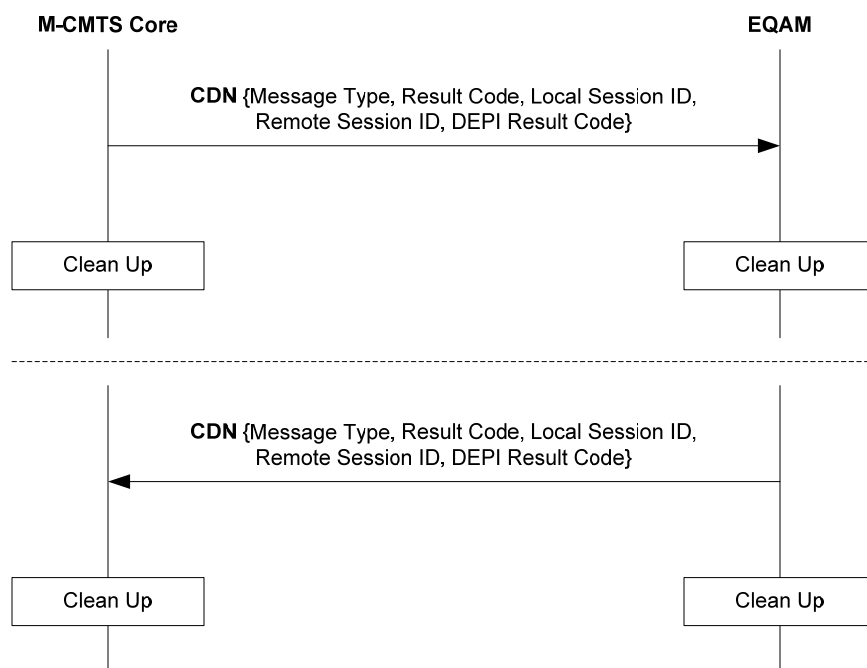


Figure 7–10 - DEPI Session Teardown

Session teardown may be initiated by either LCCE and is accomplished by sending a single CDN control message. An implementation may shut down an entire control connection and all sessions associated with the control connection by sending the StopCCN. Thus, it is not necessary to clear each session individually when tearing down the whole control connection.

7.4.2.3 Session Updates

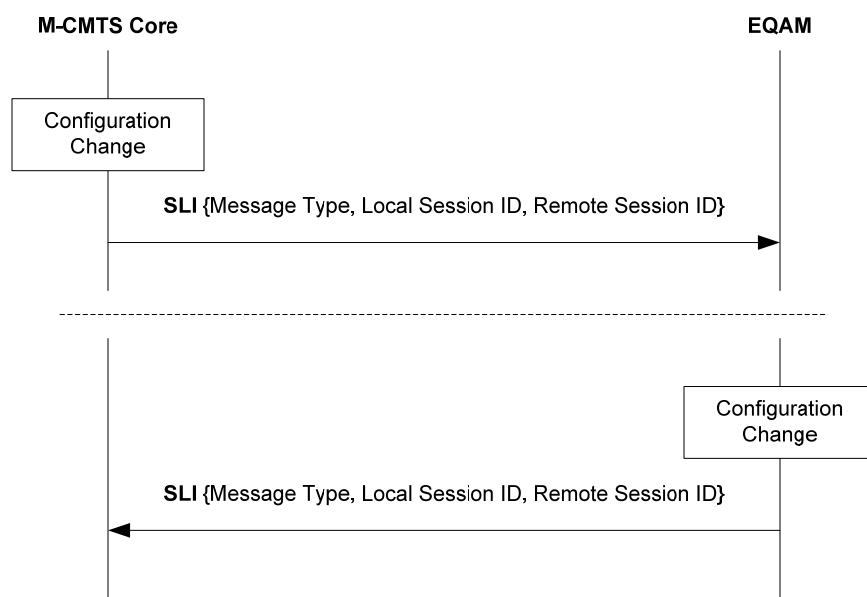


Figure 7–11 - DEPI Session Updates

If there is a configuration change to one of the EQAM parameters which is described by a DEPI AVP, the M-CMTS Core MUST send the updated AVP to the EQAM with the Set-Link-Info (SLI) message. If there is a configuration change to one of the EQAM parameters which is described by a DEPI AVP, the EQAM MUST send the updated AVP to the M-CMTS Core using an SLI message.

7.4.3 Required and Optional AVPs

In addition to the mandatory and optional AVPs listed in [RFC 3931] and modified by Table 7–3, the following DEPI AVPs listed in Table 7–2 MUST be present in the DEPI control message if mandatory, and MAY be present in DEPI control messages if optional.²⁹

Table 7–2 - DEPI Mandatory and Optional AVPs³⁰

DEPI Control Message	DEPI Mandatory AVPs	DEPI Optional AVPs
ICRQ	DEPI Resource Allocation Request DEPI Local MTU DS QAM Channel DOCSIS SYNC Control	Local UDP Port DPR Session Type
ICRP	DEPI Resource Allocation Reply DEPI Remote MTU EQAM Capabilities DS QAM Channel Frequency DS QAM Channel Power DS QAM Channel Modulation DS QAM Channel J.83 Annex DS QAM Channel Symbol Rate DS QAM Channel Interleaver Depth DS QAM Channel RF Mute	Downstream QAM Channel TSID Group
ICCN		DS QAM Channel Frequency DS QAM Channel Power DS QAM Channel Modulation DS QAM Channel J.83 Annex DS QAM Channel Symbol Rate DS QAM Channel Interleaver Depth DS QAM Channel RF Mute
SCCRQ		DEPI Redundancy Capabilities
SCCRP		DEPI Redundancy Capabilities
CDN		DEPI Result Code
StopCCN		DEPI Result Code
SLI		DS QAM Channel DOCSIS SYNC Control DS QAM Channel Frequency DS QAM Channel Power DS QAM Channel Modulation DS QAM Channel J.83 Annex DS QAM Channel Symbol Rate DS QAM Channel Interleaver Depth DS QAM Channel RF Mute DEPI Result Code ³¹ DPR Session Status

²⁹ DEPI-N-06.0307-2 corrected cross-refs, 11/26/06, PO.

³⁰ Added statements to DEPI Mandatory AVP column per DEPI-N-05.0246-3 and DEPI-N-05.0256-4 on 10/28/05 and 11/21/05. Stop CCN line added per DEPI-N-0307-1, 11/26/06, PO. Revised per DEPI-N-10.0901-5 on 3/18/10 by JB.

³¹ 1st and last line modified per DEPI-N-0307-1, 11/26/06, PO.

7.5 AVP Definitions

7.5.1 Conventional L2TPv3 AVPs

The AVP types from [RFC 3931] and [RFC 308] that are supported as part of this specification are shown in Table 7-3.³²

Table 7-3 - DEPI Supported L2TPv3 AVPs³³

Attribute Type	Control, Session	Description	Required	Not Required
0	C, S	Message Type	●	
1	S	Result Code	●	
5	C, S	Control/Session Tie Breaker		●
7	C	Host Name	●	
8	C	Vendor Name		●
10	C	Receive Window Size		●
15	S	Serial Number	●	
25	S	Physical Channel ID		●
34	S	Circuit Errors		●
36	C, S	Random Vector		●
47	C	Control Connection DSCP		●
48	S	Session DSCP		●
58	C, S	Extended Vendor ID AVP		●
59	C, S	Message Digest		●
60	C	Router ID	●	
61	C	Assigned Control Connection ID	●	
62	C	Pseudowire Capabilities List	●	
63	S	Local Session ID	●	
64	S	Remote Session ID	●	
65	S	Assigned Cookie		●
66	S	Remote End ID	●	
68	S	Pseudowire Type	●	
69	S	L2-Specific Sublayer	●	
70	S	Data Sequencing	●	
71	S	Circuit Status	●	
72	C	Preferred Language		●
73	C	Control Message Authentication Nonce		●
74	S	Tx Connect Speed		●
75	S	Rx Connect Speed		●

Conventional AVPs whose usage is specific to DEPI are described below. A more complete description as well as requirements for the conventional AVPs is in [RFC 3931].

³² Revised this sentence per DEPI-N-05.0246-3 on 10/28/05.

³³ Revised the requirement of Attribute Type 69 and 70 per DEPI-N-0257-2 on 11/21/05.

7.5.1.1 Message Type (All Messages)

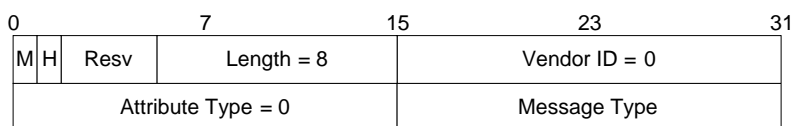


Figure 7–12 - Message Type AVP

This identifies the particular L2TPv3 Control Message. It is always the first AVP.

7.5.1.2 Result Code (StopCCN, CDN)

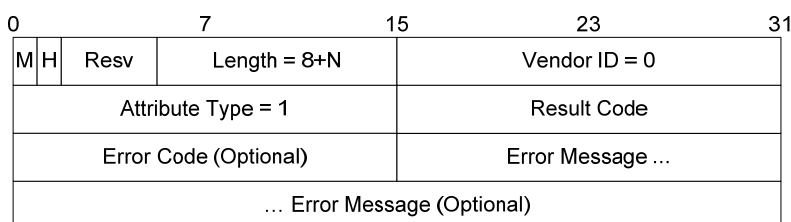


Figure 7–13 - Result Code AVP

This message contains results codes, optional error codes, and optional error messages when tearing down a Control Connection or a Session.

7.5.1.3 Host Name (SCCRQ, SCCRP)

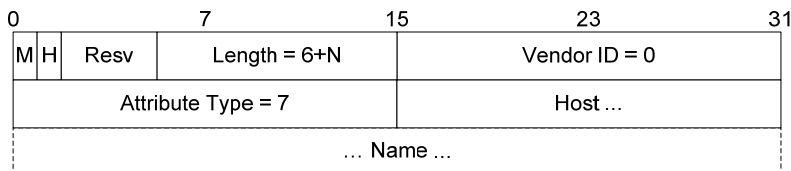


Figure 7–14 - Host Name AVP

The host name is typically the fully qualified domain name (FQDN) of each device.

7.5.1.4 Vendor Name (SCCRQ, SCCRP)

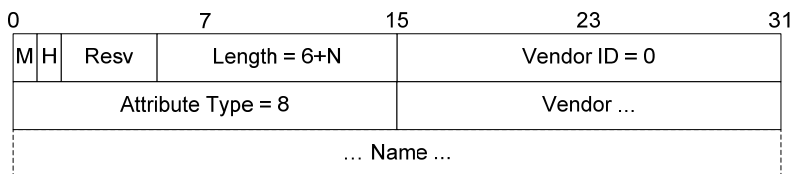


Figure 7–15 - Vendor Name AVP

The M-CMTS Core SHOULD identify itself with an ASCII Vendor ID string during the SCCRP message. The EQAM SHOULD identify itself with an ASCII Vendor ID string during the SCCRP message. Note that this is an optional AVP in [RFC 3931].

7.5.1.5 Serial Number (ICRQ, OCRQ)

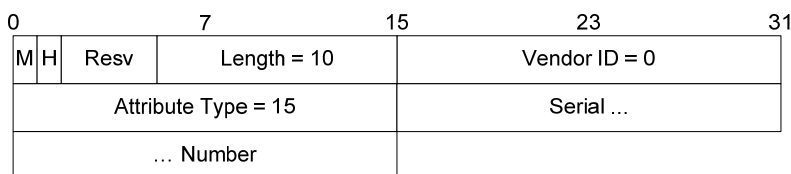


Figure 7–16 - Serial Number AVP

This number is assigned by the originator of the message and is similar in concept to a transaction ID. Its main use is to aid in debugging message flows.

7.5.1.6 Router ID (SCCRQ, SCCRP)

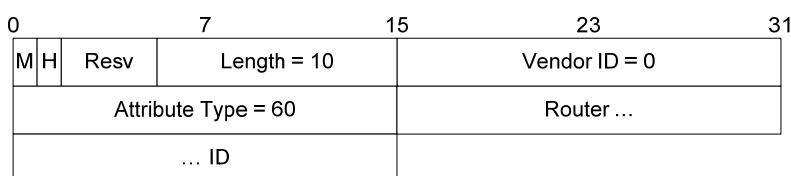


Figure 7–17 - Router ID AVP

The Router ID is an opaque number that uniquely identifies the sending LCCE. It may be the IP address of the sending LCCE, but this cannot be assumed.³⁴

7.5.1.7 Assigned Control Connection ID (SCCRQ, SCCRP, StopCCN)

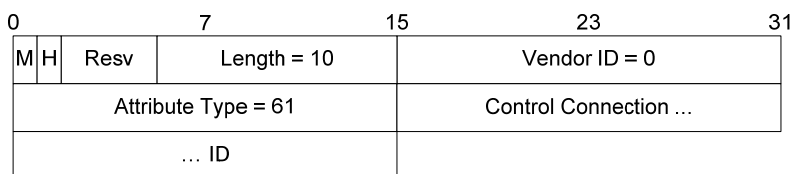


Figure 7–18 - Control Connection ID AVP

This is the control connection ID for DEPI. During SCCRQ, the M-CMTS Core uses this AVP to inform the EQAM what value of Control Connection ID to use in the L2TPv3 Control Header for control messages originated by the EQAM. During SCCRP, the EQAM uses this AVP to inform the M-CMTS Core what value of Control Connection ID to use in the L2TPv3 Control header for control messages originated by the M-CMTS Core. Since the M-CMTS Core has not been informed by the EQAM prior to the first SCCRQ message, the M-CMTS core uses a value of 0 for the control connection ID in the L2TPv3 Control Header of the SCCRQ message.

³⁴ DEPI-N-0307-1, 11/26/06, PO.

7.5.1.8 Pseudowire Capabilities List (SCCRQ, SCCRP)³⁵

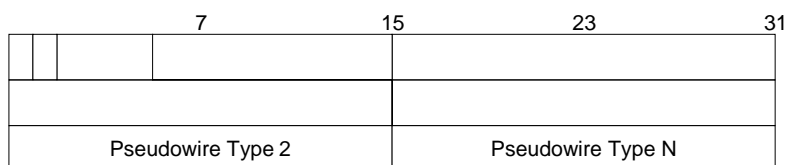


Figure 7–19 - Pseudowire Capabilities List AVP

The Pseudowire Capabilities List indicates the capabilities of the M-CMTS Core and EQAM. There are two PW Types defined for DEPI.

Table 7–4 - Pseudowire Types³⁶

Pseudowire Type	Mnemonic	Value
MPT Pseudowire	MPTPW	0x000C*
PSP Pseudowire	PSPPW	0x000D*

The M-CMTS Core **MUST** indicate its support for PSP and D-MPT mode by including one or both of the DEPI PW Types in the Pseudowire Capabilities List. The EQAM **MUST** indicate its support for PSP and D-MPT mode by including one or both of the DEPI PW Types in the Pseudowire Capabilities List.

7.5.1.9 Local Session ID (ICRQ, ICRP, ICCN, CDN, SLI)

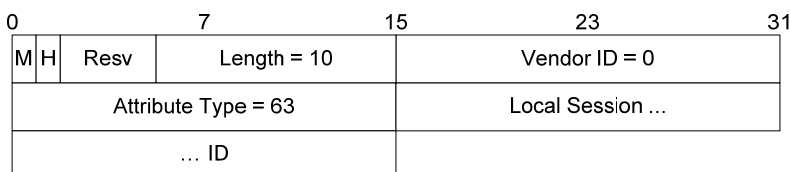


Figure 7–20 - Local Session ID AVP

When a session is established, the M-CMTS Core and EQAM each choose their own Session ID and advertise it to each other with this AVP. This means that a single session setup sets up two uni-directional sessions, one in each direction.

7.5.1.10 Remote Session ID (ICRQ, ICRP, ICCN, CDN, SLI)

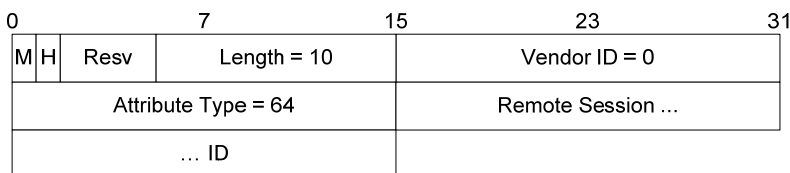
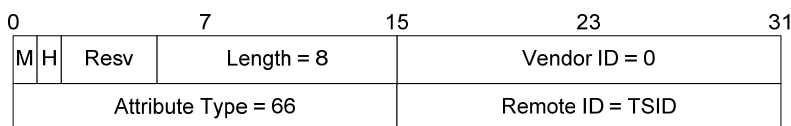


Figure 7–21 - Remote Session ID AVP

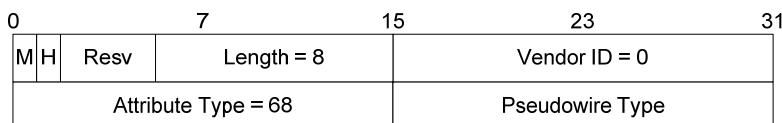
When the M-CMTS Core or EQAM send a session message to each other, the Remote Session ID is set to the session ID learned previously from the Local Session ID. If the Remote Session ID is not yet known, it is set to 0.

³⁵ Pseudowire types modified per DEPI-N-06.0307-1, 11/26/06, PO.

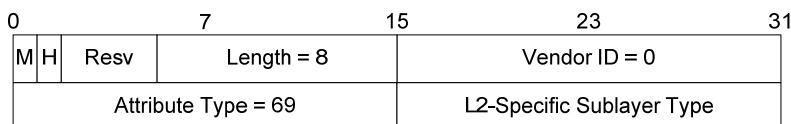
³⁶ Revised this table and added a table footnote per DEPI-N-05.0257-2 on 11/21/05; removed note following table per DEPI-N-06.0273-1 on 7/10/06.

7.5.1.11 Remote End ID (ICRQ)**Figure 7-22 - Remote End ID AVP**

DEPI uses the TSID from the QAM Channel as the Remote End ID. The TSID is an unsigned two octet integer and is used to bind a session to a QAM Channel.

7.5.1.12 Pseudowire Type (ICRQ)**Figure 7-23 - Pseudowire Type AVP**

DEPI uses the Pseudowire Type values defined in Table 7-4 to indicate the type of DEPI session requested.³⁷

7.5.1.13 L2-Specific Sublayer (ICRQ, ICRP, ICCN)³⁸**Figure 7-24 - L2-Specific Sublayer AVP**

The M-CMTS Core MUST include the L2-Specific Sublayer AVP in the ICRQ and ICCN message, indicating the L2-Specific Sublayer Header Type consistent with the Pseudowire type for the DEPI flow. The EQAM MUST include the L2-Specific Sublayer AVP in the ICRP message, indicating the L2-Specific Sublayer Header Type consistent with the Pseudowire type for the DEPI flow.

Table 7-5 - L2-Specific Sublayer Types³⁹

L2-Specific Sublayer Type	Value
MPT Specific Sublayer	3*
PSP Specific Sublayer	4*

³⁷ Cross-ref modified per DEPI-N-06.0307-1, PO. 11/26/06.

³⁸ Added the following two sections per DEPI-N-05.0257-2 on 11/21/05.

³⁹ Removed note following table per DEPI-N-06.0273-1 on 7/10/06.

7.5.1.14 Data Sequencing (ICRP)

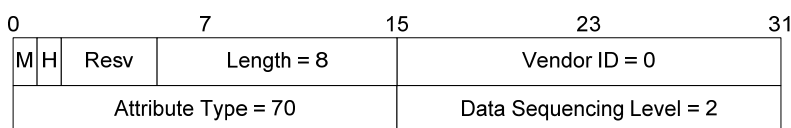


Figure 7–25 - Data Sequencing AVP

The EQAM MUST include the Data Sequencing AVP in the ICRP message, indicating Data Sequencing Level 2 is required (all incoming data packets require sequencing).

7.5.1.15 Circuit Status (ICRQ, ICRP, ICCN, SLI)

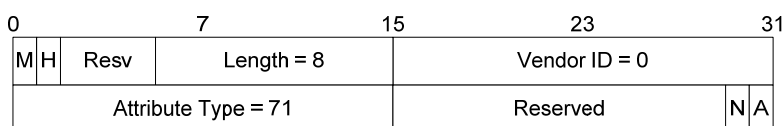


Figure 7–26 - Circuit Status AVP

N 1 bit – The New bit indicates whether the status indication is for a new DEPI session (1) or an existing DEPI session (0). The New bit SHOULD be set the first time the DEPI session is established after provisioning.

A 1 bit – The Active bit indicates whether the DEPI session is up (1) or down (0). Once the M-CMTS Core is aware that the DEPI session is down, the M-CMTS Core MUST NOT attempt to pass data traffic on the DEPI session.

DEPI uses the Circuit Status AVP to indicate whether the DEPI session is up and able to pass data traffic, or down and unable to pass data traffic. The Circuit Status ID does not control the RF output of the QAM Channel. Note that the Circuit Status AVP is sent by both the M-CMTS Core and the EQAM.

7.5.2 DEPI Specific AVPs

The AVP types defined specifically for DEPI are shown in Table 7–6. The range of Attribute Types from 0-99 is reserved for DEPI Session Specific AVPs. These AVPs are only used in L2TP session messages.

Table 7–6 - DEPI Defined General Session APVs ⁴⁰

Attribute Type	Description
0	Reserved
1	DEPI Result Code
2	DEPI Resource Allocation Request
3	DEPI Resource Allocation Reply
4	DEPI Local MTU
5	DOCSIS SYNC Control
6	EQAM Capability Bits
7	DEPI Remote MTU
8	DEPI Local UDP Port
9	DPR Session Type
10	DPR Session Status

⁴⁰ Revised per DEPI-N-10.0901-5 on 3/18/10 by JB.

7.5.2.1 DEPI Result Code (CDN, SLI)

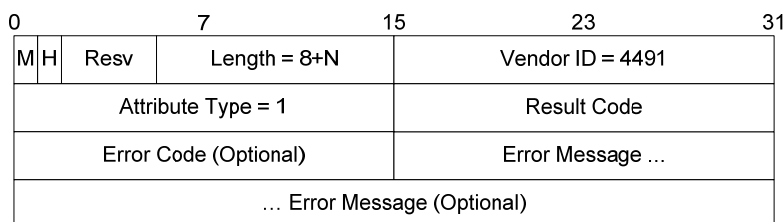


Figure 7-27 - DEPI Result and Error Code AVP

- M** 1 bit. The Mandatory bit MUST be set to a 0.
- Length** 10 bits. 8 bytes plus any additional bytes required for the Error Code and Error Message.
- Attribute Type** 2 bytes. Set to 1.
- Result Code** 2 bytes. Mandatory field. The values are as follows:

Result Code	Result Description
0	Session not established - Bad DEPI AVP Reference
1	Session not established - Bad PHY AVP Request
2	Session not established or disconnected for the reason indicated in Error Code.

Error Code	2 bytes. This field is optional. The values are as follows:
Error Code	Error Description
0	Device is not yet ready or configured properly.
1	Attempt to modify a locked PHY Parameter
2	Attempt to modify PHY Parameter failed – out of range value
3	Requested PSP Flow PHBIDs not supported
4	Incorrect pseudowire type used in session

NOTE: One cause of Error Code 0 would be if the EQAM did not have the values of M and N configured for the QAM Channel Symbol Rate.

Error Message	Variable length. This field is optional.
----------------------	--

The format of the field of this AVP is identical to the field in the standard L2TPv3 result and error code AVP except that the Vendor ID field has the value of 4491 rather than 0. The Result and Error Codes for this AVP are unique to DEPI, and are in addition to the standard Result and Error codes in the L2TPv3 Result and Error Code AVP Section 6.2.1.⁴¹

7.5.2.2 DEPI Resource Allocation Request (ICRQ)

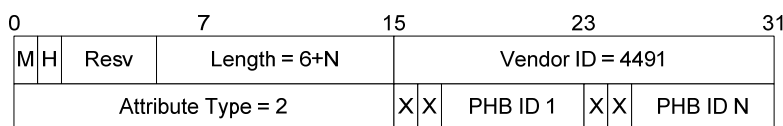


Figure 7-28 - DEPI Resource Allocation Request AVP

⁴¹ This section modified per DEPI-N-06.0308-1, 11/26/06, PO.

- M** 1 bit. The Mandatory bit MUST be set to a 1.
- Length** 10 bits. 6 bytes plus one additional byte for each flow that is requested.
- Attribute Type** 2 bytes. Set to 2.

Each flow request entry consists of:

- PHBID** 6 bits. Per Hop Behavior Identifier being requested by the M-CMTS Core. Per hop behaviors identifiers are defined in Section 6.2.1.

In the ICRQ message, the M-CMTS Core requests for a number of flows for a session. Each byte in the attribute payload represents a request for one unique flow. Each request contains the PHBID that will be used for that flow. For D-MPT mode operation, the M-CMTS Core MUST request a single flow.

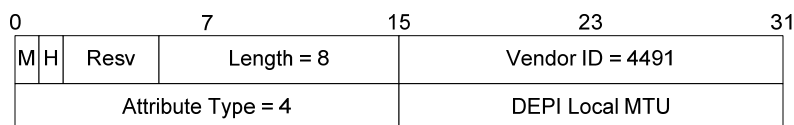
7.5.2.3 DEPI Resource Allocation Reply (ICRP)

0		7				15				23				31			
M	H	Resv	Length = 8+4*N				Vendor ID = 4491										
Attribute Type = 3						Reserved											
X	X	PHB ID 1		Reserved	Flow ID 1	UDP Destination Port 1											
X	X	PHB ID N		Reserved	Flow ID N	UDP Destination Port N											

Figure 7-29 - DEPI Resource Allocation Reply AVP

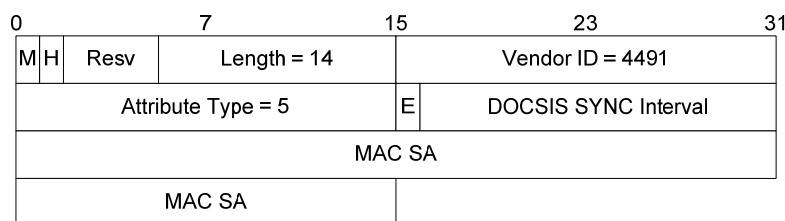
- M** 1 bit. The Mandatory bit MUST be set to a 1.
- Length** 10 bits. 8 bytes plus 4 additional bytes for each flow.
- Attribute Type** 2 bytes. Set to 3.
- Each flow response entry consists of:
- PHBID** 6 bits. Per Hop Behavior Identifier that was request by the M-CMTS Core. Per hop behaviors identifiers are defined in Section 6.2.1.
- Flow ID** 3 bits. This is the flow ID assigned by the EQAM. The flow ID is unique within a session.
- UDP Dest Port** 2 bytes. This is the UDP Destination Port as specified by the EQAM that the M-CMTS Core MUST use for the session header if the M-CMTS and EQAM have been configured to use a UDP header with L2TPv3. This value MUST be unique for each session. This value MAY be unique for each flow. If L2TPv3 has been configured to not use UDP headers, then this field MUST be set to all 0's by the EQAM and MUST be ignored by the M-CMTS Core.

In the ICRP message, the EQAM responds by creating flows that match the flows requested. The EQAM specifies the Flow ID and the UDP Destination Port for each flow. The PHBID is unchanged from the flow request field. If the EQAM does not support a PHBID referenced in the request from the M-CMTS Core, the EQAM can signal that by not including the PHBID in this response. If the EQAM cannot support any of the PHBIDs requested by the M-CMTS Core, then the EQAM MUST tear down the session by issuing a CDN message.

7.5.2.4 DEPI Local MTU (ICRQ)⁴²**Figure 7–30 - DEPI Local MTU AVP**

M	1 bit. The Mandatory bit MUST be set to a 1. ⁴³
Length	10 bits. Set to 8.
Attribute Type	2 bytes. Set to 4.
DEPI Local MTU	2 bytes. In the ICRQ message, this is the MTU (Maximum Transmission Unit) that the M-CMTS can receive from the EQAM on the CIN interface.

The MTU is Layer 3 payload of a Layer 2 frame. For DEPI, the MTU would include the L2TPv3 header and payload, the UDP header if present, and the IP header, but would not include the Ethernet Header or CRC. For example, a 1518-byte Ethernet frame (1522 bytes if VLAN tags are present) would support an MTU of 1500 bytes.

7.5.2.5 Downstream QAM Channel DOCSIS SYNC Control (ICRQ, SLI)⁴⁴**Figure 7–31 - DOCSIS SYNC AVP**

M	1 bit. The Mandatory bit MUST be set to a 1.
Length	10 bits. Set to 14.
Attribute Type	2 bytes. Set to 5.
E	1 bit. SYNC Enable. Operation is described below.
Interval	15 bits. Nominal interval between SYNC messages in 200 usec steps.
MAC SA	48 bits. IEEE 802 MAC address to be used in the source address field.

This AVP is used differently for D-MPT Mode and PSP Mode.

In D-MPT Mode, if E=0, then the EQAM MUST NOT modify the timestamp values in DOCSIS SYNC messages. If E=1, then the EQAM MUST find and correct timestamp values in SYNC messages. The DOCSIS SYNC Interval field is set to all zeros by the M-CMTS Core and ignored by the EQAM. The M-CMTS Core SHOULD set the MAC SA field of this AVP to the MAC address of the DOCSIS interface it has associated with the session. The MAC SA field is ignored by the EQAM.

⁴² Revised this section per DEPI-N-05.0256-4 on 11/21/05.

⁴³ Line added per DEPI-N-06.0308-1 11/26/06, PO.

⁴⁴ Revised this section per DEPI-N-05.0246-3 on 10/28/05.

In PSP Mode, if E=0, then the EQAM MUST NOT transmit a DOCSIS SYNC message. If E=1, then the EQAM MUST insert and send a DOCSIS SYNC message at a nominal interval specified by the Interval field and with a source MAC address specified by the MAC SA field. The EQAM MUST support DOCSIS SYNC Interval values between 0x000A (2 msec) and 0x03E8 (200 msec). Although the measured time between any two SYNC messages might vary depending on traffic, the measured time MUST be within ± 2.5 ms of the nominal value, and MUST NOT exceed the maximum value defined in Annex B. The M-CMTS Core SHOULD set the MAC SA field of this AVP to the MAC address of the DOCSIS interface it has associated with the session. The EQAM MUST use the address in the MAC SA field as the source address in the MAC management header for all subsequent SYNC messages.

The M-CMTS Core MUST use this AVP to convey the treatment of DOCSIS SYNC messages by the EQAM.

7.5.2.6 EQAM Capabilities (ICRP)⁴⁵

0			7	15	23	31
M	H	Resv	Length = 8	Vendor ID = 4491		
Attribute Type = 6				D	EQAM Capabilities Field	

Figure 7-32 - EQAM Capabilities AVP

M 1 bit. The Mandatory bit MUST be set to a 1.⁴⁶

Length 10 bits. Set to 8.

Attribute Type 2 bytes. Set to 6.

Capabilities 2 bytes. EQAM Capabilities Field. Default value of all bits is 0.

- Bit 0 ("D"): A "1" indicates that the EQAM supports DLM-EE-RQ and DLM-EE-RP packets. A "0" indicates the EQAM does not support these two DLM packets.
- Bits 1 through 15: Reserved. Sender must set to 0. Receiver must ignore.

7.5.2.7 DEPI Remote MTU (ICRP)⁴⁷

0			7	15	23	31
M	H	Resv	Length = 8	Vendor ID= 4491		
Attribute Type = 7				DEPI Remote MTU		

Figure 7-33 - DEPI Remote MTU Max Payload AVP

M 1 bit. The Mandatory bit MUST be set to a 1.⁴⁸

Length 10 bits. Set to 8.

Attribute Type 2 bytes. Set to 7.

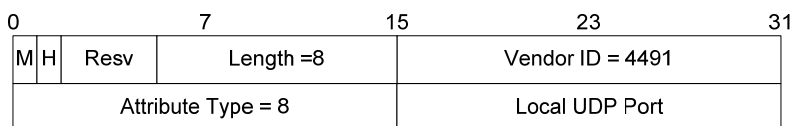
DEPI MTU 2 bytes. In the ICRP message, this is the MTU that the EQAM can receive from the M-CMTS Core on the CIN interface. The MTU is Layer 3 payload of a Layer 2 frame.

⁴⁵ Revised this section per DEPI-N-05.0246-3 on 10/28/05; title changed to ICRP per DEPI-N-06.0307-1; AVP removed from title per DEPI-N-06.0308-1 11/26/06 PO; Revised Figure 7-32 and subsequent text per DEPI-N-06.0349-2 by GO on 1/16/07.

⁴⁶ Line added; Att type modified per DEPI-N-06.0308-1 11/26/06 PO.

⁴⁷ Added this section per DEPI-N-05.0246-3 on 10/28/05.

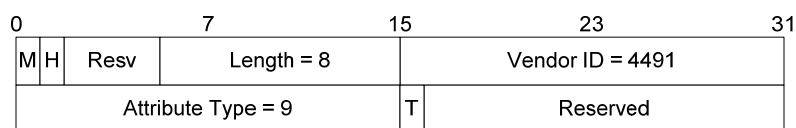
⁴⁸ Line added; Att type modified per DEPI-N-06.0308-1 11/26/06 PO.

7.5.2.8 Local UDP Port (ICRQ)⁴⁹**Figure 7-34 - Local UDP Port AVP**

- M** 1 bit. The Mandatory bit MUST be set to a 1.⁵⁰
- Length** 10 bits. Set to 8.
- Attribute Type** 2 bytes. Set to 8.
- Connect Speed** 16 bits. UDP port to be used for session packets that are being sent to the local LCP.

The M-CMTS Core would issue this AVP during the session setup if UDP is enabled and if the M-CMTS Core wants a data session to use a different UDP port for sending session packets from the EQAM to the M-CMTS Core other than the UDP port that was negotiated during the Control Connection setup.

The M-CMTS Core MAY support the Local UDP Port AVP. The EQAM MAY support the Local UDP Port AVP.

7.5.2.9 DPR Session Type (ICRQ)⁵¹**Figure 7-35 - DPR Session Type AVP**

- M** 1 bit. The Mandatory bit MUST be set to a 1.
- Length** 10 bits. Set to 8.
- Attribute Type** 2 bytes. Set to 9.
- Session Type** 2 bytes. DPR Session Type Field. Default value of all bits is 0.

- Bit 0 ("T"): When M-CMTS Core includes this AVP in the ICRQ message a value of "0" indicates that the session is setup as a primary session. A value of "1" indicates that the session is setup as a secondary session.
- Bits 1 through 15: Reserved. Sender must set to 0. Receiver must ignore.

The DPR Session Type AVP is used to control the type of DEPI sessions when Path Redundancy is deployed. The AVP field includes a single bit "T" at position 0. There are two values defined for the "T" field: "0" designates type as a primary session; "1" designates session type as a secondary session.

⁴⁹ Added this section per DEPI-N-05.0246-3 on 10/28/05.

⁵⁰ Line added per DEPI-N-06.0308-1 11/26/06 PO.

⁵¹ Added per DEPI-N-10.0901-5 on 3/18/10 by JB.

The M-CMTS Core may issue this AVP during the session setup in ICRQ message only if both the M-CMTS Core and the EQAM support Path Redundancy. The M-CMTS Core must exclude this AVP if the EQAM did not indicate support for DPR during control connection establishment.

7.5.2.10 DPR Session Status (SLI)⁵²

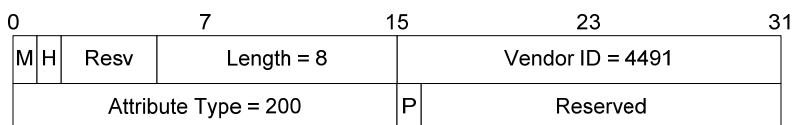


Figure 7–36 - DPR Session Status AVP

- M** 1 bit. The Mandatory bit MUST be set to a 1.
- Length** 10 bits. Set to 8.
- Attribute Type** 2 bytes. Set to 10.
- Session Status** 2 bytes. DPR Session Status Field. Default value of all bits is 0.

- Bit 0 ("S"): A value of "1" indicates that the EQAM intends to shutdown the session. A usage of a value of "0" is undefined.
- Bits 1 through 15: Reserved. Sender must set to 0. Receiver must ignore.

The DPR Session Status AVP can be used by the EQAM to signal to the M-CMTS Core the intent to terminate a session in the near future. The objective of sending an early warning is to allow the M-CMTS core ample time to switch-over the DEPI traffic to an alternate session. This is important in particular when multiple sessions are affected. The AVP field includes a single bit "S" at position 0. When sending this AVP in the SLI message the EQAM must set the value of the bit "S" to one.

The EQAM MAY issue this AVP before terminating the session with a CDN message. This AVP may only be used if both the M-CMTS core and the EQAM support DPR. The EQAM SHOULD send this AVP at least 500ms before issuing the CDN message.

7.5.3 QAM Channel PHY AVPs

The QAM Channel Physical Layer specific AVP types defined for DEPI are shown in Figure 7–5. The range of Attribute Types from 100-199 is reserved for QAM Channel PHY AVPs. These AVPs are only used in L2TP session messages.

Table 7–7 - DEPI Defined QAM Channel PHY AVPs

Attribute Type	Description
100	Downstream QAM Channel TSID Group
101	Downstream QAM Channel Frequency
102	Downstream QAM Channel Power
103	Downstream QAM Channel Modulation
104	Downstream QAM Channel J.83 Annex
105	Downstream QAM Channel Symbol Rate
106	Downstream QAM Channel Interleaver Depth
107	Downstream QAM Channel RF Block Muting ⁵³

⁵² Added per DEPI-N-10.0901-5 on 3/18/10 by JB.

⁵³ DEP-N-06.0309-2 modified last line, 11/26/06, PO.

These AVPs define the generic PHY parameters for a QAM Channel. These AVPs are sent from the EQAM to the M-CMTS Core to inform the M-CMTS Core of the EQAM current configuration and which values are allowed to be changed. This AVP is then sent from the M-CMTS Core to the EQAM to configure selected PHY level parameters.

The following fields have a common meaning across this group of AVPs, and are described once here:

- M** 1 bit. The Mandatory bit **MUST** be set to a 1 for both ICRP and ICCN (if applicable).
- L** 1 bit. Lock bit. This bit allows the EQAM to indicate which elements of the configuration have been locked down in configuration. For ICRP (from EQAM to M-CMTS Core), a value of 0 indicates the parameter described in the Attribute Value field is Read-Only. A value of 1 indicates the parameter is Read/Write. For ICCN (M-CMTS Core to EQAM), this value is set to 0 by the M-CMTS Core and ignored by the EQAM.

TSID Group ID 7 bits. If the referenced attribute is common to other QAM Channels, this field is set to a TSID Group as defined by a TSID Group AVP. Otherwise, this field is set to all zeros.

The AVP programming options listed below in this specification may not be available in all EQAM products. To be considered compliant to the DEPI Specification, an M-CMTS Core or an EQAM **MUST** support a particular QAM Channel AVP attribute only if that attribute represents a feature available on that particular platform.⁵⁴ For example, if an EQAM does not support J.83 Annex C as a feature, then it does not have to support the QAM Channel AVP Annex C attribute value.

7.5.3.1 Downstream QAM Channel TSID Group (ICRP)

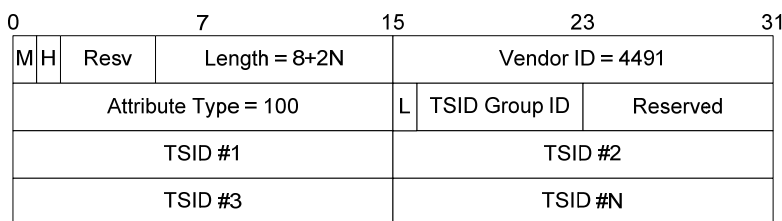


Figure 7–37 - TSID Group AVP

Length 10 bits. Variable. Set to (8 + 2*number of TSID entries).

Attribute Type 2 bytes. Set to 100.

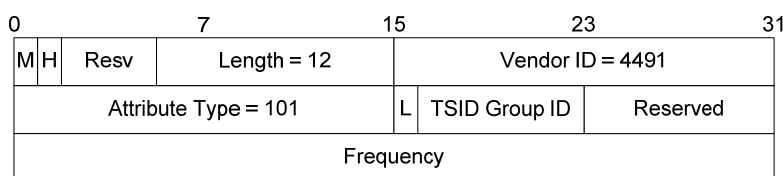
L 1 bit. Lock bit. Not used. Set to 0.

TSID Group ID 7 bits. This is the TSID Group ID that the TSIDs in this list belong to.

TSID #1-N 16 bits. List of TSIDs.

Some PHY level attribute types may be common to more than one QAM Channel. As such, changing that attribute on one QAM Channel may change that attribute on other QAM Channels. The EQAM indicates this dependency by defining TSID groups. This AVP **MAY** be repeated to define more than one TSID Group. Each TSID group is associated with one or more PHY level parameters by including the TSID Group ID within the PHY parameter AVP.

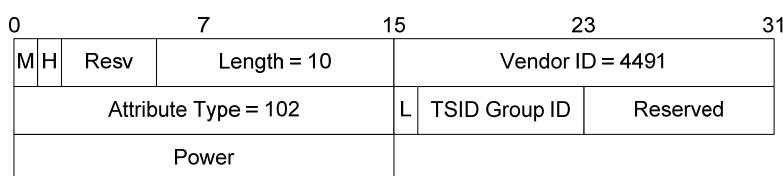
⁵⁴ DEPI-N-06.0307-1 changed a to an, 11/26/06, PO.

7.5.3.2 Downstream QAM Channel Frequency (ICRP, ICCN, SLI)**Figure 7–38 - Frequency AVP**

Length 10 bits. Set to 12.

Attribute Type 2 bytes. Set to 101.

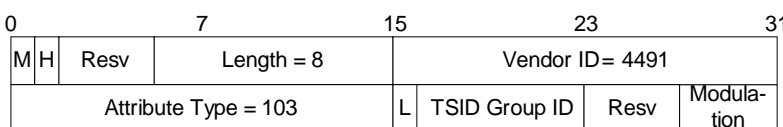
Frequency 4 bytes. This specifies the downstream frequency of a QAM Channel. This is the center frequency of the downstream channel in Hz stored as a 32-bit binary number.

7.5.3.3 Downstream QAM Channel Power (ICRP, ICCN, SLI)**Figure 7–39 - Power AVP**

Length 10 bits. Set to 10.

Attribute Type 2 bytes. Set to 102.

Power 2 bytes. TX Power in dBmV (unsigned 16-bit, 0.1-dB units)

7.5.3.4 Downstream QAM Channel Modulation (ICRP, ICCN, SLI)**Figure 7–40 - Modulation AVP**

Length 10 bits. Set to 8.

Attribute Type 2 bytes. Set to 103.

Modulation 4 bits. This indicates the modulation type of the downstream QAM Channel. The values of this field are:

0 = 64-QAM

1 = 256-QAM

2-15 = reserved

7.5.3.5 Downstream QAM Channel J.83 Annex (ICRP, ICCN, SLI)

0	7	15	23	31
M	H	Resv	Length = 8	
Attribute Type = 104			Vendor ID = 4491	
			L	TSID Group ID
			Resv	J.83 Annex

Figure 7-41 - J.83 Annex AVP

Length 10 bits. Set to 8.

Attribute Type 2 bytes. Set to 104.

J.83 4 bits. This indicates the Annex of [ITU-T J.83] to be used on the downstream QAM Channel. The J.83 Annex defines the values of:

- Alpha (which in turn is dependent upon the choice of modulation)
- Forward Error Correction Frame Sync on/off
- Forward Error Correction Parity Bytes
- Trellis Coding enabled/disabled

The values of this field are:

0 = Annex A / DVB EN-300429

1 = Annex B

2 = Annex C

3-15 = reserved

Note that a particular EQAM might only support a subset of the attribute values listed above. For more information, refer to [DRFI].

7.5.3.6 Downstream QAM Channel Symbol Rate (ICRP, ICCN, SLI)

0	7	15	23	31
M	H	Resv	Length = 8+4*N	
Attribute Type = 105			Vendor ID = 4491	
			L	TSID Group ID
			Reserved	
M			N	
M			N	

Figure 7-42 - Symbol Rate AVP

Length 10 bits. Set to 8 plus 4 times the number of M/N pairs.

Attribute Type 2 bytes. Set to 105.

M 2 bytes. Numerator of frequency to symbol co-efficient.

N 2 bytes. Denominator of frequency to symbol co-efficient.

The downstream symbol rate is set by choosing the appropriate values for M and N such that:

$$\text{Symbol Rate (Msps)} = 10.24 \text{ MHz} * M / N$$

In the ICRP message, the EQAM MUST list all the M and N value pairs that it has been configured to support. The EQAM MAY include a M/N pair, each with a value of 0xFFFF, to indicate that the EQAM has a variable symbol rate capability. In that case, the M-CMTS Core can request a value of M and N that the M-CMTS Core has been configured to use. Note that the lock bit is asserted when the M/N values are pre-configured, and de-asserted when a variable symbol rate capability is indicated.

If the EQAM has not been configured with M and N values and does not support a variable symbol rate option, then the EQAM MUST reject the session setup, and return the appropriate error code.

In the ICCN message, the M-CMTS Core MUST select one of those M and N pairs to indicate to the EQAM what symbol rate to use. The M-CMTS Core will subsequently use the values of M and N in the UCD MAC management message.

It should be noted that in operational scenarios where multiple downstreams may be used as sources of synchronization for CMs that drive a common upstream, that those multiple downstreams will have to provide the same M/N values since the single M-CMTS Core upstream receiver can only operate with one M/N value.

7.5.3.7 Downstream QAM Channel Interleaver Depth (ICRP, ICCN, SLI)

0	7	15	23	31
M	H	Resv	Length = 10	
Attribute Type = 106			L	TSID Group ID
I		J		

Figure 7-43 - Interleaver Depth AVP

Length 10 bits. Set to 10.

Attribute Type 2 bytes. Set to 106.

I 1 byte. This indicates the I value of the interleaver depth of the downstream QAM Channel.

J 1 byte. This indicates the J value of the interleaver depth of the downstream QAM Channel.

7.5.3.8 Downstream QAM RF Block Muting (ICRP, ICCN)⁵⁵

0	7	15	23	31
M	H	Resv	Length = 8	
Attribute Type = 107			L	TSID Group ID
		U	QAM Ch Status	

Figure 7-44 - RF Mute AVP

Length 10 bits. Set to 8.

Attribute Type 2 bytes. Set to 107.

QAM Ch Status 1 byte. Bit 0 ("U") = 0 to unmute the RF output of an entire block of QAM Channels. Bit 0 = 1 to mute the RF output of an entire block of QAM Channels. Bits 7-1 are reserved. They should be set to 0 when transmitted and ignored when received. The block of QAM Channels affected by this command corresponds to the TSID Group indicated in this AVP.

7.5.4 DEPI Redundancy Capabilities AVPs⁵⁶

The AVP types defined specifically for DEPI redundancy are shown in Table below. The range of Attribute Types from 200-220 is reserved for DEPI Redundancy Capabilities Specific AVPs.

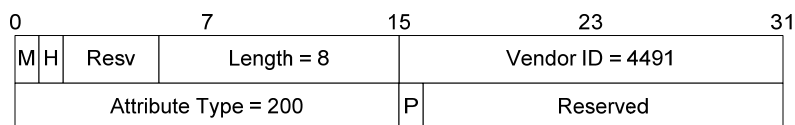
Table 7-8 - DEPI Defined Redundancy APVs

Attribute Type	Description
200	DEPI Redundancy Capabilities

This an optional AVP is used to negotiate DEPI redundancy capabilities between the M-CMTS Core and the EQAM.

⁵⁵ DEP-N-06.0309-2 modified tile and QUAM def, 11/26/06, PO; Revised Figure 7-42 and subsequent text per DEPI-N-06.0349-2 by GO on 1/16/07.

⁵⁶ Revised per DEPI-N-10.0901-5 on 3/18/10 by JB.

7.5.4.1 DEPI Redundancy Capabilities (SCCRQ, SCCRP)⁵⁷**Figure–7-45 - DEPI Redundancy Capabilities AVP**

M	1 bit. The Mandatory bit MUST be set to a 0.
Length	10 bits. Set to 8.
Attribute Type	2 bytes. Set to 200.
Redundancy Capabilities	2 bytes. DEPI HA Capabilities Field. Default value of all bits is 0.

- Bit 0: ("P") A "1" indicates that the CMTS Core or the EQAM supports DPR. A "0" indicates that the CMTS Core or the EQAM does not support DPR.
- Bits 1 through 15: Reserved. Sender must set to 0. Receiver must ignore.

This AVP is used in negotiate DEPI redundancy capabilities. It MAY be supported by the CMTS core. This AVP MAY be supported by the EQAM.

The AVP is sent in the SCCRQ by the M-CMTS Core with "P" bit set to "1" when the M-CMTS Core supports DPR. If the EQAM supports DPR it includes DEPI Redundancy Capabilities AVP with the "P" bit set to one in SCCRP. If the EQAM does not support DPR the EQAM may return SCCRP without the DEPI Redundancy Capabilities AVP or return the AVP with the "P" bit set to "0".

⁵⁷ Revised per DEPI-N-10.0901-5 on 3/18/10 by JB.

8 DEPI FORWARDING PLANE

NOTE: This section is normative.

The DEPI protocol uses the L2TPv3 protocol over IP either with or without a UDP header. The choice of whether to use a UDP header is based upon system configuration and is the same choice for both the control messages and data messages.

Within the L2TPv3 payload, there are two types of payloads used for DEPI. The first is a MPEG Transport Stream (D-MPT) based format and the second is a Packet Streaming Protocol (PSP) based format. The choice of which format to use is based upon the type of traffic being carried and the capabilities negotiated between the M-CMTS Core and the EQAM.

8.1 L2TPv3 Transport Packet Format

This section describes the various fields of the L2TPv3 packet as it applies to DEPI. The outer encapsulation of the L2TPv3 datagram is shown with a UDP header in Figure 8–1 and without a UDP header in Figure 8–2.

8.1.1 Data Message with a UDP Header

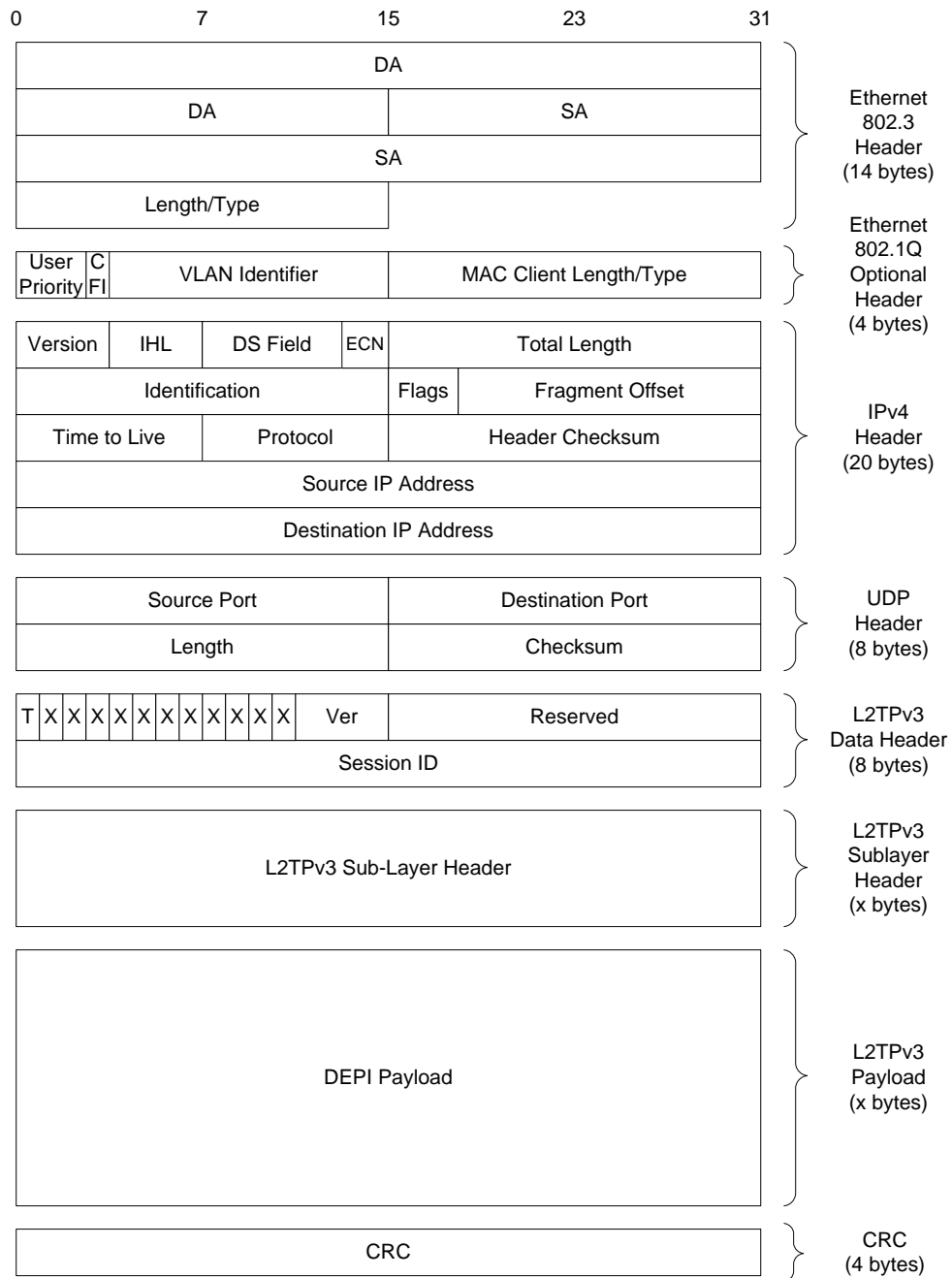


Figure 8–1 - L2TPv3 Data Packet Outer Encapsulation with UDP

8.1.2 Data Message without a UDP Header

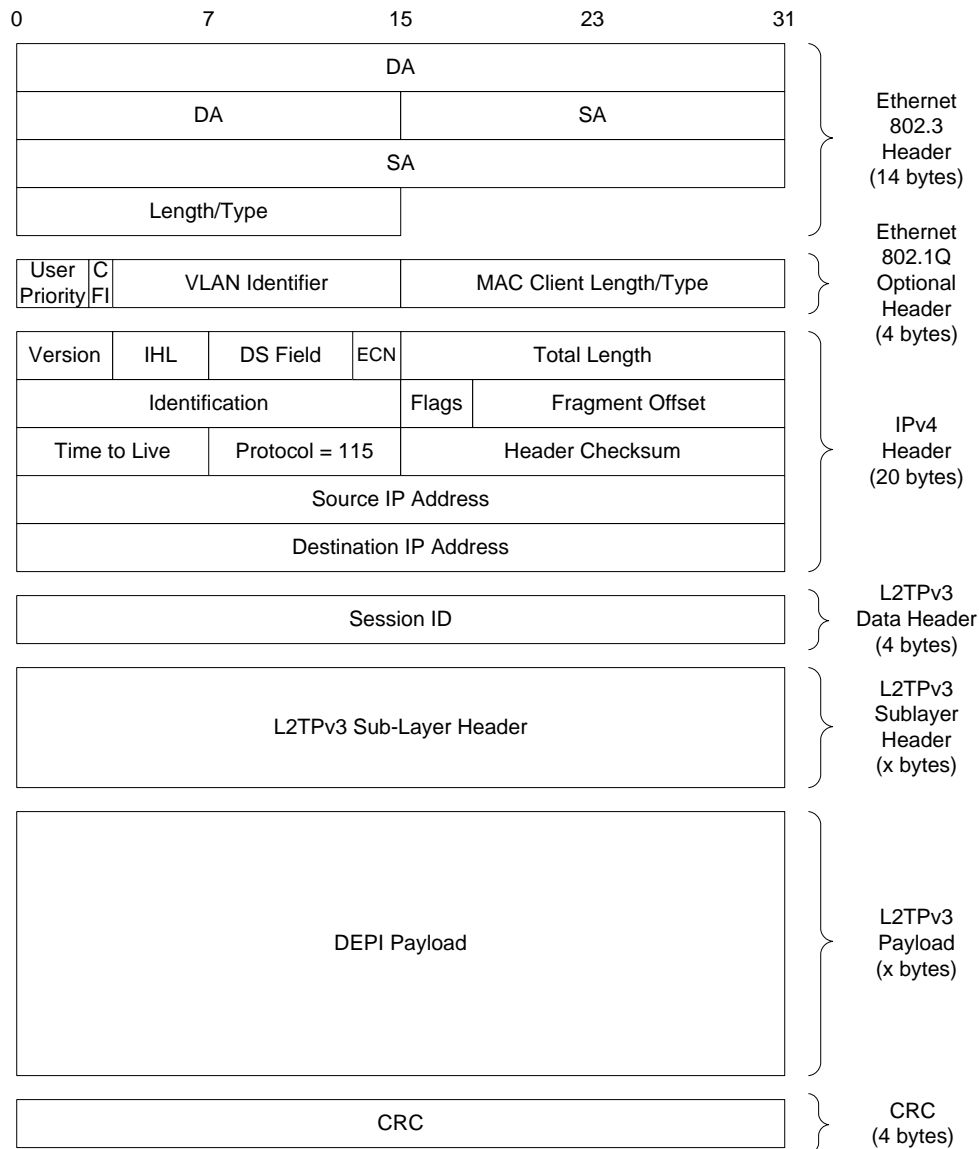


Figure 8–2 - L2TPv3 Data Packet Outer Encapsulation without UDP

8.1.3 Specific Headers for Data Messages

8.1.3.1 L2TPv3 Data Header

The L2TPv3 fields as defined by [RFC 3931] are used as follows:

T	Transport bit. 1 bit. Set to 0 to indicating that this is a data message
X	Reserved bits. 11 bits. Set to 0 by M-CMTS Core; ignored by EQAM.
Version	Version Field. 4 bits. Set to 3.
Reservation	Reserved field. 16 bits. Not used. Set to 0 by M-CMTS Core; ignored by EQAM.
Session ID	Session Identifier. 32 bits. This value is negotiated by the L2TPv3 control plane.

The L2TPv3 cookie field is not required to be supported in DEPI.

The M-CMTS Core MUST support the L2TPv3 data header. The EQAM MUST support the L2TPv3 data header.

8.1.3.2 L2TPv3 DEPI Sub-Layer Header

DEPI supports two pseudowire types. The first type, known as D-MPT, is used for transporting MPEG packets. The second type, known as PSP, is used for transporting DOCSIS frames. Each pseudowire type has a unique L2TPv3 DEPI sub-layer header format. The fields of these sub-layer headers are defined in Sections 8.2 and 8.3.

Additionally, both pseudowire types support a latency measurement sub-layer header, the fields of which are defined in Section 8.4.

The M-CMTS Core MUST use the appropriate DEPI Sub-layer header for the pseudowire type of the DEPI session.

The EQAM MUST accept packets from the M-CMTS Core that contain the appropriate DEPI sub-layer header for the negotiated pseudowire type. The EQAM MUST send a CDN message to tear down a session in which packets are received with the wrong pseudowire type. The EQAM MUST ignore packets received that do not comply with these L2TPv3 DEPI sub-layer header definitions.

8.1.3.3 DEPI Payload

The payload contains one or more segments. In D-MPT mode, each segment is a 188 byte MPEG packet. In PSP mode, a segment contains either a full DOCSIS frame or a partial DOCSIS frame.

8.2 DOCSIS MPT Sub-Layer Header⁵⁸

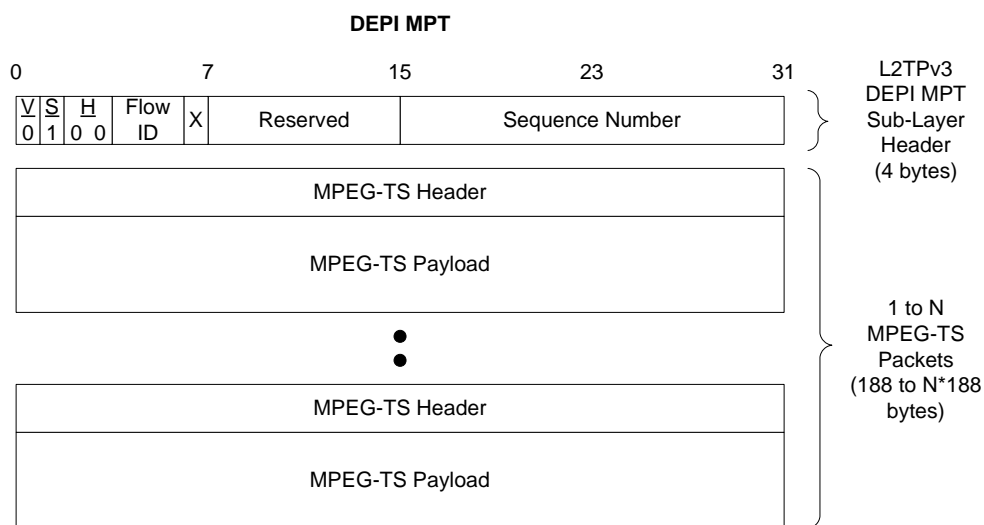


Figure 8–3 - DOCSIS MPT Sub-layer Header and Payload

V	1 bit. VCCV bit. Set to 0. Reserved for compatibility with [RFC 5085].
S	1 bit. Sequence bit. Set to 1 to indicate that the sequence number field is valid. Set to 0 to indicate that the sequence field is not valid.
H	2 bits. Extended Header bits. Set to '00' to indicate a DEPI sub-layer header which matches the current active pseudowire type (either D-MPT or PSP).
X	1 bit. Reserved bit. Set to all zeros at the transmitter, ignored at the receiver.
Flow ID	3 bits. Flow Identifier.

⁵⁸ Title and text following H modified per DEPI-N-06.0207-1, 11/26/06, PO.

Reserved	1 byte. Reserved field. Set to all zeros at the transmitter, ignored at the receiver.
Seq Num	2 bytes. Sequence Number. The sequence number increments by one for each data packet sent, and may be used by the receiver to detect packet loss. The initial value of the sequence number SHOULD be random (unpredictable).

The M-CMTS Core MUST NOT put stuffing bytes between the UDP header and the first MPEG-TS header or between consecutive MPEG-TS packets. The M-CMTS Core MUST support all bits in the MPT sub-layer header.

The EQAM MUST accept one to seven MPEG-TS packets in a L2TPv3 payload when the path MTU is 1500 bytes in length. The length of an Ethernet frame containing seven MPEG-TS packets with L2TPv3 with a D-MPT L2TPv3 sublayer, UDP, IPv4, 802.1Q headers is 1378 bytes. If the EQAM, the M-CMTS Core, and the network between them all allow larger MTU sizes, the M-CMTS Core MAY increase the total number of MPEG-TS packets transmitted per L2TP packet.⁵⁹

The M-CMTS Core MAY insert null MPEG packets into the D-MPT stream. A null MPEG packet is 188 bytes in length with a reserved PID value of 0x1FFF as defined in [ISO 13818]. The EQAM MAY discard these null MPEG packets. The EQAM is only required to support one flow for MPT mode.

8.3 PSP Sub-Layer Header⁶⁰

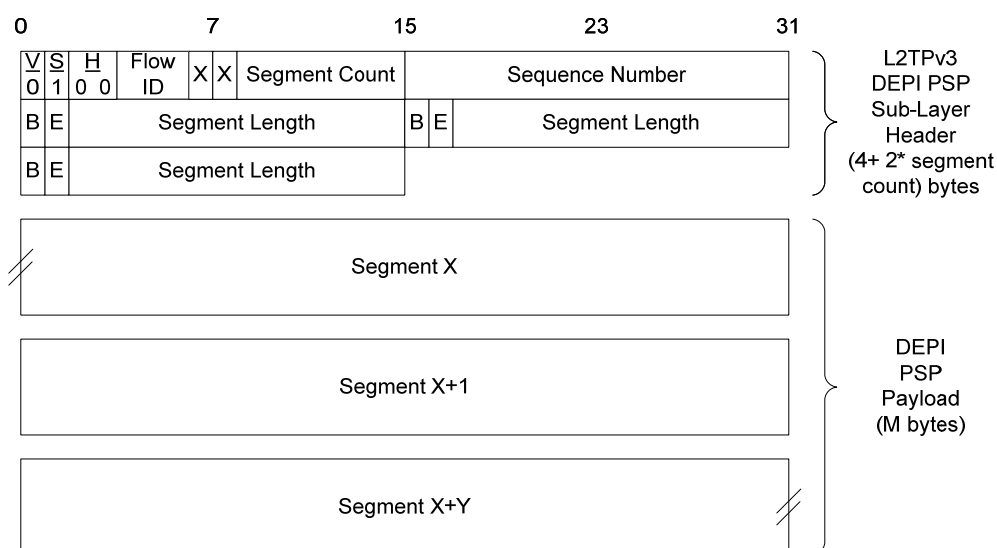


Figure 8-4 - DEPI PSP Sub-layer Header and Payload

V	1 bit. VCCV bit. Set to 0. Reserved for compatibility with [RFC 5085].
S	1 bit. Sequence bit. Set to 1 to indicate that the sequence number field is valid. Set to 0 to indicate that the sequence field is not valid.
H	2 bits. Extended Header bits. Set to '00' to indicate a DEPI sub-layer header which matches the current active pseudowire type (either D-MPT or PSP).
X	1 bit. Reserved bit. Set to all zeros at the transmitter, ignored at the receiver.
Flow ID	3 bits. Flow Identifier.
Segment Count	7 bits. This is the number of segments in the DEPI PSP Payload, and this is also the number of 2 byte entries in the PSP Segment Table.

⁵⁹ Revised the first requirement in this paragraph per DEPI-N-05.0256-4 on 11/21/05.

⁶⁰ Title and text following H modified per DEPI-N-06.0207-1, 11/26/06, PO.

- Seq Num** 2 bytes. Sequence Number. The sequence number increments by one for each data packet sent, and may be used by the receiver to detect packet loss. The initial value of the sequence number SHOULD be random (unpredictable).
- B** Begin bit. 1 bit. Set to a 1 to indicate that the PSP Frame contains the beginning of a DOCSIS frame. Otherwise, set to 0.
- E** End bit. 1 bit. Set to a 1 to indicate that the PSP Frame contains the end of a DOCSIS frame. Otherwise, set to 0.

Segment Length 14 bits. Length of DEPI segment in bytes.

The Packet Streaming Protocol can take a series of DOCSIS frames, assemble them into a stream of back to back DOCSIS frames, and then split that stream up into PSP PDUs. In doing so, the first and last DOCSIS frame of a PSP PDU may be split into segments across PSP PDUs. DOCSIS frames which are not the first or last frame in a PSP PDU will not be split. A DOCSIS frame may be split into more than two segments and therefore may be spread across more than two PSP PDUs.

The Segment Table provides information on the contents in each of the subsequent PSP frames. This includes signifying if the frame is the beginning, middle, end, or an entire DOCSIS frame.

8.4 DEPI Latency Measurement (DLM) Sub-Layer Header

The DEPI Latency Measurement (DLM) Sub-Layer Header is used by the M-CMTS Core and the EQAM to measure the delay and latency of the CIN. This measurement is important as the transition network has the potential to affect the latency budgets already established in [RFI2.0] for legacy DOCSIS 1.x and 2.0 devices. To perform this measurement, a packet is sent using the DEPI Latency Measurement Sub-Layer Header (shown in Figure 8–5) to which the receiver responds. This sub-layer header is designed to be used within any active L2TPv3 session between the M-CMTS and the EQAM. It may be used with both MPT and PSP Pseudowire types. It is anticipated that this particular message exchange may occur between hardware mechanisms at either end of the DEPI interface.

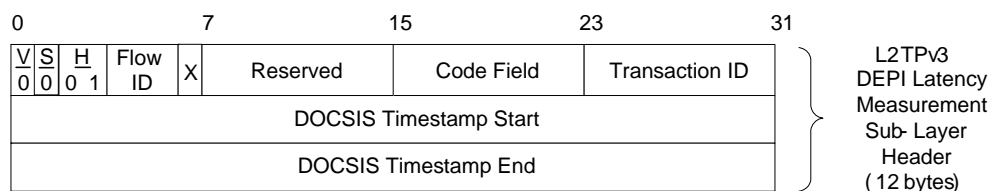


Figure 8–5 - DLM Sub-Layer Header⁶¹

- V** 1 bit. VCCV bit. Set to 0. Reserved for compatibility with [RFC 5085].
- S** 1 bit. Sequence bit. Set to 0.
- H** 2 bits. Extended Header bits. Set to '01' to indicate the presence of the latency measurement sub-layer header. ⁶²
- X** 1 bit. Reserved bit. Set to all zeros at the transmitter, ignored at the receiver.
- Flow ID** 3 bits. Flow Identifier.
- Reserved** 1 byte. Reserved field. Set to all zeros at the transmitter, ignored at the receiver.
- Code Field** 1 byte. The permitted values are described below:

⁶¹ Revised this figure per DEPI-N-05.0246-3 on 10/28/05.

⁶² DEPI-N-06.0307-1, 11/26/06, PO.

- A value of 0 indicates a DLM-EI-RQ (DLM EQAM Ingress Request) packet originated by the M-CMTS Core requesting a measurement to be made at reference point adjacent to the DEPI ingress port of the EQAM.
- A value of 1 indicates a DLM-EI-RP (DLM EQAM Ingress Reply) packet originated by the EQAM with a Timestamp End value calculated at reference point adjacent to the DEPI ingress port of the EQAM.
- A value of 2 indicates a DLM-EE-RQ (DLM EQAM Egress Request) packet originated by the M-CMTS core requesting a measurement to be made at reference point adjacent to the DEPI egress port of the EQAM.
- A value of 3 indicates a DLM-EE-RP (DLM EQAM Egress Reply) packet originated by the EQAM with a Timestamp End value calculated at reference point adjacent to the DEPI egress port of the EQAM.
- The values of 4 through 255 are reserved.

Transaction ID 1 byte. This is a unique ID assigned by the sender and returned by receiver. The transaction ID is unique per transaction.⁶³

Timestamp Start 4 bytes. Timestamp sent by sender.

Timestamp End 4 bytes. Timestamp existing at the receiver.

The M-CMTS Core MUST support the sending of a DLM-EI-RQ packet and the receiving of a DLM-EI-RP packet. The M-CMTS Core MAY support the sending of a DLM-EE-RQ packet and the receiving of a DLM-EE-RP packet. The CMTS Core (Sender) MUST send the DLM packet to the EQAM on an existing DEPI Session flow (either PSP or MPT). The M-CMTS Core MUST set the proper DSCP values for the DLM packet based on the DEPI Session being measured. The M-CMTS Core MUST provide a configuration mechanism to set the sampling interval through the M-CMTS Core MIB.

The M-CMTS Core MUST report delta measurements that exceed a configured threshold through the M-CMTS Core MIB. The M-CMTS Core MUST NOT send a DLM-EI-RQ or DLM-EE-RQ packet to a particular DEPI session, if there is already a DLM-EI-RQ or DLM-EE-RQ outstanding for that session, or if a DOCSIS frame on that flow has been segmented and the complete DOCSIS frame has not been sent. The M-CMTS Core MUST place the current DOCSIS 32-bit timestamp value in the Timestamp Start field of the message. The M-CMTS Core SHOULD use a timestamp value that is accurate to within a 100 μ s of the current timestamp as derived from DTI.

The EQAM MUST support the receiving of a DLM-EI-RQ packet and the sending of a DLM-EI-RP packet. The EQAM MAY support the receiving of a DLM-EE-RQ packet and the sending of a DLM-EE-RP packet. The EQAM MUST support the use of the DLM packet within any active DEPI session. The EQAM is not required to support more than one concurrent latency measurement per session. The EQAM MUST ensure that timestamp value inserted in the Timestamp End field is accurate to within 100 μ s of the current timestamp used for SYNC insertion/correction.

For DLM-EI-RQ packets, the EQAM MUST perform the Timestamp insertion prior to queuing the DEPI frame on the MPT or PSP QoS queues. For DLM-EE-RQ packets, if supported, the EQAM MUST perform the Timestamp insertion at the point where the SYNC message is originated. This is outlined in Figure 6–1. The EQAM MUST send the completed Latency Measurement Packet back to the M-CMTS Core that originated the measurement request, and do so with the EQAM DLM Timer value specified in Annex B.

An EQAM that does not support a DLM-EE-RQ packet MUST silently discard the DLM packet without generating a response packet.⁶⁴

⁶³ DEPI-N-06.0307-1, 11/26/06, PO.

⁶⁴ Editorially separated the previous paragraphs for ease of use per DEPI-N-05.0259-3 on 11/11/05.

8.5 M-CMTS Core Output Rate

It is possible that if the M-CMTS Core was to send at data rate which exactly equaled the payload rate of the downstream QAM, and those packets were subject to jitter, that the EQAM would insert an MPEG-TS Null. Once the packets from the M-CMTS Core arrived, there would be an output queue delay that would equal the worst case jitter present at the DEPI input of the EQAM. That queuing delay would not be removed until the input to the EQAM was interrupted and the internal queue was drained. Further, the rate at which this delay is removed is related to the amount of jitter the input stream has, the peak input rate, and the maximum burst size of the input stream.

The M-CMTS Core **MUST** be able to rate limit the aggregate of all DEPI flows, including any null MPEG packets that the M-CMTS Core may have inserted, that are destined to the same QAM Channel within an EQAM.⁶⁵ The peak rate of this aggregate **MUST** be configurable to be a percentage of the QAM Channel payload. The burst size of this aggregate **MUST** be configurable. The default burst size of the aggregate **MUST** be the equivalent of three frames per DEPI session. (For a frame size of 1522 bytes, this would be 4566 bytes).

⁶⁵ DEPI-N-06.0307-1, 11/26/06, PO.

Annex A DEPI MTU⁶⁶

A.1 L2TPv3 Lower Layer Payload Size

Typically an interface calculates its default maximum payload size by asking the interface below it in the interface column what its maximum payload size and considering its own encapsulation. For example, by default, Ethernet has a frame size of 1518 (without VLANs). The Ethernet encapsulation is 18 bytes, leaving 1500 bytes of payload (MTU) to its upper layer. IP then subtracts the IP header size (typically 20 bytes) to arrive at 1480 bytes available to its upper layer. As an example of D-MPT over UDP, UDP must then subtract the UDP header size of 8 bytes, arriving at a payload of 1472 bytes. L2TPv3 must subtract the L2TPv3 Data Session Header size in bytes (8), the L2SS D-MPT header of 4 bytes, and calculate its payload as the remainder (typically 1460). This remainder is the defined maximum payload size for an L2TPv3 session that would exist over Ethernet/IP/UDP/L2TPv3. For D-MPT without UDP, the remainder becomes 1472 bytes, because there is no UDP header and the L2TPv3 Data Session Header is 4 bytes. For PSP, the PSP header including the maximum PSP segment table size needs to be taken into account.⁶⁷

A.2 Maximum Frame Size for DEPI

This Annex documents the maximum frame size of DEPI when a PSP Pseudowire is used without fragmenting or concatenation.

Table A-1 - MTU of DEPI

Field				Size	
DEPI Frame	Ethernet Header			14 bytes	
	802.1Q Header			4 bytes	
	DEPI MTU	IPv4 Header*		20 bytes	
		UDP Header**		8 bytes	
		L2TPv3 Header**		8 bytes	
		DEPI-PSP Header***		6 bytes	
		DOCSIS Frame	DOCSIS Header****		6-246 bytes
			Ethernet Header		14 bytes
			802.1Q Header		4 bytes
			Ethernet PDU		1500 bytes
			Ethernet CRC		4 bytes
	Ethernet CRC			4 bytes	
Total with PSP, no UDP, IPv4, no VLAN			1570 to 1862		
Total with PSP, UDP, IPv4, no VLAN			1582 to 1874		

* Currently, this specification only requires support for IPv4. If IPv6 were to be used for transport, then value should be increased by an additional 20 bytes plus the length of any IPv6 Extension Headers.

** The higher values correspond to the use of a UDP Header, and the lower values to the lack of a UDP encapsulation.

*** A PSP header is 4 bytes plus 2 bytes for each segment. Only one segment is shown. (A D-MPT header is 4 bytes.)

**** A typical DOCSIS header with BPI and no other extended headers is 11 bytes.

Only one PSP segment is included in the above calculations for simplicity. Additional segments would be needed when PSP is concatenating or fragmenting. Note that a 1500 byte payload in a PSP frame could contain as many as

⁶⁶ Revised this Annex per DEPI-N-05.0256-4 on 11/21/05.

⁶⁷ Revised this paragraph per DEPI-N-06.0305-2, 11/22/06, PO.

20 uncompressed TCPs ACKs (64 byte Ethernet packets plus 6 to 11 bytes of DOCSIS OH) which could create as many as 22 segments (first and last packets are fragmented) which would create a segment table size of 44 bytes, in addition to the standard 4 byte PSP header. For other payload types such as VoIP packets with high codec compression and with PHS enabled, or with larger MTUs, the number of segments could be even higher.⁶⁸

A.3 Path MTU Discovery

Path MTU Discovery relies on the fact that the network elements between the M-CMTS Core and the EQAM all support this protocol [RFC 1191]. If these network elements do not support Path MTU Discovery then this mechanism cannot be used and the static configuration option should be used instead.

Path MTU Discovery (PMTUD) works when the IP path MTU between the M-CMTS Core and the EQAM is less than the total IP datagram size generated when using the payload size negotiated during L2TPv3 session establishment, and the Don't Fragment (DF) bit is set in the IP header. In this circumstance, when the M-CMTS Core sends packets larger than the network can support, then network elements between the M-CMTS Core and the EQAM may generate an ICMP Destination Unreachable message with the code "fragmentation needed and DF set" (ICMP Type 3 code 4, also referred to as "Datagram Too Big" message), as per [RFC 791], toward the source of the tunneled packet, if ICMP unreachables are allowed.

This ICMP error message includes at least the IP header and the next 8 bytes of the IP data (corresponding to the UDP header when using L2TPv3 over UDP, or to the Session ID and first 4 bytes of the L2SS when using L2TPv3 over IP) from the offending packet. The M-CMTS Core and the EQAM should have a way to map the source and destination IP address contained in the IP Header embedded in the ICMP Data to an L2TP Control Connection. Note that from [RFC 1191], a "PMTU is associated with a path, which is a particular combination of IP source and destination address and perhaps a Type-of-service (TOS)". Upon successfully processing the ICMP Destination Unreachable message, the M-CMTS Core and EQAM should reduce the Max Payload of all the sessions associated with the control connection mapped from the ICMP Destination Unreachable message to the size requested in the Next-Hop MTU field of the message. Both the Max Payload and the size contained in the Next-Hop MTU field express a Layer 3 payload of a Layer 2 frame, including the IP header and IP data. The Max Payload MUST NOT be increased by receiving an ICMP Destination Unreachable message. The M-CMTS Core and EQAM may periodically attempt to increase the Max Payload of the session to its negotiated maximum and restart this process in case the path through the network has changed and large MTUs are allowed. This technique is described in [RFC 1191]. The Max Payload size learned through this process will never be greater than the negotiated maximum learned during session establishment. The Path MTU Discovery procedures for IP version 6 are described in [RFC 1981].⁶⁹

⁶⁸ Section and preceding table modified per DEPI-N-06.0305-2, 11/22/06, PO.

⁶⁹ A.3 revised per DEPI-N-0305-2, 11/27/06, PO.

Annex B Parameters and Constants ⁷⁰

Table B-1 - Parameters and Constants

System	Name	Time Reference	Minimum Value	Default Value	Maximum Value
M-CMTS Core, EQAM	SYNC Interval	Nominal time between transmission of SYNC messages			200 ms
M-CMTS Core, EQAM	HELLO Timer	L2TPv3 section 4.4		60 sec	
M-CMTS Core, EQAM	Control Message Timeout	L2TPv3 section 4.2	First attempt: 1 sec, then second attempt 2 sec, then third attempt: 4 sec, then each additional attempt: 8 sec.		
M-CMTS Core, EQAM	Control Message Retry Count	L2TPv3 section 4.2			10
M-CMTS Core, EQAM	StopCCN Timeout	L2TPv3 section 3.3.2	31 sec		
EQAM	EQAM DLM Timer	Time between receipt and retransmission of a DLM packet.			100 ms
EQAM	EQAM DPR Forewarning Interval	Time between transmission of SLI message with DPR Session Status AVP and session termination via CDN.	500ms		

⁷⁰ Revised per DEPI-N-10.0901-5 on 3/18/10 by JB.

Annex C DOCS-IF-M-CMTS-MIB (normative)⁷¹

DOCS-IF-M-CMTS-MIB DEFINITIONS ::= BEGIN

IMPORTS

```

MODULE-IDENTITY,
OBJECT-IDENTITY,
OBJECT-TYPE,
Unsigned32,
Integer32,
Gauge32,
Counter32,
TimeTicks
                                FROM SNMPv2-SMI

TimeStamp,
TruthValue,
RowStatus,
StorageType,
AutonomousType,
TEXTUAL-CONVENTION
                                FROM SNMPv2-TC

OBJECT-GROUP,
MODULE-COMPLIANCE
                                FROM SNMPv2-CONF

SnmpAdminString
                                FROM SNMP-FRAMEWORK-MIB

PhysicalIndexOrZero,
PhysicalIndex
                                FROM ENTITY-MIB

ifIndex,
InterfaceIndex,
InterfaceIndexOrZero
                                FROM IF-MIB

TenthdBmV
                                FROM DOCS-IF-MIB

docsQosServiceFlowId
                                FROM DOCS-QOS-MIB

SnmpTagValue
                                FROM SNMP-TARGET-MIB

InetAddressType,
InetAddress,
InetPortNumber
                                FROM INET-ADDRESS-MIB

clabProjDocsis
                                FROM CLAB-DEF-MIB;

```

docsIfMcmtsMib MODULE-IDENTITY

```

LAST-UPDATED      "200812090000Z" -- December 9, 2008
ORGANIZATION      "Cable Television Laboratories, Inc"
CONTACT-INFO
    "Postal: Cable Television Laboratories, Inc.
     858 Coal Creek Circle
     Louisville, Colorado 80027-9750
     U.S.A.
     Phone: +1 303-661-9100
     Fax:   +1 303-661-9199
     E-mail: mibs@cablelabs.com"
DESCRIPTION

```

⁷¹ Annex added per DEPI-N-08.0696-2.

"This MIB module contains the management objects for the configuration and management of the External PHY interface (DEPI) of the M-CMTS architecture (Modular CMTS).

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REVISION "200812090000Z" -- December 9, 2008

DESCRIPTION

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and published as CM-SP-DEPI-I06-081209."

REVISION "200712060000Z" -- December 6, 2007

DESCRIPTION

"Revised Version includes ECN M-OSSI-N-07.0562-5 and
and published as I07."

REVISION "200705180000Z"

DESCRIPTION

"Revised Version includes ECN M-OSSI-N-07.0419-3 and
ECN M-OSSI-N-07-0398-1 and published as I05."

REVISION "200702230000Z"

DESCRIPTION

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and published as I04."

REVISION "200511160000Z"

DESCRIPTION

"Revised Version
includes ECN M-OSSI-N-05.0254-5"

REVISION "200508050000Z"

DESCRIPTION

"Initial version of the DOCSIS Modular CMTS MIB
module.
This revision is published as part of the CableLabs
M-CMTS OSS specification"

::= { clabProjDocsis 6 }

-- -----
-- Textual Conventions
-- -----

ClDotIdUserPriority ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"A 3-bit priority ID used in the IEEE 802.1q packet header."

SYNTAX INTEGER (0..7)

DepiFlowId ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"A 3-bit DEPI flow ID used in the DEPI sublayer header."

SYNTAX INTEGER (0..7)

VlanId ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"A 12-bit VLAN ID used in the VLAN Tag header."

SYNTAX INTEGER (1..4094)

```

-----
-- Main Groups
-----

docsIfMCmtsNotifications OBJECT IDENTIFIER ::= { docsIfMCmtsMib 0 }
docsIfMCmtsObjects       OBJECT IDENTIFIER ::= { docsIfMCmtsMib 1 }
docsIfMCmtsBaseObjects   OBJECT IDENTIFIER ::= { docsIfMCmtsObjects 1 }
docsIfMCmtsCoreObjects   OBJECT IDENTIFIER ::= { docsIfMCmtsObjects 2 }
docsIfMCmtsEqamObjects   OBJECT IDENTIFIER ::= { docsIfMCmtsObjects 3 }
docsIfMCmtsDepiObjects   OBJECT IDENTIFIER ::= { docsIfMCmtsObjects 4 }

docsIfMCmtsDepiSessionObjects OBJECT IDENTIFIER ::=
                                { docsIfMCmtsDepiObjects 1 }
docsIfMCmtsDepiQosObjects   OBJECT IDENTIFIER ::=
                                { docsIfMCmtsDepiObjects 2 }

-----
-- DOCSIS RF Interface Extension objects
-- M-CMTS Base Extensions
-----

-----
--
-- Phy Parameters dependencies OBJECT-IDENTITY definitions
-----

docsIfMCmtsBaseAdmin OBJECT-IDENTITY
    STATUS      current
    DESCRIPTION
        "Registration point for M-CMTS characterization of PHY
        parameters dependencies."
    ::= { docsIfMCmtsBaseObjects 1 }

docsPHYParamFixValue OBJECT-IDENTITY
    STATUS      current
    DESCRIPTION
        "Indicates that this PHY parameter is fix and cannot
        be changed."
    ::= { docsIfMCmtsBaseAdmin 1 }

docsPHYParamSameValue OBJECT-IDENTITY
    STATUS      current
    DESCRIPTION
        "Indicates that the PHY parameter value is the same for
        the elements in a dependency group; thus, a change in
        the PHY parameter of an element in the group will change
        the PHY parameter value in the other elements of the
        dependency group."
    ::= { docsIfMCmtsBaseAdmin 2 }

docsPHYParamAdjacentValues OBJECT-IDENTITY
    STATUS      current
    DESCRIPTION
        "Indicates that the PHY parameter has an adjacency or
        sequence pattern for the elements in a dependency group
        e.g., A group of channels all using J.83 Annex A, may set
        frequencies in the group by setting a 6 MHz spacing
        between the channels in the group. Vendors may rather
        use a more detailed vendor-specific OBJECT-IDENTITY or a
        table pointer to describe this type of PHY parameter

```

```

        adjacencies."
    ::= { docsIfMCmtsBaseAdmin 3 }

docsPHYParamFrequencyRange OBJECT-IDENTITY
    STATUS          current
    DESCRIPTION
        "This object indicates that the frequency in a group ID
        is constrained to a frequency range. Vendors may extend
        the MIB construct containing this reference to detail such
        constraints or rather use a more detailed vendor-specific
        OBJECT-IDENTITY or a table pointer to describe the
        frequency range supported."
    ::= { docsIfMCmtsBaseAdmin 4 }

-- -----
-- DOCSIS RF Interface Extension objects
-- M-CMTS Core Extensions
-- -----

docsIfMCmtsCoreDownstreamTable OBJECT-TYPE
    SYNTAX          SEQUENCE OF DocsIfMCmtsCoreDownstreamEntry
    MAX-ACCESS      not-accessible
    STATUS          deprecated
    DESCRIPTION
        "M-CMTS Core extensions for the DOCSIS RFI Downstream
        docsIfDownstreamTable.
        This table is deprecated and the equivalent management
        information is now part of the DOCS-DRF-MIB MIB Module."
    ::= { docsIfMCmtsCoreObjects 1 }

docsIfMCmtsCoreDownstreamEntry OBJECT-TYPE
    SYNTAX          DocsIfMCmtsCoreDownstreamEntry
    MAX-ACCESS      not-accessible
    STATUS          deprecated
    DESCRIPTION
        "A conceptual row for this table.
        There is a corresponding entry for each entry of
        docsIfDownstreamChannelTable."
    INDEX { ifIndex }
    ::= { docsIfMCmtsCoreDownstreamTable 1 }

DocsIfMCmtsCoreDownstreamEntry ::= SEQUENCE
{
    docsIfMCmtsCoreDownstreamType          INTEGER,
    docsIfMCmtsCoreDownstreamPhyDependencies  BITS
}

docsIfMCmtsCoreDownstreamType OBJECT-TYPE
    SYNTAX          INTEGER {
        integrated(1),
        external(2)
    }
    MAX-ACCESS      read-only
    STATUS          deprecated
    DESCRIPTION
        "The value 'integrated' means the Downstream Interface is
        integrated to the DOCSIS MAC interface. This type
        corresponds to the legacy DOCSIS Downstream Interface of
        ifType 128.
        The value 'external' indicates a Downstream External
        Interface that is associated to a QAM channel by mechanisms
        like a DEPI session."
    ::= { docsIfMCmtsCoreDownstreamEntry 1 }

```

```
docsIfMCmtsCoreDownstreamPhyDependencies OBJECT-TYPE
    SYNTAX BITS {
        frequency(0),
        bandwidth(1),
        power(2),
        modulation(3),
        interleaver(4),
        j83Annex(5),
        symbolRate(6),
        mute(7)
    }
    MAX-ACCESS read-only
    STATUS deprecated
    DESCRIPTION
        "The PHY parameters being flagged in the DEPI session as
        DEPI TSID group dependencies.
        A value of all bits on zero indicates no TSID group
        dependencies for PHY parameters. If this object value is
        the zero length string , indicates no DEPI session is
        configured for the M-CMTS Downstream interface or the
        Downstream interface is of the type 'integrated'."
    DEFVAL { 'h' }
    ::= { docsIfMCmtsCoreDownstreamEntry 2 }
```

```
-- -----
-- DOCSIS RF Interface Extension objects
-- M-CMTS EQAM device Extensions
-- -----
```

```
docsIfMCmtsEqamDownstreamTable OBJECT-TYPE
    SYNTAX SEQUENCE OF DocsIfMCmtsEqamDownstreamEntry
    MAX-ACCESS not-accessible
    STATUS deprecated
    DESCRIPTION
        "M-CMTS EQAM extensions for the DOCSIS RFI Downstream
        docsIfDownstreamTable."
    ::= { docsIfMCmtsEqamObjects 1 }
```

```
docsIfMCmtsEqamDownstreamEntry OBJECT-TYPE
    SYNTAX DocsIfMCmtsEqamDownstreamEntry
    MAX-ACCESS not-accessible
    STATUS deprecated
    DESCRIPTION
        "A conceptual row for this table."
    INDEX { ifIndex }
    ::= { docsIfMCmtsEqamDownstreamTable 1 }
```

```
DocsIfMCmtsEqamDownstreamEntry ::= SEQUENCE
{
    docsIfMCmtsEqamDownstreamTSID                Unsigned32,
    docsIfMCmtsEqamDownstreamPhyDependencies      BITS,
    docsIfMCmtsEqamDownstreamDevicePhyParamLock   BITS,
    docsIfMCmtsEqamDownstreamDeviceConfigPhyParamLock BITS,
    docsIfMCmtsEqamDownstreamAllocationType        INTEGER,
    docsIfMCmtsEqamDownstreamAllocationStatus      BITS,
    docsIfMCmtsEqamDownstreamAllocationTimeout     Unsigned32,
    docsIfMCmtsEqamDownstreamDRRPAdvertizing       TruthValue,
    docsIfMCmtsEqamDownstreamUdpPortMapping        InetPortNumber
}
```

```
docsIfMCmtsEqamDownstreamTSID OBJECT-TYPE
    SYNTAX Unsigned32 (0..65535)
```

```

MAX-ACCESS  read-write
STATUS      deprecated
DESCRIPTION
    "Represents the TSID value for the QAM channel of this
    M-CMTS Downstream Interface.
    The value '0' indicates no TSID is being configured in the
    EQAM device for this interface entry."
 ::= { docsIfMCmtsEqamDownstreamEntry 1 }

```

docsIfMCmtsEqamDownstreamPhyDependencies OBJECT-TYPE

```

SYNTAX      BITS {
    frequency(0),
    bandwidth(1),
    power(2),
    modulation(3),
    interleaver(4),
    j83Annex(5),
    symbolRate(6),
    mute(7)
}
MAX-ACCESS  read-only
STATUS      deprecated
DESCRIPTION
    "The summary of the M-CMTS Downstream Interface
    dependencies based on the constraints of
    docsIfMCmtsEqamGroupDependencyEntry.
    A BIT position set to '1' indicates the PHY parameter
    belongs to a dependency group (DEPI TSID group).
    The opposite, a BIT position set to '0', indicates
    the QAM channel does not belong to a dependency group."
DEFVAL { 'h }
 ::= { docsIfMCmtsEqamDownstreamEntry 2 }

```

docsIfMCmtsEqamDownstreamDevicePhyParamLock OBJECT-TYPE

```

SYNTAX      BITS {
    frequency(0),
    bandwidth(1),
    power(2),
    modulation(3),
    interleaver(4),
    j83Annex(5),
    symbolRate(6),
    mute(7)
}
MAX-ACCESS  read-only
STATUS      deprecated
DESCRIPTION
    "Indicates if by design the QAM Channel is directly
    configurable. This BIT set is derived from the
    dependency group a QAM channel belongs where
    docsIfMCmtsEqamGroupDependencyType is equal to
    docsPHYParamFixValue
    When a specific BIT is set to '1', the PHY parameter
    in docsIfMCmtsDepiSessionConfigTable is locked for SNMP
    SETs, returning 'notWritable' on SET attempts.
    When a specific BIT is set to '0', the PHY parameter
    in docsIfMCmtsDepiSessionConfigTable is processed.
    Note that when a BIT is set to '0' an SNMP SET as described
    above may affect the PHY parameter in other QAM channels
    as described in docsIfMCmtsEqamGroupDependencyTable
    or rejected with error 'wrongValue' based on the constrains
    indicated by the EQAM capabilities
    docsIfMCmtsEqamDownstreamCapabilitiesTable of

```

DOCS-If-M-CMTS-MIB.
 This object contains information that is used to signal
 'lock' PHY parameters to other entities via interfaces such
 as DEPI and ERMI."

```
 ::= { docsIfMCmtsEqamDownstreamEntry 3 }
```

docsIfMCmtsEqamDownstreamDeviceConfigPhyParamLock OBJECT-TYPE

```
SYNTAX      BITS {
    frequency(0),
    bandwidth(1),
    power(2),
    modulation(3),
    interleaver(4),
    j83Annex(5),
    symbolRate(6),
    mute(7)
}
MAX-ACCESS  read-write
STATUS      deprecated
DESCRIPTION
    "Administrative configuration of lock bits for EQAM
    channels PHY parameters.

    A BIT set of this object is meaningful when the same BIT
    set in docsIfMCmtsEqamDownstreamDevicePhyParamLock is set
    to '0'. Therefore, a SET to this object when the entry
    value of docsIfMCmtsEqamDownstreamDevicePhyParamLock is
    set to '1' returns error 'wrongValue'.

    When a PHY parameter BIT in this object is set to '1'
    the QAM channel PHY parameter in
    docsIfMCmtsDepiSessionConfigTable is locked
    for SNMP SETs returning error 'notWritable' on those
    attempts.

    Sets to this object could be complex; as a rule of
    thumb, SNMP agents ignore bits that are not recognized
    (e.g., extensions). An attempt to set BITS while
    docsIfMCmtsEqamDownstreamDeviceConfigPhyParamLock is set
    to '1' is rejected and the error code 'wrongValue' is
    returned."
 ::= { docsIfMCmtsEqamDownstreamEntry 4 }
```

docsIfMCmtsEqamDownstreamAllocationType OBJECT-TYPE

```
SYNTAX      INTEGER {
    docsisOnly(1),
    videoOnly(2),
    any(3)
}
MAX-ACCESS  read-write
STATUS      deprecated
DESCRIPTION
    "Indicates the mechanisms authorized to reserve and control
    this M-CMTS Downstream interface.
    When configured to 'docsisOnly' indicates that it can be
    allocated only to serve data over DOCSIS.
    When configured to 'videoOnly' indicates that it can be
    allocated only to video services and not for Data over
    DOCSIS.
    'any' indicates the M-CMTS Downstream Interface can be
    reserved for DOCSIS or video services."
 ::= { docsIfMCmtsEqamDownstreamEntry 5 }
```

docsIfMCmtsEqamDownstreamAllocationStatus OBJECT-TYPE

```
SYNTAX      BITS {
    other(0),
    docsisDeps(1),
    docsisErm(2),
    videoErm(3)
}
```

MAX-ACCESS read-only

STATUS deprecated

DESCRIPTION

"Indicates the service(s) the M-CMTS Downstream Interface is allocated for.

'other' BIT set to '1' indicates the resource is currently allocated to DOCSIS and/or Video services by a proprietary mechanism.

'docsisDeps' BIT set to '1' indicates the DEPI Control mechanism is currently in use in the M-CMTS Downstream Interface allocation, e.g., an L2TPv3 DEPI Session.

'docsisErm' indicates that ERM Resource Allocation Interface is being used in the M-CMTS Downstream Interface allocation.

'video' indicates the resource is currently allocated by a video control plane using an extension of the M-CMTS ERM Resource Control Plane.

All BITS set to zero or a zero-length octet string indicates the M-CMTS Downstream Interface is available for allocation constrained to the type of resource allocation referenced by docsIfMCmtsEqamDownstreamAllocationType.

It may be the case where several BITS are set to '1' simultaneously:

The most common case is 'docsisDeps' and 'docsisERM' BITS. In this situation, the ERM has allocated the QAM channel and the DEPI Session handles optional parameters configuration and/or in-band link status.

Combinations like 'docsisDeps' and 'videoERM' may indicate concurrent services, which is vendor specific."

REFERENCE

"DEPI L2TP ERM RTSP section 7"

::= { docsIfMCmtsEqamDownstreamEntry 6 }

docsIfMCmtsEqamDownstreamAllocationTimeout OBJECT-TYPE

```
SYNTAX      Unsigned32 (0..120)
```

UNITS "seconds"

MAX-ACCESS read-write

STATUS deprecated

DESCRIPTION

"Indicates the number of seconds the EQAM device waits before advertising the QAM channel resource is idle and/or accepting a session establishment from a different control plane to the previous one. As a side effect, the entry in docsIfMCmtsDepsSessionConfigTable is aged out and destroyed only after the expiration of this reservation timeout. A value zero makes the resource available immediately for allocation to others.

Note that not explicit indefinite timeout needs to be defined to indicate exclusive allocation to a requester. The EQAM device can support this condition for example by configuring restricted access to certain Resource Allocation control plane to a particular IP host in the

```

        form of source IP or authentication mechanisms."
 ::= { docsIfMCmtsEqamDownstreamEntry 7 }

docsIfMCmtsEqamDownstreamDRRPAdvertizing OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS   read-write
    STATUS       deprecated
    DESCRIPTION
        "Indicates when a QAM channel resource should be advertised
        via DRRP (DOCSIS Resource Registration Protocol) to an Edge
        Resource Manager (ERM).

        This Object is useful when a device is allocated for
        instance to DOCSIS only by a static reservation
        (docsIfMCmtsEqamDownstreamAllocationType 'docsisOnly').
        It means an Edge Resource Manager won't have this QAM
        channel resource available allocate upon requests from
        different entities.

        Note that DRRP currently does not signal EQAM resources
        as reserved for a particular service.
        The MIB objects docsIfMCmtsEqamDownstreamDRRPAdvertizing
        and docsIfMCmtsEqamDownstreamAllocationType are used
        primarily to statically reserve QAM channels and prevent
        its allocation by dynamic means such ERM or some other
        existing mechanisms. Therefore, caution is needed when
        setting this object to 'true' since the allocation Type
        docsIfMCmtsEqamDownstreamAllocationType is not known by
        ERMs with DRRP support."
    DEFVAL { true }
 ::= { docsIfMCmtsEqamDownstreamEntry 8 }

docsIfMCmtsEqamDownstreamUdpPortMapping OBJECT-TYPE
    SYNTAX      InetPortNumber
    MAX-ACCESS   read-only
    STATUS       deprecated
    DESCRIPTION
        "The UDP Port within a L2TPv3 Session PDU the EQAM uses
        to map DEPI flows to the EQAM channels associated to this
        table entry.
        When the EQAM device does not support UDP port mapping to
        DEPI flows, this object reports the value 1701 (the default
        UDP port when M-CMTS Initiates a DEPI session with L2TPv3
        header over UDP)."
 ::= { docsIfMCmtsEqamDownstreamEntry 9 }

-- -----
-- EQAM M-CMTS Downstream Interface Capabilities
-- -----

docsIfMCmtsEqamDownstreamCapabilitiesTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsEqamDownstreamCapabilitiesEntry
    MAX-ACCESS   not-accessible
    STATUS       deprecated
    DESCRIPTION
        "This table contains the QAM channel capabilities
        for the M-CMTS Downstream Interface PHY parameters in the
        EQAM device.
        This table is deprecated and the equivalent management
        information is now part of the DOCS-DRF-MIB MIB Module."
 ::= { docsIfMCmtsEqamObjects 2 }

docsIfMCmtsEqamDownstreamCapabilitiesEntry OBJECT-TYPE

```

```

SYNTAX      DocsIfMCmtsEqamDownstreamCapabilitiesEntry
MAX-ACCESS  not-accessible
STATUS      deprecated
DESCRIPTION
    "A conceptual row for this table."
INDEX { ifIndex }
 ::= { docsIfMCmtsEqamDownstreamCapabilitiesTable 1 }

```

```

DocsIfMCmtsEqamDownstreamCapabilitiesEntry ::= SEQUENCE
{
    docsIfMCmtsEqamDownstreamCapabFrequency          BITS,
    docsIfMCmtsEqamDownstreamCapabBandwidth          BITS,
    docsIfMCmtsEqamDownstreamCapabPower              BITS,
    docsIfMCmtsEqamDownstreamCapabModulation          BITS,
    docsIfMCmtsEqamDownstreamCapabInterleaver        BITS,
    docsIfMCmtsEqamDownstreamCapabJ83Annex           BITS,
    docsIfMCmtsEqamDownstreamCapabConcurrentServices BITS,
    docsIfMCmtsEqamDownstreamCapabServicesTransport  BITS,
    docsIfMCmtsEqamDownstreamCapabMuting             BITS
}

```

docsIfMCmtsEqamDownstreamCapabFrequency OBJECT-TYPE

```

SYNTAX      BITS {
    eqamDependency(0),
    adjacentChannel(1),
    adjacentChannelOrder(2)
}

```

```

MAX-ACCESS  read-only
STATUS      deprecated

```

DESCRIPTION

"The QAM channel frequency capabilities.

'eqamDependency' BIT set to '1' indicates the QAM channel frequency value has dependencies with other QAM channels and an entry that includes this QAM channel is in docsIfMCmtsEqamGroupDependencyTable for the PHY parameter 'frequency'.

'adjacentChannel' BIT set to '1' indicates the QAM channel frequencies in the dependency group (DEPI TSID group) are adjacent and constrained in a frequency range based on the number of QAM channels in the dependency group.

'adjacentChannelOrder' BIT set to '1' indicates the QAM channel frequency adjacency is based in the QAM channel sequence like entPhysicalParentRelPos in EntPhysicalTable or other vendor sequence.

e.g., a dependency group of four QAM channels with 'adjacentChannelOrder' BIT set to '1':
The 4th QAM channel in the sequence gets a frequency assignment $f + 1 \times \text{bandwidth}$ when the frequency value of the 3rd QAM channel in the sequence is set to f .
Similarly the 1st QAM channel in the sequence gets a frequency assignment of $f - 2 \times \text{bandwidth}$ and the 2nd QAM channels gets a frequency of $f - 1 \times \text{bandwidth}$.

'adjacentChannel' 'adjacentChannelOrder' BITs may be set to '1' when a dependency group includes the QAM channel of this M-CMTS Downstream interface and the value of the object docsIfMCmtsEqamGroupDependencyType is docsPHYParamAdjacentValues.

'adjacentChannel' BIT may be set to '1' if

```

        'eqamDependency' BIT is set to '1'. The same way,
        'adjacentChannelOrder' BIT may be set to '1' and implies
        'adjacentChannel' BIT is set to '1'."
    ::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 1 }

docsIfMCmtsEqamDownstreamCapabBandwidth OBJECT-TYPE
    SYNTAX      BITS {
        eqamDependency(0),
        chan6Mhz(1),
        chan8Mhz(2)
    }
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "The QAM channel Bandwidth capabilities.
        'eqamDependency' BIT set to '1' indicates the QAM channel
        bandwidth value has dependencies with other QAM channels
        as indicated in docsIfMCmtsEqamGroupDependencyTable.

        'chan6Mhz' set to '1' indicates 6 MHz channel width
        support.
        'chan8Mhz' set to '1' indicates 8 MHz channel width
        support.

        When 'eqamDependency' BIT is set to '1', a set to the
        channel bandwidth PHY parameter of a QAM channels in a
        dependency group (with docsIfMCmtsEqamGroupDependencyType
        set to docsPHYParamSameValue), sets the same channel
        bandwidth value to all QAM channels in the dependency
        group."
    ::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 2 }

docsIfMCmtsEqamDownstreamCapabPower OBJECT-TYPE
    SYNTAX      BITS {
        eqamDependency(0)
    }
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "The QAM channel Power capabilities.
        'eqamDependency' BIT set to '1' indicates the QAM channel
        power value has dependencies with other QAM channels
        as indicated in docsIfMCmtsEqamGroupDependencyTable.

        When 'eqamDependency' BIT is set to '1', a set to the
        power level PHY parameter of a QAM channels in a
        dependency group (with docsIfMCmtsEqamGroupDependencyType
        set to docsPHYParamSameValue), sets the same power
        level to all QAM channels in the dependency group."
    ::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 3 }

docsIfMCmtsEqamDownstreamCapabModulation OBJECT-TYPE
    SYNTAX      BITS {
        eqamDependency(0),
        qam64(1),
        qam256(2)
    }
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "The QAM channel Modulation capabilities.
        'eqamDependency' BIT set to '1' indicates the QAM channel
        modulation value has dependencies with other QAM channels

```

as indicated in docsIfMCmtsEqamGroupDependencyTable.

'qam64' set to '1' indicates 64-QAM modulation support.
 'qam256' set to '1' indicates 256-QAM modulation support.

When 'eqamDependency' BIT is set to '1', a set to the modulation PHY parameter of a QAM channels in a dependency group (with docsIfMCmtsEqamGroupDependencyType set to docsPHYParamSameValue), sets the same modulation type to all QAM channels in the dependency group."

```
::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 4 }
```

docsIfMCmtsEqamDownstreamCapabInterleaver OBJECT-TYPE

```
SYNTAX      BITS {
    eqamDependency(0),
    taps8Increment16(1),
    taps16Increment8(2),
    taps32Increment4(3),
    taps64Increment2(4),
    taps128Increment1(5),
    taps12Increment17(6),
    taps128Increment2(7),
    taps128Increment3(8),
    taps128Increment4(9),
    taps128Increment5(10),
    taps128Increment6(11),
    taps128Increment7(12),
    taps128Increment8(13)
}
```

MAX-ACCESS read-only

STATUS deprecated

DESCRIPTION

"The QAM channel Interleaver capabilities.

'eqamDependency' BIT set to '1' indicates the QAM channel interleave value has dependencies with other QAM channels as indicated in docsIfMCmtsEqamGroupDependencyTable.

'taps8Increment16' set to '1' indicates the support of
 j = 8, i = 16 interleave.

'taps16Increment8' set to '1' indicates the support of
 j = 16, i = 8 interleave.

'taps32Increment4' set to '1' indicates the support of
 j = 32, i = 4 interleave.

'taps64Increment2' set to '1' indicates the support of
 j = 64, i = 2 interleave.

'taps128Increment1' set to '1' indicates the support of
 j = 128, i = 1 interleave.

'taps12Increment17' set to '1' indicates the support of
 j = 12, i = 17 interleave.

'taps128Increment2' set to '1' indicates the support of
 j = 128, i = 2 interleave.

'taps128Increment3' set to '1' indicates the support of
 j = 128, i = 3 interleave.

'taps128Increment4' set to '1' indicates the support of
 j = 128, i = 4 interleave.

'taps128increment5' set to '1' indicates the support of
j = 128, i = 5 interleave.

'taps128increment6' set to '1' indicates the support of
j = 128, i = 6 interleave.

'taps128increment7' set to '1' indicates the support of
j = 128, i = 7 interleave.

'taps128increment8' set to '1' indicates the support of
j = 128, i = 8 interleave.

When 'eqamDependency' BIT is set to '1', a set to the
interleave PHY parameter of a QAM channels in a
dependency group (with docsIfMCmtsEqamGroupDependencyType
set to docsPHYParamSameValue), sets the same Interleave
value to all QAM channels in the dependency group."

::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 5 }

docsIfMCmtsEqamDownstreamCapabJ83Annex OBJECT-TYPE

```
SYNTAX      BITS {
    eqamDependency(0),
    annexA(1),
    annexB(2),
    annexC(3)
}
```

MAX-ACCESS read-only

STATUS deprecated

DESCRIPTION

"The QAM channel J.83 Annex Capabilities.

'eqamDependency' BIT set to '1' indicates the QAM channel
J.83 Annex value has dependencies with other QAM channels
as indicated in docsIfMCmtsEqamGroupDependencyTable.

'annexA' set to '1' indicates J.83 Annex A support.

'annexB' set to '1' indicates J.83 Annex B support.

'annexC' set to '1' indicates J.83 Annex C support.

When 'eqamDependency' BIT is set to '1', a set to the
J.83 Annex PHY parameter of a QAM channels in a
dependency group (with docsIfMCmtsEqamGroupDependencyType
set to docsPHYParamSameValue), sets the same J.83 Annex
value to all QAM channels in the dependency group."

::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 6 }

docsIfMCmtsEqamDownstreamCapabConcurrentServices OBJECT-TYPE

```
SYNTAX      BITS {
    eqamDependency(0),
    videoAndDocsis(1)
}
```

MAX-ACCESS read-only

STATUS deprecated

DESCRIPTION

"The QAM channel Concurrent Services Capabilities.

'eqamDependency' BIT set to '1' indicates the QAM channel
is part of a dependency group that supports concurrent
services mode as indicated in
docsIfMCmtsEqamGroupDependencyTable.

'videoAndDocsis' BIT set to '1' indicates video transport
and DOCSIS transport can be supported simultaneously.

Video and DOCSIS transport service types are described in
docsIfMCmtsEqamDownstreamCapabServicesTransport."

```

::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 7 }

docsIfMCmtsEqamDownstreamCapabServicesTransport OBJECT-TYPE
    SYNTAX      BITS {
        qamDependency(0),
        mpeg2OverIP(1),
        dmpt(2),
        psp(3)
    }
    MAX-ACCESS   read-only
    STATUS        deprecated
    DESCRIPTION
        "The QAM channel Services transports modes Capabilities.

        'eqamDependency' BIT set to '1' indicates the QAM channel
        Service transport type has dependencies with other QAM
        channels as indicated in
        docsIfMCmtsEqamGroupDependencyTable.

        'mpeg2OverIP' set to '1' indicates video transports as
        conventional VoD is supported (known as MPT mode, MPEG-2
        transport).
        'dmpt' set to 1 indicates DOCSIS MPT mode (D-MPT) support.
        'psp' set to 1 indicates DOCSIS Packet Streaming Protocol
        mode (PSP) support.

        When 'eqamDependency' BIT is set to '1', a request to set
        a QAM channel to a service type in a dependency group
        (with docsIfMCmtsEqamGroupDependencyType set to
        docsPHYParamSameValue) may be rejected."
    ::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 8 }

docsIfMCmtsEqamDownstreamCapabMuting OBJECT-TYPE
    SYNTAX      BITS {
        eqamDependency(0)
    }
    MAX-ACCESS   read-only
    STATUS        deprecated
    DESCRIPTION
        "The QAM channel muting capabilities.
        'eqamDependency' BIT set to '1' indicates the EQAM Mute
        state has dependencies with other QAM channels as
        indicated in docsIfMCmtsEqamGroupDependencyTable.

        When 'eqamDependency' BIT is set to '1', a request to
        mute a QAM channels in a dependency group (with
        docsIfMCmtsEqamGroupDependencyType set to
        docsPHYParamSameValue), sets all QAM channels in the
        dependency group to mute."
    ::= { docsIfMCmtsEqamDownstreamCapabilitiesEntry 9 }

-- -----
-- EQAM M-CMTS Group Dependency of PHY parameters Definitions
-- Defines the group of QAM channels that may be impacted for
-- individual QAM channels PHY parameters changes. Extends ENTITY-MIB
-- -----

docsIfMCmtsEqamGroupDependencyTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsEqamGroupDependencyEntry
    MAX-ACCESS   not-accessible
    STATUS        deprecated

```

DESCRIPTION

"This table describes the rules that identify groups of QAM channels with PHY parameters dependencies. A PHY parameter dependency group means that a set to a QAM channel parameter may affect the value of other QAM Channels in the group.

TSID is a broadcast term borrowed by the M-CMTS architecture to represent a unique identifier of QAM channels in the M-CMTS architecture.

TSID Group is the DEPI concept of a set of QAM channels with a PHY parameter dependency. This module refers to TSID group as a PHY dependency Group.

This table uses the ENTITY-MIB physical component structure to allows the managed system to describe the QAM channels' PHY parameters dependencies. A management entity can use the information from this table to generate the DEPI TSID Groups.

Examples of PHY dependencies could be usage of adjacent frequencies, or QAM channels of RF ports restricted, or same interleaver value, modulation and J.83 Annex value.

Additional details and rules to describe the PHY parameter dependency is indicated in docsIfMCmtsEqamGroupDependencyType.

Vendors may extend via other MIB modules the usage of docsIfMCmtsEqamGroupDependencyType.

This table is deprecated and the equivalent management information is now part of the DOCS-DRF-MIB MIB Module."

```
::= { docsIfMCmtsEqamObjects 3 }
```

docsIfMCmtsEqamGroupDependencyEntry OBJECT-TYPE

SYNTAX DocsIfMCmtsEqamGroupDependencyEntry

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"A conceptual row of this table.

QAM channels are modeled as PhysicalClass 'port' from the ENTITY-MIB.

An QAM channel can be represented as part of an entity MIB containment tree as follows:

```
chassis(EQAM device)
    .container(EQAM Slot)
        .module(field-replaceable-module)
            .module ( Physical RF spigot)
                . port (QAM channel)
```

PhysicalClass 'stack' is left optional and not included as a reference or examples for this table.

Based on the hardware capabilities the Agent will create entries in this table including the entPhysicalEntry of the close element to the root (e.g., up to 'chassis' or 'stack') including the PHY parameter of the dependency as part of the entry index

The Aggregation is then defined as all the QAM channels (entity PhysicalClass = 'port') below the tree as indicated in entyPhysicalContainsTable.

Logical or software dependencies of the QAM channels PHY parameters in addition to the hardware dependency entries can be present and MUST persist to system re-initialization. The storage realization of hardware dependent entries are 'permanent' or 'readOnly'. The storage realization of logical dependency entries is 'nonVolatile'.

PHY parameters dependencies being logically defined may be present in this table but its configuration is outside of the scope of this MIB Module, including the definition of simulated Physical components such backplane types or modules accomplish its logical grouping.

PHY parameters with no Physical entities associated in this table indicates no PHY dependencies for certain groups of QAM channels.

Administrative changes to the docsIfMCmtsEqamGroupDependencyPhyParamLock are preserved in non-volatile memory upon system re-initialization.

Note that any change in the system due to the insertion or removal of components will reset to factory default the entries associated to those components.

An entry in this table is reflected in the MIB object docsIfMExtDownstreamTSIDGroupPhyParamFlag for individual QAM channels.

A recursive method to find the PHY dependency group of an QAM channel A, PHY parameter X is as follows:

The parent tree of QAM channel A is recursively calculated by navigating entyPhysicalContainsTable from bottom to top $P_i(P_{l..P_n})$

The list M_j ($M_{l..M_n}$) of docsIfMCmtsEqamGroupDependencyPhysicalIndex represents the values from this table with PHY parameter docsIfMCmtsEqamGroupDependencyPhyParam X and/or 'all'

The list Q_i ($Q_{l..n}$) is the list of matches of M_i in P_i

Q_i with the lower position in the entyPhysicalContainsTable is selected Q_y and M_y is the group criteria selected.

All QAM channels B_i below M_y are candidates of being in the dependency group.

Each B_i is verified as A for its own B_{P_i} parent tree to verify that in effect M_y is the lowest denominator in M_i B_{P_i} intersection to become part of the Dependency Group of A."

```
INDEX { docsIfMCmtsEqamGroupDependencyPhyParam,
        docsIfMCmtsEqamGroupDependencyPhysicalIndex }
 ::= { docsIfMCmtsEqamGroupDependencyTable 1 }
```

```
DocsIfMCmtsEqamGroupDependencyEntry ::= SEQUENCE
{
    docsIfMCmtsEqamGroupDependencyPhyParam      INTEGER,
    docsIfMCmtsEqamGroupDependencyPhysicalIndex PhysicalIndexOrZero,
```

```

docsIfMCmtsEqamGroupDependencyGroupID          Unsigned32,
docsIfMCmtsEqamGroupDependencyType              AutonomousType
}

docsIfMCmtsEqamGroupDependencyPhyParam OBJECT-TYPE
SYNTAX      INTEGER {
    noDependencies(0),
    all(1),
    frequency(2),
    bandwidth(3),
    power(4),
    modulation(5),
    interleave(6),
    annex(7),
    symbolRate(8),
    mute(9)
}
MAX-ACCESS  not-accessible
STATUS      deprecated
DESCRIPTION
    "This object represents the type of DOCSIS PHY parameter
    that may have dependencies when setting an individual
    object in the dependency group.
    The value 'all' may be used as a wildcard to indicate
    all PHY parameters. The other enumeration values are
    DOCSIS PHY parameters.

    The opposite to 'all' is 'noDependencies', which indicates
    no dependencies in PHY parameters, but is only used to
    indicate no dependencies across all the EQAM device. Thus,
    when used, 'noDependencies' is accompanied by
    docsIfMCmtsEqamGroupDependencyPhysicalIndex '0' as the only
    entry in the table.
    In this way it is clearly distinguished when an EQAM device
    has dependencies instead of an empty table."
 ::= { docsIfMCmtsEqamGroupDependencyEntry 1 }

docsIfMCmtsEqamGroupDependencyPhysicalIndex OBJECT-TYPE
SYNTAX      PhysicalIndexOrZero
MAX-ACCESS  not-accessible
STATUS      deprecated
DESCRIPTION
    "Indicates the physical element from where the PHY
    parameter dependency for QAM channels applies.
    All the QAM channels elements under this Physical index
    will belong to a dependency group of the specified PHY
    parameter."
 ::= { docsIfMCmtsEqamGroupDependencyEntry 2 }

docsIfMCmtsEqamGroupDependencyGroupID OBJECT-TYPE
SYNTAX      Unsigned32 (1..127)
MAX-ACCESS  read-only
STATUS      deprecated
DESCRIPTION
    "The internal ID assigned for the QAM channels in the
    dependency group.
    The value of this object is unique in the scope of the
    PHY parameter being mapped."
 ::= { docsIfMCmtsEqamGroupDependencyEntry 3 }

docsIfMCmtsEqamGroupDependencyType OBJECT-TYPE
SYNTAX      AutonomousType
MAX-ACCESS  read-only

```

```

STATUS      deprecated
DESCRIPTION
    "The description of the type of dependency associated
    with this dependency group.
    Basic type of dependencies are docsPHYParamSameValue,
    docsPHYParamAdjacentValues, docsPHYParamFrequencyRange.
    Vendors may define their own rules and policies to describe
    their implementation dependency definitions such as
    RowPointers to table entries or OBJECT-IDENTITY clauses.
    If the dependency is not described this object is set to
    zeroDotZero, although the dependency does exist."
 ::= { docsIfMCmtsEqamGroupDependencyEntry 4 }

-----
-- EQAM M-CMTS Global configuration
-- Defines the structure to include configuration rules applicable
-- at EQAM device initialization and management actions
-- Uses the containment structure of the ENTITY-MIB to create the global
-- configuration rules.
-----

docsIfMCmtsEqamGlobCfgDownTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsEqamGlobCfgDownEntry
    MAX-ACCESS   not-accessible
    STATUS      deprecated
    DESCRIPTION
        "A Table for setting multiple parameters of multiple
        QAM channels.
        Creating an entry in this table will set automatically
        all QAM Channels in the containment tree of
        docsIfMCmtsEqamGlobCfgDownPhysicalIndex in
        entPhysicalContainsTable to the parameter values
        specified during the row creation.

        docsIfMCmtsEqamGlobCfgDownPhysicalIndex MUST be a valid
        Physical index of entPhysicalTable.

        The ways to configure QAM channels parameters are:
        1) Globally.
            Using this table, docsIfMCmtsEqamGlobCfgDownTable
        2) Directly.
            Using docsIfMCmtsEqamDownstreamTable and
            docsIfDownstreamChannelTable to change parameters
            and lock status of individual QAM channels.

        In general an entry in this table will set the parameters
        of QAM channels of the containment tree recursively the
        same way as doing directly as described in 2)above. It
        means, potentially there could be rejections based on
        locked parameters and/or PHY dependencies that prevent
        the sets.

        The row creation in this table is not rejected or set in
        'inactive' or 'notInService' state due individual QAM
        channels in the group failures due the global set, instead,
        an error status is reported per entry.

        The processing of the entries in this table (e.g., at system
        initialization) is sequential; therefore, it could be
        overlapping rules based on the containment tree level of
        the entries."
 ::= { docsIfMCmtsEqamObjects 4 }

```

```
docsIfMCmtsEqamGlobCfgDownEntry OBJECT-TYPE
    SYNTAX      DocsIfMCmtsEqamGlobCfgDownEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The index of this table.
        Entries in this table persist after system
        re-initialization.
        It is common to have 'holes' in this table
        since not all the parameters associated with a QAM channel
        might be desired of global set, therefore, columnar values
        do not handle default values for entry creation."
    INDEX { docsIfMCmtsEqamGlobCfgDownIndex }
    ::= { docsIfMCmtsEqamGlobCfgDownTable 1 }
```

```
DocsIfMCmtsEqamGlobCfgDownEntry ::= SEQUENCE
{
    docsIfMCmtsEqamGlobCfgDownIndex      Unsigned32,
    docsIfMCmtsEqamGlobCfgDownPhysicalIndex PhysicalIndexOrZero,
    docsIfMCmtsEqamGlobCfgDownBandwidth  Integer32,
    docsIfMCmtsEqamGlobCfgDownPower      TenthdBmV,
    docsIfMCmtsEqamGlobCfgDownModulation INTEGER,
    docsIfMCmtsEqamGlobCfgDownInterleave INTEGER,
    docsIfMCmtsEqamGlobCfgDownAnnex      INTEGER,
    docsIfMCmtsEqamGlobCfgDownSymbolRateM Unsigned32,
    docsIfMCmtsEqamGlobCfgDownSymbolRateN Unsigned32,
    docsIfMCmtsEqamGlobCfgDownLockParams BITS,
    docsIfMCmtsEqamGlobCfgDownExecutionCode INTEGER,
    docsIfMCmtsEqamGlobCfgDownErrorsCount Gauge32,
    docsIfMCmtsEqamGlobCfgDownRowStatus  RowStatus
}
```

```
docsIfMCmtsEqamGlobCfgDownIndex OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The unique identifier of entries in this table."
    ::= { docsIfMCmtsEqamGlobCfgDownEntry 1 }
```

```
docsIfMCmtsEqamGlobCfgDownPhysicalIndex OBJECT-TYPE
    SYNTAX      PhysicalIndexOrZero
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The ENTITY-MIB Physical Index that includes the QAM
        channels associated to the global parameter being set.
        The QAM Channels covered by this global set are those
        linked to the entPhysicalContainsTable containment tree
        starting at the value of this object.
        The value '0' indicates all containment
        elements in the managed system."
    ::= { docsIfMCmtsEqamGlobCfgDownEntry 2 }
```

```
docsIfMCmtsEqamGlobCfgDownBandwidth OBJECT-TYPE
    SYNTAX      Integer32 (6000000 | 8000000)
    UNITS       "hertz"
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The object for global configuration of Downstream
        channel bandwidth of the QAM channels in the containment
        tree of docsIfMCmtsEqamGlobCfgDownPhysicalIndex."
```

A set to this object is reflected in docsIfDownChannelWidth of the QAM channels being set.
The syntax of this object is Integer32 to maintain the same type of docsIfDownChannelWidth as initially defined in RFC 2670."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 3 }
```

docsIfMCmtsEqamGlobCfgDownPower OBJECT-TYPE

```
SYNTAX      TenthdBmV
UNITS       "dBmV"
MAX-ACCESS  read-create
STATUS      deprecated
DESCRIPTION
```

"The object for global configuration of Downstream channel Power Level of the QAM channels in the containment tree of docsIfMCmtsEqamGlobCfgDownPhysicalIndex.
A set to this object is reflected in docsIfDownChannelPower of the QAM channels being set."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 4 }
```

docsIfMCmtsEqamGlobCfgDownModulation OBJECT-TYPE

```
SYNTAX      INTEGER {
    qam64(3),
    qam256(4)
}
MAX-ACCESS  read-create
STATUS      deprecated
DESCRIPTION
```

"The object for global configuration of Downstream channel modulation of the QAM channels in the containment tree of docsIfMCmtsEqamGlobCfgDownPhysicalIndex.
A set to this object is reflected in docsIfDownChannelModulation of the QAM channels being set.
Values '1' and '2' are not used, only '3' and '4' to maintain compatibility with docsIfDownChannelModulation enumeration values initially defined in RFC 2670."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 5 }
```

docsIfMCmtsEqamGlobCfgDownInterleave OBJECT-TYPE

```
SYNTAX      INTEGER {
    unknown(1),
    other(2),
    taps8Increment16(3),
    taps16Increment8(4),
    taps32Increment4(5),
    taps64Increment2(6),
    taps128Increment1(7),
    taps128Increment17(8),
    taps128Increment2(9),
    taps128Increment3(10),
    taps128Increment4(11),
    taps128Increment5(12),
    taps128Increment6(13),
    taps128Increment7(14),
    taps128Increment8(15)
}
MAX-ACCESS  read-create
STATUS      deprecated
DESCRIPTION
```

"The object for global configuration of Downstream channel interleave of the QAM channels in the containment tree of docsIfMCmtsEqamGlobCfgDownPhysicalIndex."

A set to this object is reflected in docsIfDownChannelInterleave of the QAM channels being set. Values are defined as follows:

		64QAM/256QAM
'taps8Increment16' :	protection	5.9/4.1 usec,
	latency	.22/.15 msec
'taps16Increment8' :	protection	12/8.2 usec,
	latency	.48/.33 msec
'taps32Increment4' :	protection	24/16 usec,
	latency	.98/.68 msec
'taps64Increment2' :	protection	47/33 usec,
	latency	2/1.4 msec
'taps128Increment1' :	protection	95/66 usec,
	latency	4/2.8 msec
'taps12increment17' :	protection	18/14 usec,
	latency	0.43/0.32 msec

Values below are not defined for DOCSIS RFI MIB for docsIfDownChannelInterleave. The EQAM Channel supports these values for video services (see docsIfMCmtsEqamDownstreamCapabInterleaver specific EQAM supported values).

'taps128increment2' :	protection	190/132 usec,
	latency	8/5.6 msec
'taps128increment3' :	protection	285/198 usec,
	latency	12/8.4 msec
'taps128increment4' :	protection	379/264 usec,
	latency	16/11 msec
'taps128increment5' :	protection	474/330 usec,
	latency	20/14 msec
'taps128increment6' :	protection	569/396 usec,
	latency	24/17 msec
'taps128increment7' :	protection	664/462 usec,
	latency	28/19 msec
'taps128increment8' :	protection	759/528 usec,
	latency	32/22 msec

Setting this object without setting docsIfMCmtsEqamGlogCfgDownAnnex may end up with particular QAM channels set rejections due to incompatible Annex parameters, in which case the error 'errorSetFailures' is reported in docsIfMCmtsEqamGlobCfgDownExecutionCode."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 6 }
```

docsIfMCmtsEqamGlogCfgDownAnnex OBJECT-TYPE

```
SYNTAX      INTEGER {
    annexA(3),
    annexB(4),
    annexC(5)
}
```

MAX-ACCESS read-create

STATUS deprecated

DESCRIPTION

"The object for global configuration of Downstream channel J.83 Annex of the QAM channels in the containment tree of docsIfMCmtsEqamGlobCfgDownPhysicalIndex. A set to this object is reflected in docsIfDownChannelAnnex of the QAM channels being set. Values '1' and '2' are not used, only '3', '4' and '5' to maintain compatibility with docsIfDownChannelAnnex enumeration values initially defined in RFC 2670.

This object set has dependencies with
 docsIfDownChannelInterleave,
 docsIfMCmtsEqamGlobCfgDownBandwidth and probably
 docsIfMCmtsEqamGlobCfgDownSymbolRateM/N, in particular
 in the rare event of changing the J.83 Annex type for the
 already configured EQAM.

An entry set with an invalid combination of J.83 Annex
 PHY parameters mentioned above is not executed and
 reported as error code 'errorNoCommitted' in
 docsIfMCmtsEqamGlobCfgDownExecutionCode.

If an entry sets this object but any of the other J.83
 Annex PHY related objects, is missing, the missing
 parameters are set to a default value only in the case
 of a change of J.83 Annex type (e.g., setting Annex A when
 currently in Annex B)."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 7 }
```

docsIfMCmtsEqamGlobCfgDownSymbolRateM OBJECT-TYPE

SYNTAX Unsigned32 (1..65535)

MAX-ACCESS read-create

STATUS deprecated

DESCRIPTION

"The object for global configuration of Downstream
 channel Symbol M factor of the QAM channels in the
 containment tree of
 docsIfMCmtsEqamGlobCfgDownPhysicalIndex.

When setting M and N Symbol Rate parameters, both
 docsIfMCmtsEqamGlobCfgDownSymbolRateM and
 docsIfMCmtsEqamGlobCfgDownSymbolRateN objects MUST
 be present in the entry, otherwise an error code
 'notCommitted' is reported in
 docsIfMCmtsEqamGlobCfgDownExecutionCode of this entry.

Setting this object without setting
 docsIfMCmtsEqamGlobCfgDownAnnex may end up with particular
 QAM channels set rejections due to incompatible Annex
 parameters, in which case the error 'errorSetFailures' is
 reported in docsIfMCmtsEqamGlobCfgDownExecutionCode."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 8 }
```

docsIfMCmtsEqamGlobCfgDownSymbolRateN OBJECT-TYPE

SYNTAX Unsigned32 (1..65535)

MAX-ACCESS read-create

STATUS deprecated

DESCRIPTION

"The object for global configuration of Downstream
 channel Symbol M factor of the QAM channels in the
 containment tree of
 docsIfMCmtsEqamGlobCfgDownPhysicalIndex.

When setting M and N Symbol Rate parameters, both
 docsIfMCmtsEqamGlobCfgDownSymbolRateM and
 docsIfMCmtsEqamGlobCfgDownSymbolRateN objects MUST
 be present in the entry, otherwise an error code
 'notCommitted' is reported in
 docsIfMCmtsEqamGlobCfgDownExecutionCode of this entry."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 9 }
```

docsIfMCmtsEqamGlobCfgDownLockParams OBJECT-TYPE

SYNTAX BITS {

frequency(0),

```

    bandwidth(1),
    power(2),
    modulation(3),
    interleaver(4),
    j83Annex(5),
    symbolRate(6)
}
MAX-ACCESS    read-create
STATUS        deprecated
DESCRIPTION
    "The object for global configuration of Downstream
    channel lock state of the PHY parameters of the QAM
    channels in the containment tree of
    docsIfMCmtsEqamGlobCfgDownPhysicalIndex.

    A locked PHY parameter is blocked for sets via Management
    or other means such as DEPI session.

    Setting a BIT to '1' locks the corresponding PHY parameter
    for configuration, returning error 'wrongValue' on SET
    attempts until administratively unlocked.

    A set to this object is reflected in
    docsIfMCmtsEqamDownstreamDeviceConfigPhyParamLock of the
    QAM channels being set.
    Note that setting a BIT to '0' does not necessarily grant
    write access to a PHY parameter, because of existing
    hardware constraints indicated in
    docsIfMCmtsEqamDownstreamDevicePhyParamLock."
DEFVAL { 'h' }
::= { docsIfMCmtsEqamGlobCfgDownEntry 10 }

docsIfMCmtsEqamGlobCfgDownExecutionCode OBJECT-TYPE
    SYNTAX      INTEGER {
        complete(1),
        errorNoPhysIndex(2),
        errorNoQAMChannels(3),
        errorSetFailures(4),
        errorNoCommitted(5),
        warningDependencies(6),
        errorOther(7)
    }
    MAX-ACCESS    read-only
    STATUS        deprecated
    DESCRIPTION
        "Indicates the status of the global configuration entry
        execution. If different than 'none', represents the last
        error condition present.
        'complete' indicates the Global configuration success with
        no errors.
        'errorNoPhysIndex' indicates the value of
        docsIfMCmtsEqamGlobCfgDownPhysicalIndex does not
        exist.
        'errorSetFailures' indicates the global set was commit but
        individual QAM channels reported errors on sets. The
        counter docsIfMCmtsEqamGlobCfgDownErrorCount is
        increased for each QAM channel set failure.
        'errorNoCommitted' indicates the entry was not committed as
        sets to the associated QAM channels due to inconsistent
        PHY parameters. Few possible cases are:
        - refer to the docsIfMCmtsEqamGlogCfgDownAnnex
        constraints and related Annex objects as it
        describes.
```

- setting an unique parameter with wrong syntax, leaving the entry in 'notReady' status See RowStatus Object description.

'warningDependencies' indicates the command was executed and the system may have detected dependencies. This execution code is optional and considered a warning rather than an error, as the management entity can have knowledge about group dependencies prior to setting an entry by inspecting docsIfMCmtsEqamGroupDependencyTable.

'errorOther' indicates an error condition not considered in the above situations.

As multiple QAM channels are set only the last error condition is maintained in case of a no 'complete' execution status. A warning condition (e.g., 'warningDependencies' does not override an existing error condition (other enumeration values)."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 12 }
```

docsIfMCmtsEqamGlobCfgDownErrorsCount OBJECT-TYPE

SYNTAX Gauge32

MAX-ACCESS read-only

STATUS deprecated

DESCRIPTION

"The number of error cases where a QAM channel was not successfully set. This value starts counting at zero any time the global configuration entry is executed.

This object is reset back to zero in case of a successful set."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 13 }
```

docsIfMCmtsEqamGlobCfgDownRowStatus OBJECT-TYPE

SYNTAX RowStatus

MAX-ACCESS read-create

STATUS deprecated

DESCRIPTION

"The status of this conceptual table row entry.

In order to create an entry the object

docsIfMCmtsEqamGlobCfgDownPhysicalIndex MUST be set

This table has 'holes' for all the read-create' objects not specified in the setup.

An entry is set to 'active' status if at least one read-create object of the list below is set, otherwise, the entry is in 'notReady' status.

```
docsIfMCmtsEqamGlobCfgDownBandwidth
docsIfMCmtsEqamGlobCfgDownPower
docsIfMCmtsEqamGlobCfgDownModulation
docsIfMCmtsEqamGlobCfgDownInterleave
docsIfMCmtsEqamGlobCfgDownAnnex
docsIfMCmtsEqamGlobCfgDownSymbolRateM
docsIfMCmtsEqamGlobCfgDownSymbolRateN
```

Once an entry is active the QAM channels associated to the docsIfMCmtsEqamGlobCfgDownPhysicalIndex containment tree are set to the parameters specified in the entry.

The Entry remains in 'active' row status and the execution status is reported by

docsIfMCmtsEqamGlobCfgDownExecutionCode.

Setting a previously set object to a new value or specifying an object not initially set during row creation, sets the entry in row status 'notInService'. A set of this object to 'active' triggers again the global configuration action. As a rule, the EQAM device is not expected to track old parameter values. Thus, the set to 'active' of the entry performs the global set of all the old and new parameters defined in the entry.

Due to the possible value 'notInService' as a valid configuration state, this entry MUST NOT be aged out when Row Status is 'notInService'."

```
::= { docsIfMCmtsEqamGlobCfgDownEntry 14 }
```

```
-- -----
-- CMTS and EQAM Channel Block configuration
-- Configuration and diagnostic of block Channels.
-- This table is only for Block Channels Physical containments
-- Other configuration parameters (PHY) applicable to all channels in a
-- Block Channel are set through docsIfMCmtsEqamGlobCfgDownTable
-- -----
```

docsIfMCmtsChannelBlockTable OBJECT-TYPE

SYNTAX SEQUENCE OF DocsIfMCmtsChannelBlockEntry

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"This table configure attributes of block channels and Controls channel Block Tests.

A channel block is an ENTITY-MIB containment of PhysicalClass 'module' that represent an RF connector. This Table is deprecated and the equivalent management information is now part of the DOCS-DRF-MIB MIB Module"

```
::= { docsIfMCmtsEqamObjects 5 }
```

docsIfMCmtsChannelBlockEntry OBJECT-TYPE

SYNTAX DocsIfMCmtsChannelBlockEntry

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"The conceptual row entry of this table Entries in this table are created at system Initialization for Block Channels compliant to DRFI Specification. Sets in entries of this table persist after system initialization."

INDEX { docsIfMCmtsChannelBlockPhysicalIndex }

```
::= { docsIfMCmtsChannelBlockTable 1 }
```

DocsIfMCmtsChannelBlockEntry ::= SEQUENCE

```
{
  docsIfMCmtsChannelBlockPhysicalIndex      PhysicalIndex,
  docsIfMCmtsChannelBlockNumberChannels     Unsigned32,
  docsIfMCmtsChannelBlockCfgNumberChannels  Unsigned32,
  docsIfMCmtsChannelBlockMute                TruthValue,
  docsIfMCmtsChannelBlockTestType           INTEGER,
  docsIfMCmtsChannelBlockTestIfIndex        InterfaceIndexOrZero
}
```

docsIfMCmtsChannelBlockPhysicalIndex OBJECT-TYPE

SYNTAX PhysicalIndex

```

MAX-ACCESS    not-accessible
STATUS        deprecated
DESCRIPTION
    "The Physical Index of the QAM Channel Block."
 ::= { docsIfMCmtsChannelBlockEntry 1 }

```

docsIfMCmtsChannelBlockNumberChannels OBJECT-TYPE

```

SYNTAX        Unsigned32
MAX-ACCESS    read-only
STATUS        deprecated
DESCRIPTION
    "The Number of QAM Channels N associated to this entry."
 ::= { docsIfMCmtsChannelBlockEntry 2 }

```

docsIfMCmtsChannelBlockCfgNumberChannels OBJECT-TYPE

```

SYNTAX        Unsigned32(1..119)
MAX-ACCESS    read-write
STATUS        deprecated
DESCRIPTION
    "The Number of QAM Channels N' to configure for the
    QAM block.
    The maximum number of channels per block follows the
    consideration of maximum number of digital channels in
    a headend described in the DRFI specification.
    As a rule N' is valid if is less or equal to N. In addition
    N minimal requirements consist of even numbers and 1
    (one QAM channel per Block Channel). Odd number of QAM
    channels per Block Channel are of optional implementation.
    A Set to an invalid value or not supported value returns
    Error 'wrongValue'."
 ::= { docsIfMCmtsChannelBlockEntry 3 }

```

docsIfMCmtsChannelBlockMute OBJECT-TYPE

```

SYNTAX        TruthValue
MAX-ACCESS    read-write
STATUS        deprecated
DESCRIPTION
    "The Mute control object for the Block Channel
    A set to this object to 'true' is reflected in
    ifOperStatus set to 'down' of the QAM channels
    associated to the block Channel.
    The opposite, a set to this object to 'false', is not
    necessarily reflected as ifOperStatus set to 'up' since
    other interface conditions might prevent such status."
 ::= { docsIfMCmtsChannelBlockEntry 4 }

```

docsIfMCmtsChannelBlockTestType OBJECT-TYPE

```

SYNTAX        INTEGER {
                    noTest(1),
                    offOthersNormal(2),
                    allOff(3),
                    onOthersOff(4),
                    cwOnOthersOff(5),
                    cwOnOthersNormal(6),
                    clockTest(7)
                }
MAX-ACCESS    read-only
STATUS        deprecated
DESCRIPTION
    "A set of in-service and out-of-service test modes.
    The value 'noTest'(1) is the normal condition after
    reinitialization where the QAM channels are expected in

```

operation.

'noTest'

It is also used to take out of testing mode
a QAM channel within the block.

In-service tests modes:

'offOthersNormal'

It is the condition where the QAM Channel indicated in
docsIfMCmtsChannelBlockTestIfIndex has its carrier
suppressed and the other channels in the
Block Channel are operational.

'alloff'

All QAM channels carriers in the channel block are
Suppressed.

'onOthersOff'

It is the condition where the QAM channel indicated in
docsIfMCmtsChannelBlockTestIfIndex is in operation
and the other QAM channels in the channel Block have
their carriers suppressed.

Out-of-service test modes:

'cwOnOthersOff'

It is the condition where the QAM channel indicated in
docsIfMCmtsChannelBlockTestIfIndex transmits a
continuous wave (CW) while the other QAM
channels in the channel Block have their carriers
suppressed.

'cwOnOthersNormal'

It is the condition where the QAM channel indicated
in docsIfMCmtsChannelBlockTestIfIndex transmits a
continuous wave (CW) while the other QAM channels in
the channel Block are operational.

'clockTest'

It is the condition where the QAM channel indicated in
docsIfMCmtsChannelBlockTestIfIndex transmits a sequence
of alternating -1 and 1 symbols.

This object value does not persist after system
Reinitialization.

The value of this object is meaningless if
docsIfMCmtsChannelBlockTestIfIndex is set to zero."

```
::= { docsIfMCmtsChannelBlockEntry 5 }
```

docsIfMCmtsChannelBlockTestIfIndex OBJECT-TYPE

SYNTAX InterfaceIndexOrZero

MAX-ACCESS read-write

STATUS deprecated

DESCRIPTION

"The ifIndex of the QAM channel to perform the QAM
channel test.

A Set to a value that does not correspond to a QAM
Channel within the Block channel returns error

'wrongValue'.

A set to zero stops a current test execution."

```
::= { docsIfMCmtsChannelBlockEntry 6 }
```

--

-- DEPI Management objects

-- Applicable to both M-CMTS core and EQAM device

```
--
--
-- DEPI Control Table
--
```

docsIfMCmtsDepsessionConfigTable OBJECT-TYPE

SYNTAX SEQUENCE OF DocsIfMCmtsDepsessionConfigEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The Control table for the configuration of M-CMTS Downstream Interfaces.

The M-CMTS Downstream Interface configuration information is contained in this table.

Currently L2TPv3 is the defined tunnel mechanism for DEPI sessions. There may be other DEPI tunnel methods defined in the future.

The configuration of entries with docsIfMCmtsDepsessionConfigMethod equal to 'l2tpControl' follows the rule below:

Only one L2TPv3 Control Plane from a M-CMTS Core IP is established per EQAM IP host destination indicated in docsIfMCmtsDepsessionConfigRemoteAddr. There may be other L2TPv3 Control Plane connections from different M-CMTSs to the same EQAM IP host."

```
::= { docsIfMCmtsDepsessionObjects 1 }
```

docsIfMCmtsDepsessionConfigEntry OBJECT-TYPE

SYNTAX DocsIfMCmtsDepsessionConfigEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A conceptual row for this table.

Entries are created by either management operations or other M-CMTS applications or interfaces (e.g., ERMI), the persistence of an entry is indicated in docsIfMCmtsDepsessionConfigStorage.

The DEPI connection mechanism using L2TPv3 is initiated when an entry in this table is set to active. The following conditions apply:

- o If the M-CMTS L2TPv3 Control Connection with the remote EQAM Host IP in docsIfMCmtsDepsessionConfigRemoteAddr does not exist, a DEPI L2TPv3 control Connection is created.
- o There may be cases where the control plane with the EQAM IP host exists or is in progress, (e.g., a previously created entry with same EQAM IP host), thus the M-CMTS MUST avoid multiple L2TP Control Connection State machines.
- o DEPI L2TPv3 sessions are created based on the TSID value. Only the first entry with row status 'active' with a particular TSID value will try to establish a L2TPv3 session. Other entries with same TSID value return state of 'depiSessionError' in docsIfMCmtsDepsessionInfoState.

Relationships with the DOCSIS MAC domain IfStackTable:

This control considers the ability of the M-CMTS to use a manager-specified Downstream interface value for the configuration of the DOCSIS MAC domain downstream interfaces of the M-CMTS architecture.

- o When docsIfMCmtsDepiSessionConfigCableDownstreamIfIndex is a non-zero value the value of docsIfMCmtsDepiSessionConfigCableMacLayerIfIndex MUST be an existing DOCSIS MAC layer interface.
- o If an entry in this table already exists for the specified docsIfMCmtsDepiSessionConfigCableDownstreamIfIndex, or corresponds to an ifIndex signaled as 'integrated' in docsIfMCmtsDownstreamType a newly created entry set to active is rejected and reported in docsIfMCmtsDepiSessionInfoState as 'invalidDSInterfaceValue'.
- o The M-CMTS accepts or rejects the creation of a new table entry based on the possibility of adding a new Downstream interface to the MAC domain. On success it is reported in docsIfMCmtsDownstreamType as 'depisession'.

Relationship with DRF Interface tables:

Setting an entry to active creates or updates (when docsIfMCmtsDepiSessionConfigCableMCmtsDownIfIndex is provided in the row creation; see the object description for details) the corresponding entry in the following tables:

ifTable,
docsIfDownstreamChannelTable,
docsDrfDownstreamTable/
docsIfMCmtsEqamDownstreamTable,
docsIfMCmtsDepiSessionInfoTable, and
docsIfMCmtsDepiSessionStatsTable

In the EQAM device this table is normally created by the M-CMTS Core initiated DEPI session, although manual configuration may be supported, with the difference that EQAM devices are not required to initiate DEPI sessions. EQAM device Operation of configured entries is not detailed in this MIB module."

```
INDEX { docsIfMCmtsDepiSessionConfigIndex }
 ::= { docsIfMCmtsDepiSessionConfigTable 1 }
```

```
DocsIfMCmtsDepiSessionConfigEntry ::= SEQUENCE
{
    docsIfMCmtsDepiSessionConfigIndex          Unsigned32,
    docsIfMCmtsDepiSessionConfigCableMacIfIndex
                                                InterfaceIndexOrZero,
    docsIfMCmtsDepiSessionConfigCableMCmtsDownIfIndex
                                                InterfaceIndexOrZero,
    docsIfMCmtsDepiSessionConfigAddrType        InetAddressType,
    docsIfMCmtsDepiSessionConfigLocalAddr       InetAddress,
    docsIfMCmtsDepiSessionConfigRemoteAddr      InetAddress,
    docsIfMCmtsDepiSessionConfigL2TPv3HeaderType INTEGER,
    docsIfMCmtsDepiSessionConfigMethod          INTEGER,
    docsIfMCmtsDepiSessionConfigTSID            Unsigned32,
```

```

docsIfMCmtsDepsessionConfigDEPIMode          INTEGER,
docsIfMCmtsDepsessionConfigRsrcAllocReq       Unsigned32,
docsIfMCmtsDepsessionConfigCinPhbIdPolicy     SnmpTagValue,
docsIfMCmtsDepsessionConfigSyncEnabled        TruthValue,
docsIfMCmtsDepsessionConfigSyncInterval       Unsigned32,
docsIfMCmtsDepsessionConfigPhyParamsFlag      BITS,
docsIfMCmtsDepsessionConfigChannelFrequency   Unsigned32,
docsIfMCmtsDepsessionConfigChannelModulation  INTEGER,
docsIfMCmtsDepsessionConfigChannelInterleave  INTEGER,
docsIfMCmtsDepsessionConfigChannelPower       TenthdBmV,
docsIfMCmtsDepsessionConfigChannelAnnex       INTEGER,
docsIfMCmtsDepsessionConfigChannelSymbolRateM Unsigned32,
docsIfMCmtsDepsessionConfigChannelSymbolRateN Unsigned32,
docsIfMCmtsDepsessionConfigChannelOutputRate  Unsigned32,
docsIfMCmtsDepsessionConfigChannelBurstSize   Unsigned32,
docsIfMCmtsDepsessionConfigStorage            StorageType,
docsIfMCmtsDepsessionConfigRowStatus          RowStatus,
docsIfMCmtsDepsessionConfigChannelId          Unsigned32
}

docsIfMCmtsDepsessionConfigIndex OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4294967295)
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "The index for entries in this conceptual table."
    ::= { docsIfMCmtsDepsessionConfigEntry 1 }

docsIfMCmtsDepsessionConfigCableMacIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS   read-create
    STATUS      current
    DESCRIPTION
        "Defines the MAC domain (ifType docsCableMacLayer) on
        which the DEPI Session is being set for an existing M-CMTS
        Downstream interface.

        This object MUST be set to a valid DOCSIS MAC layer
        interface in order to make the entry active."
    ::= { docsIfMCmtsDepsessionConfigEntry 2 }

docsIfMCmtsDepsessionConfigCableMCmtsDownIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS   read-create
    STATUS      current
    DESCRIPTION
        "Defines the Downstream channel index on which the DEPI
        Session is being set.

        The set of this object is optional. When this object is not
        specified the M-CMTS is expected to generate an internal
        value with its corresponding ifStackTable dependencies at
        the time of making this entry active.

        When setting this value to a non-zero value, this object
        and docsIfMCmtsDepsessionConfigCableMacIfIndex MUST
        correspond to a valid Cable and MCmtsDownstream interfaces
        pair from the ifStackTable.

        A set to an ifIndex corresponding to an ifType 128

```

```

        (docsCableDownstream Interface) won't allow to turn the
        entry active."
    DEFVAL { 0 }
    ::= { docsIfMCmtsDepsessionConfigEntry 3 }

docsIfMCmtsDepsessionConfigAddrType OBJECT-TYPE
    SYNTAX      InetAddressType
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The type of InetAddress for
        docsIfMCmtsDepsessionConfigLocalAddr and
        docsIfMCmtsDepsessionConfigRemoteAddr."
    DEFVAL { ipv4 }
    ::= { docsIfMCmtsDepsessionConfigEntry 4 }

docsIfMCmtsDepsessionConfigLocalAddr OBJECT-TYPE
    SYNTAX      InetAddress
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The InetAddress of the local entity the DEPI Session
        is set."
    DEFVAL { '00000000'h }
    ::= { docsIfMCmtsDepsessionConfigEntry 5 }

docsIfMCmtsDepsessionConfigRemoteAddr OBJECT-TYPE
    SYNTAX      InetAddress
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The InetAddress of the remote peer the DEPI Session
        is set."
    DEFVAL { '00000000'h }
    ::= { docsIfMCmtsDepsessionConfigEntry 6 }

docsIfMCmtsDepsessionConfigL2TPv3HeaderType OBJECT-TYPE
    SYNTAX      INTEGER {
                    ip(1),
                    udp(2)
                }
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "Indicates the type of L2TPv3 header being configured for
        the DEPI session.
        The value 'ip' means L2TPv3 Header Over IP
        The value 'udp' means L2TPv3 Header Over UDP. A M-CMTS Core
        initiates a DEPI session with L2TPv3 over UDP using the
        port number 1701 as destination port. The EQAM replies
        may modify its UDP source port as indicated in the L2TPv3
        RFC to convey the DEPI specification option of mapping
        DEPI flows to a QAM Channel within an EQAM."
    DEFVAL { udp }
    ::= { docsIfMCmtsDepsessionConfigEntry 7 }

docsIfMCmtsDepsessionConfigMethod OBJECT-TYPE
    SYNTAX      INTEGER {
                    other(1),
                    l2tpControl(2)
                }
    MAX-ACCESS   read-create
    STATUS       current

```

DESCRIPTION

"Indicates the DEPI Tunnel mechanism used for the DEPI session. Currently only 'l2tpControl' is supported. The value 'other' is used to indicate other means."

```
::= { docsIfMCmtsDepsessionConfigEntry 8 }
```

docsIfMCmtsDepsessionConfigTSID OBJECT-TYPE

SYNTAX Unsigned32 (0..65535)

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The TSID to be associated to the DEPI Session.

TSID is a 16-bit unsigned integer value configured per QAM channel in the EQAM device and serves as a QAM channel identifier at several network levels.

When this object is set to 0, at the most the L2TPv3 Control Plane of the DEPI session is established but not DEPI L2TPv3 Session itself. It means, there might be the situations where the DEPI Control Plane already exists e.g., a different DEPI session to same EQAM device. In this case the new entry will not trigger the DEPI Control Plane creation. The TSID value zero may accomplish functions like testing of DEPI Control Plane connectivity without launching the DEPI Session itself; DLM over a M-CMTS Core - EQAM devices path with no Active sessions for administrative purposes."

```
::= { docsIfMCmtsDepsessionConfigEntry 9 }
```

docsIfMCmtsDepsessionConfigDEPIMode OBJECT-TYPE

```
SYNTAX      INTEGER {
                dmpt(1),
                psp(2)
            }
```

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The DEPI mode of operation of this entry

'dmpt' indicates DOCSIS MPT mode (D-MPT)

'psp' indicates Packet Streaming Protocol."

```
::= { docsIfMCmtsDepsessionConfigEntry 10 }
```

docsIfMCmtsDepsessionConfigRsrcAllocReq OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"A reference to docsIfMCmtsDepsessionConfigRsrcAllocIndex of docsIfMCmtsDepsessionConfigRsrcAllocTable used in the DEPI Session setup by the M-CMTS Core to configure EQAM PHBIDs. M-CMTS uses only the PHBIDs from the docsIfMCmtsDepsessionConfigRsrcAllocTable for the DEPI resource allocation request, ignoring DEPI Flow ID values and UDP Ports.

For the EQAM this object has no meaning as it is set to zero always."

```
DEFVAL { 0 }
```

```
::= { docsIfMCmtsDepsessionConfigEntry 11 }
```

docsIfMCmtsDepsessionConfigCinPhbIdPolicy OBJECT-TYPE

SYNTAX SnmpTagValue

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"A list of tags to reference CIN PHB policies in docsIfMCmtsDepsPhbPolicyTable for this DEPI session.

This object is not meaningful for the EQAM, and reports a zero length octet string."

```
::= { docsIfMCmtsDepsSessionConfigEntry 12 }
```

docsIfMCmtsDepsSessionConfigSyncEnabled OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"Indicates the DOCSIS Sync message handling at the Edge QAM based upon PSP or DMPT mode of operation.

In MPT mode 'true' indicates the EQAM MUST perform

Sync TimeStamp correction. In PSP mode 'true' indicates the EQAM MUST insert DOCSIS Sync messages."

REFERENCE

"DEPI Specification Section 6.5"

DEFVAL { false }

```
::= { docsIfMCmtsDepsSessionConfigEntry 13 }
```

docsIfMCmtsDepsSessionConfigSyncInterval OBJECT-TYPE

SYNTAX Unsigned32 (10..1000)

UNITS "docsisSyncSteps"

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"Indicates the time nominal time interval for EQAM to insert DOCSIS Sync messages when operating in PSP mode. In DMPT mode this value is ignored.

The unit reference of this object is steps of 200 usec.

This object range covers the EQAM required support of DOCSIS Sync interval from 2 msec to 200 msec."

DEFVAL { 1000 }

```
::= { docsIfMCmtsDepsSessionConfigEntry 14 }
```

docsIfMCmtsDepsSessionConfigPhyParamsFlag OBJECT-TYPE

SYNTAX BITS {

frequency(0),

bandwidth(1),

power(2),

modulation(3),

interleaver(4),

j83Annex(5),

symbolRate(6),

mute(7)

}

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"When configuring an entry, DOCSIS PHY parameters may be set directly or default values are used to populate the entry.

This object indicates which PHY parameter sets need to be sent by the M-CMTS Core in the DEPI session request.

A BIT position set to '1' indicates the PHY parameter is set during the DEPI session establishment.

In the EQAM indicates the PHY parameters set by the M-CMTS core during the DEPI Session establishment procedure."

DEFVAL { 'h' }

```
::= { docsIfMCmtsDepsSessionConfigEntry 15 }
```

docsIfMCmtsDepsessionConfigChannelFrequency OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The channel frequency for the Downstream DEPI Session.
A DEPI Session establishment success will update the
corresponding ifIndex entry of docsIfChannelFrequency
with this entry value if provided in entry creation,
or the EQAM DEPI Frequency parameter advertised
during the DEPI session negotiation."

REFERENCE

"DEPI specification"

DEFVAL { 0 }

::= { docsIfMCmtsDepsessionConfigEntry 16 }

docsIfMCmtsDepsessionConfigChannelModulation OBJECT-TYPE

SYNTAX INTEGER {

unknown(1),

qam64(3),

qam256(4)

}

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The channel modulation for the Downstream DEPI Session.
A DEPI Session establishment success will update the
corresponding ifIndex entry of docsIfDownChannelModulation
with this entry value if provided in entry creation,
or the EQAM DEPI Modulation parameter advertised
during the DEPI session negotiation."

DEFVAL { unknown }

::= { docsIfMCmtsDepsessionConfigEntry 17 }

docsIfMCmtsDepsessionConfigChannelInterleave OBJECT-TYPE

SYNTAX INTEGER {

unknown(1),

taps8Increment16(3),

taps16Increment8(4),

taps32Increment4(5),

taps64Increment2(6),

taps128Increment1(7),

taps12increment17(8),

-- non RFIv2 MIB 2670 interleave modes

taps128increment2(9),

taps128increment3(10),

taps128increment4(11),

taps128increment5(12),

taps128increment6(13),

taps128increment7(14),

taps128increment8(15)

}

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The channel Interleaver for the Downstream DEPI Session.
A DEPI Session establishment success will update the
corresponding ifIndex entry of docsIfDownChannelInterleave
with this entry value if provided in entry creation,
or the EQAM DEPI interleaver parameter advertised
during the DEPI session negotiation."

DEFVAL {unknown }

::= { docsIfMCmtsDepsessionConfigEntry 18 }

```
docsIfMCmtsDepsessionConfigChannelPower OBJECT-TYPE
    SYNTAX      TenthdBmV
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The channel power level for the Downstream DEPI Session.
        A DEPI Session establishment success will update the
        corresponding ifIndex entry of docsIfDownChannelPower
        with this entry value if provided in entry creation,
        or the EQAM DEPI power level parameter advertised
        during the DEPI session negotiation."
    DEFVAL { 0 }
    ::= { docsIfMCmtsDepsessionConfigEntry 19 }
```

```
docsIfMCmtsDepsessionConfigChannelAnnex OBJECT-TYPE
    SYNTAX      INTEGER {
        unknown(1),
        annexA(3),
        annexB(4),
        annexC(5)
    }
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The channel J.83 Annex type for the Downstream DEPI
        Session.
        A DEPI Session establishment success will update the
        corresponding ifIndex entry of docsIfDownChannelAnnex
        with this entry value if provided in entry creation,
        or the EQAM DEPI power level parameter advertised
        during the DEPI session negotiation. Also the value
        of docsIfDownChannelWidth is set according to
        the J.83 specification."
    DEFVAL { unknown }
    ::= { docsIfMCmtsDepsessionConfigEntry 20 }
```

```
docsIfMCmtsDepsessionConfigChannelSymbolRateM OBJECT-TYPE
    SYNTAX      Unsigned32 (1..65535)
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The value M for the estimation of the DS Symbol Rate
        as (10.24 MHz ) * M / N"
    DEFVAL { 1 }
    ::= { docsIfMCmtsDepsessionConfigEntry 21 }
```

```
docsIfMCmtsDepsessionConfigChannelSymbolRateN OBJECT-TYPE
    SYNTAX      Unsigned32 (1..65535)
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The value N for the estimation of the DS Symbol Rate
        as (10.24 MHz ) * M / N"
    DEFVAL { 1 }
    ::= { docsIfMCmtsDepsessionConfigEntry 22 }
```

```
docsIfMCmtsDepsessionConfigChannelOutputRate OBJECT-TYPE
    SYNTAX      Unsigned32 (0..100)
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
```

"The percentage of the maximum output rate for the aggregated traffic that is being sent through this M-CMTS Downstream interface to the QAM channel associated with this DEPI session. Using a value lower than 100% of the QAM channel configured payload rate prevents the build up of a queue delay when MPEG-TS nulls are added in the presence of jitter in the CIN. This object is meaningful only to the M-CMTS core. The EQAM device reports a value 0."

REFERENCE

"DEPI M-CMTS Core Output Rate"

DEFVAL { 99 }

::= { docsIfMCmtsDepsessionConfigEntry 23 }

-- TBD IfSpeed Values relationship to DEPI tunnel MTU

docsIfMCmtsDepsessionConfigChannelBurstSize OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The maximum burst size for the aggregate output rate of this M-CMTS Downstream Interface. The default value of this object corresponds to 3 M-CMTS Core payload MTUs.

This value has no meaning for the EQAM device and reports a value of 0."

::= { docsIfMCmtsDepsessionConfigEntry 24 }

docsIfMCmtsDepsessionConfigStorage OBJECT-TYPE

SYNTAX StorageType

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The storage realization of the entry.

No columnar values can be changed if the StorageType of an entry is 'permanent'."

::= { docsIfMCmtsDepsessionConfigEntry 25 }

docsIfMCmtsDepsessionConfigRowStatus OBJECT-TYPE

SYNTAX RowStatus

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The status of this conceptual table row entry.

In order to set an entry to the 'active' status, the MIB objects below must be set to proper values:

Other objects default values are used for the DEPI session

docsIfMCmtsDepsessionConfigCableMacIfIndex

docsIfMCmtsDepsessionConfigRemoteAddr

docsIfMCmtsDepsessionConfigTSID

docsIfMCmtsDepsessionConfigDEPIMode

docsIfMCmtsDepsessionConfigRsrcAllocReq

docsIfMCmtsDepsessionConfigMethod

docsIfMCmtsDepsessionConfigPhyFlag

docsIfMCmtsDepsessionConfigChannelId must be unique within the MAC sublayer domain in order to set this entry to active,

PHY parameters listed below are not required to be populated in this table, then default values are used to populate the entry or implementation may opt to not instantiate those objects.

```
docsIfMCmtsDepsessionConfigChannelFrequency
docsIfMCmtsDepsessionConfigChannelModulation
docsIfMCmtsDepsessionConfigChannelInterleave
docsIfMCmtsDepsessionConfigChannelPower
docsIfMCmtsDepsessionConfigChannelAnnex
docsIfMCmtsDepsessionConfigSyncInterval
```

When the row entry is 'active' the DEPI tunnel control and/or the DEPI session is established. Retries and timeouts are proper of the DEPI Tunnel protocol used.

For L2TPv3 while the entry is active the M-CMTS must continue to set the DEPI session and log the respective errors for unsuccessful operations.

Relationship with the IfTable ifAdminStatus

Setting ifAdminStatus from ifTable to the interface pointed by this entry (docsIfMCmtsDepsessionConfigCableMCmtsDownIfIndex) to 'down' sets this entry Row Status to 'notInService'. A set to ifAdminStatus to 'up' while in 'down' state sets back the Row Status to 'active'.

The opposite is not true: a set to this object to 'active' when previously 'notInService' and while ifAdminStatus is 'down' returns an error 'inconsistentValue', such only one point of contact is needed to enable and disable the interface.

Setting this object to 'notInService' while ifAdminStatus is 'down' sets ifOperStatus to 'down'.

Setting this entry to 'notInService' will tear down the DEPI session. DEPI Tunnel Control teardown in the absence of sessions is Tunnel protocol dependent, e.g., for L2TPv3 Control Connections may use tunnel Idle Timeout objects defined in L2TP-MIB.

Due to the dependencies of IfAdminStatus and this table row Status, M-CMTS Core and EQAM devices MUST not age out entries with Row Status 'notInService' and docsIfMCmtsDepsessionInfoState in 'ifAdminStatusSetToDown'.

```
::= { docsIfMCmtsDepsessionConfigEntry 26 }
```

docsIfMCmtsDepsessionConfigChannelId OBJECT-TYPE

```
SYNTAX      Unsigned32
MAX-ACCESS  read-create
STATUS      current
```

DESCRIPTION

"The downstream channel identification of this M-CMTS Downstream interface.
During entry creation The M-CMTS Core assigns a Channel ID if this object is not provided.
When this object is set to a Channel ID value already in use by a different downstream interface within the same MAC domain the error 'inconsistentValue' error is

```

        returned if this entry is active."
    ::= { docsIfMCmtsDepsessionConfigEntry 27 }

docsIfMCmtsDepsessionInfoTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsDepsessionInfoEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table provides M-CMTS Downstream Interface with
        DEPI session information related to the DEPI session
        configuration process."
    ::= { docsIfMCmtsDepsessionObjects 2 }

docsIfMCmtsDepsessionInfoEntry OBJECT-TYPE
    SYNTAX      DocsIfMCmtsDepsessionInfoEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A conceptual row for this table.
        Entries in this table are created when a DEPI Session
        Configuration Table entry becomes active. Both entries
        are linked through
        docsIfMCmtsDepsessionConfigCableMCmtsDownIfIndex, which is
        equivalent to ifIndex from other M-CMTS Downstream
        interface tables."
    INDEX { ifIndex }
    ::= { docsIfMCmtsDepsessionInfoTable 1 }

DocsIfMCmtsDepsessionInfoEntry ::= SEQUENCE
{
    docsIfMCmtsDepsessionInfoCfgIndex          Unsigned32,
    docsIfMCmtsDepsessionInfoUdpPort           InetPortNumber,
    docsIfMCmtsDepsessionInfoMaxPayload        Unsigned32,
    docsIfMCmtsDepsessionInfoPathPayload       Unsigned32,
    docsIfMCmtsDepsessionInfoIncludeDOCSISMsgs TruthValue,
    docsIfMCmtsDepsessionInfoRsrcAllocResp     Unsigned32,
    docsIfMCmtsDepsessionInfoConnCtrlID       Unsigned32,
    docsIfMCmtsDepsessionInfoEQAMSessionID     Unsigned32,
    docsIfMCmtsDepsessionInfoOwner             INTEGER,
    docsIfMCmtsDepsessionInfoState             INTEGER,
    docsIfMCmtsDepsessionInfoErrorCode         INTEGER,
    docsIfMCmtsDepsessionInfoCreationTime      TimeStamp,
    docsIfMCmtsDepsessionInfoStorage           StorageType
}

docsIfMCmtsDepsessionInfoCfgIndex OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4294967295)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of the docsIfMCmtsDepsessionConfigTable index
        (docsIfMCmtsDepsessionConfigIndex) associated to this
        M-CMTS Downstream Interface Entry."
    ::= { docsIfMCmtsDepsessionInfoEntry 1 }

docsIfMCmtsDepsessionInfoUdpPort OBJECT-TYPE
    SYNTAX      InetPortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The UDP Port reported by the EQAM when the DEPI session
        uses the L2TPv3 Header Over UDP."

```

This object reports a value 0 when the DEPI session is running with the L2TPv3 Session IP Header. This port number is negotiated between the M-CMTS Core and the EQAM according to the L2TPv3 RFC."

```

::= { docsIfMCmtsDepsessionInfoEntry 2 }

```

docsIfMCmtsDepsessionInfoMaxPayload OBJECT-TYPE

```

SYNTAX      Unsigned32 (1..4294967295)
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The maximum MTU negotiated between the M-CMTS Core and the
    EQAM during the DEPI session establishment process.
    The local payload MTU is known from the IfEntry of this
    M-CMTS Downstream Interface. It considers the header
    subtractions as indicated in the DEPI specification."
REFERENCE
    "DEPI specification, Signaling
    DEPI specification Annex A"
::= { docsIfMCmtsDepsessionInfoEntry 3 }

```

docsIfMCmtsDepsessionInfoPathPayload OBJECT-TYPE

```

SYNTAX      Unsigned32 (1..4294967295)
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "The maximum MTU traversing the CIN from M-CMTS Core to the
    EQAM. This calculated by the M-CMTS core by procedures such
    MTU discovery as described in the DEPI specification."
REFERENCE
    "DEPI specification, Network MTU"
::= { docsIfMCmtsDepsessionInfoEntry 4 }

```

docsIfMCmtsDepsessionInfoIncludeDOCSISMsgs OBJECT-TYPE

```

SYNTAX      TruthValue
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "Reports if the M-CMTS includes DOCSIS MAP messages
    and other MAC Management messages in the Downstream
    interface entry associated with this DEPI control entry.
    The CMTS determines weather the M-CMTS Downstream Interface
    includes DOCSIS messages as part of the DEPI payload."
DEFVAL { false }
::= { docsIfMCmtsDepsessionInfoEntry 5 }

```

docsIfMCmtsDepsessionInfoRsrcAllocResp OBJECT-TYPE

```

SYNTAX      Unsigned32 (0..4294967295)
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "In the M-CMTS core a reference to
    docsIfMCmtsDepsessionInfoRsrcAllocIndex of
    docsIfMCmtsDepsessionInfoRsrcAllocTable as reported by the EQAM
    during the DEPI session establishment process.

    The number of PHBIDs in the entries referenced in
    docsIfMCmtsDepsessionInfoRsrcAllocReq and this object
    may differ if the EQAM Host IP signals a partial list of
    PBHIDs during the DEPI session establishment.

    In the EQAM a value 0 indicates no reference to
    docsIfMCmtsDepsessionInfoRsrcAllocTable. A non-zero value indicates

```

```

        the value of docsIfMCmtsDepiRsrcAllocIndex in
        docsIfMCmtsDepiRsrcAllocTable as being signaled by the EQAM
        to the M-CMTS Core."
    DEFVAL { 0 }
    ::= { docsIfMCmtsDepiSessionInfoEntry 6 }

docsIfMCmtsDepiSessionInfoConnCtrlID OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "Indicates the DEPI Tunnel Connection Control Identifier
        For L2TPv3 this corresponds to CCID."
    ::= { docsIfMCmtsDepiSessionInfoEntry 7 }

docsIfMCmtsDepiSessionInfoEQAMSessionID OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "Indicates the DEPI Session Identifier associated to the
        EQAM IP host. In the M-CMTS it corresponds to the L2TPv3
        Remote Session ID, while in the EQAM indicates the local
        Session ID. This object in conjunction with the Connection
        Control ID identifies the DEPI session."
    ::= { docsIfMCmtsDepiSessionInfoEntry 8 }

docsIfMCmtsDepiSessionInfoOwner OBJECT-TYPE
    SYNTAX      INTEGER {
        management(1),
        dynamic(2)
    }
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The creation method of the entry. Applicable to both
        M-CMTS Core and EQAM devices.

        'management'
            Indicates the entry was created via a direct
            configuration management such as SNMP or command line.

        'dynamic'
            Indicates the entry was created via a mechanism
            different of user management, e.g., auto discovery or
            dynamic addition with the assistance of other
            Interfaces like ERMI.

        Writable columnar values of entries with this object set
        to 'dynamic' should not be changed via management
        operations. An attempt to do so returns an SNMP error
        'notWritable'."
    ::= { docsIfMCmtsDepiSessionInfoEntry 9 }

docsIfMCmtsDepiSessionInfoState OBJECT-TYPE
    SYNTAX      INTEGER {
        other(1),
        depiSessionUp(2),
        depiSessionError(3),
        depiSessionInProgress(4)
    }
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION

```

```

    "A high level state of the DEPI session.
    'depiSessionUp'
        Indicates the DEPI session is UP and able to pass
        traffic.
    'depiSessionError'
        Indicates the DEPI session encountered
        an error and the DEPI session was disconnected or
        never reached the session connection state.
        docsIfMCmtsDepiSessionInfoErrorCode indicates possible
        reasons for the error conditions.
    'depiSessionInProgress'
        Indicates that the DEPI session has been configured,
        but has not yet become active."
    ::= { docsIfMCmtsDepiSessionInfoEntry 10 }

docsIfMCmtsDepiSessionInfoErrorCode OBJECT-TYPE
    SYNTAX      INTEGER {
        none(1),
        invalidMACInterfaceValue(2),
        invalidDSInterfaceValue(3),
        noResourcesForDSInterfaceIndex(4),
        l2tpv3Error(5),
        ifAdminStatusSetToDown(6)
    }
    MAX-ACCESS   read-only
    STATUS        current
    DESCRIPTION
        "The error Code raised when docsIfMCmtsDepiSessionInfoState
        is 'depiSessionError'
        'invalidMACInterfaceValue'
            Indicates wrong assignment of the M-CMTS MAC interface
            ifIndex.
        'invalidDSInterfaceValue'
            Indicates wrong assignment of the M-CMTS Downstream
            interface ifIndex
        'noResourcesForDSInterfaceIfIndex'
            Indicates the M-CMTS Core has no more resources to
            assign a session to this entry.
        'l2tpv3Error'
            An L2TPv3 StopCCN or CDN message was issued
        'ifAdminStatusSetToDown'
            Indicates the ifAdminStatus was set to down and the
            session was torn down. More details are in the Row
            Status and ifAdminStatus relationship, described in
            docsIfMCmtsDepiSessionConfigRowStatus.

        More detail state may be provided by the proper DEPI tunnel
        Mechanism, e.g., L2TP-MIB l2tpTunnelStatsEntry."
    ::= { docsIfMCmtsDepiSessionInfoEntry 11 }

docsIfMCmtsDepiSessionInfoCreationTime OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS   read-only
    STATUS        current
    DESCRIPTION
        "The sysUptime when the entry was turned active."
    ::= { docsIfMCmtsDepiSessionInfoEntry 12 }

docsIfMCmtsDepiSessionInfoStorage OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS   read-only
    STATUS        current
    DESCRIPTION

```

```

        "The storage realization of the entry.
        This object value is the same as the corresponding
        entry of docsIfMCmtsDepsSessionInfoStorage."
    ::= { docsIfMCmtsDepsSessionInfoEntry 13 }

--
-- DEPI Session Resource Allocation Table
-- Sets DEPI FlowIds policies to map DOCSIS Packets to DEPI Flow IDs
--

docsIfMCmtsDepsRsrcAllocTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsDepsRsrcAllocEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing PHBIDs Resources used for DEPI
        applications.

        At the M-CMTS core these entries contain information
        about the mapping of egress traffic to PHBIDs and DEPI flow
        IDs also known as DEPI payload encapsulation.

        For the M-CMTS Core there are two type of entries:
        o One set of entries is a preconfigured list of PHBIDs
          used for M-CMTS requests to EQAM IP Host, e.g., the MIB
          object docsIfMCmtsDepsSessionConfigRsrcAllocReq
          references those type of entry sets.
          In those entries the values of
          docsIfMCmtsDepsRsrcAllocUdpPort,
          docsIfMCmtsDepsRsrcAllocFlowId,
          docsIfMCmtsDepsRsrcAllocPolicyCinPolicyTag and
          docsIfMCmtsDepsRsrcAllocPolicyScnTags
          are ignored by the M-CMTS.

        o The second set of entries has the responses from the EQAM
          IP host to the M-CMTS when the DEPI session request is
          successful. The object
          docsIfMCmtsDepsSessionInfoRsrcAllocResp in
          docsIfMCmtsDepsSessionInfoTable references an entry of
          this type.

        The EQAM MAY implement this table to configure the
        different queue prioritization of the DEPI flow IDs, PHBIDs
        and UDP ports triplet used in the DEPI Resource allocation
        response to the M-CMTS. If this table is not implemented by
        the EQAM device the object
        docsIfMCmtsDepsSessionInfoRsrcAllocResp is
        set to zero, and the DEPI session Resource Allocation
        response is vendor specific. Also the EQAM device MAY
        implement this table as read-only for the purpose of
        debugging the DEPI Resource Allocation Responses sent to
        the M-CMTS core."
    ::= { docsIfMCmtsDepsSessionObjects 3 }

docsIfMCmtsDepsRsrcAllocEntry OBJECT-TYPE
    SYNTAX      DocsIfMCmtsDepsRsrcAllocEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A conceptual row for this table.
        At minimum two entries for docsIfMCmtsDepsRsrcAllocSeq
        (two Flow ID entries) per docsIfMCmtsDepsRsrcAllocIndex
        value are needed for DEPI PSP mode."

```

When the docsIfMCmtsDepiRsrcAllocIndex is used for DMPT mode one flow Id entry value is required.

The PHBIDs contained in this entry are expanded with the tags of docsIfMCmtsDepiRsrcAllocPolicySCNTags to indicate the association of PSP packets attributes such as DOCSIS MAPS, DOCSIS MAC messages and DOCSIS Service Flows to a DEPI Flow ID. Thus, the EQAM IP Host uses those DEPI flow IDs to prioritize the QAM channel traffic."

```
INDEX { docsIfMCmtsDepiRsrcAllocIndex, docsIfMCmtsDepiRsrcAllocSeq }
::= { docsIfMCmtsDepiRsrcAllocTable 1 }
```

```
DocsIfMCmtsDepiRsrcAllocEntry ::= SEQUENCE
```

```
{
  docsIfMCmtsDepiRsrcAllocIndex      Unsigned32,
  docsIfMCmtsDepiRsrcAllocSeq        Unsigned32,
  docsIfMCmtsDepiRsrcAllocPhbId      Unsigned32,
  docsIfMCmtsDepiRsrcAllocFlowId     DepiFlowId,
  docsIfMCmtsDepiRsrcAllocUdpPort    InetPortNumber,
  docsIfMCmtsDepiRsrcAllocPolicyScnTags SnmpTagValue,
  docsIfMCmtsDepiRsrcAllocStorage     StorageType,
  docsIfMCmtsDepiRsrcAllocRowStatus   RowStatus,
  docsIfMCmtsDepiRsrcAllocCinPolicyTag SnmpAdminString
}
```

```
docsIfMCmtsDepiRsrcAllocIndex OBJECT-TYPE
```

```
SYNTAX      Unsigned32 (1..4294967295)
```

```
MAX-ACCESS  not-accessible
```

```
STATUS      current
```

```
DESCRIPTION
```

"The first index of this table.
Multiple DEPI Flow Ids are within a
docsIfMCmtsDepiRsrcAllocIndex value."

```
::= { docsIfMCmtsDepiRsrcAllocEntry 1 }
```

```
docsIfMCmtsDepiRsrcAllocSeq OBJECT-TYPE
```

```
SYNTAX      Unsigned32 (1..4294967295)
```

```
MAX-ACCESS  not-accessible
```

```
STATUS      current
```

```
DESCRIPTION
```

"The sequence index for entries within the same
docsIfMCmtsDepiRsrcAllocIndex value.
EQAM IP Host may reply with less PHBIDs than requested,
then, the M-CMTS Core skips the sequence index of missing
PHBIDs when creating the Resource Allocation entry
response.

As a rule of thumb this object has the minimal queuing
priority information for DEPI flows treatment in the EQAM.
The lowest sequence value indicates the DEPI Flow ID with
the highest priority treatment at the EQAM (e.g., DOCSIS
MAC messages should be allocated to that flow) and the
highest sequence number indicates the DEPI Flow ID with the
lowest priority."

```
::= { docsIfMCmtsDepiRsrcAllocEntry 2 }
```

```
docsIfMCmtsDepiRsrcAllocPhbId OBJECT-TYPE
```

```
SYNTAX      Unsigned32 (0..63)
```

```
MAX-ACCESS  read-create
```

```
STATUS      current
```

```
DESCRIPTION
```

"The PHB identifier (per-Hop-Behavior ID) associated with
this entry. This PHBID is used solely to signal to the EQAM

what it's local traffic policy should be for the DEPI flow, and is independent of the PHBs in the CIN.
 In PSP a minimum of two PHBIDs for two flow IDs corresponds to PHBIDs EF (46) and BE (0). BE is the PHBID for the one Flow ID PHBID required in DMPT mode."

```
 ::= { docsIfMCmtsDepiRsrcAllocEntry 3 }
```

docsIfMCmtsDepiRsrcAllocFlowId OBJECT-TYPE

```
SYNTAX      DepiFlowId
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "The Flow ID value reported in the Resource Allocation
    Response for the corresponding PHBID."
DEFVAL { 0 }
```

```
 ::= { docsIfMCmtsDepiRsrcAllocEntry 4 }
```

docsIfMCmtsDepiRsrcAllocUdpPort OBJECT-TYPE

```
SYNTAX      InetPortNumber
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "The UDP Port reported by the Resource Allocation
    Response for the corresponding PHBID in this table."
DEFVAL { 0 }
```

```
 ::= { docsIfMCmtsDepiRsrcAllocEntry 5 }
```

docsIfMCmtsDepiRsrcAllocPolicyScnTags OBJECT-TYPE

```
SYNTAX      SnmpTagValue
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "A list of Service Class Names (SCN) tags associated to
    PHBID/Flow IDs.
    The policies associated to each DEPI Flow ID of this table
    allow the mapping of specific DOCSIS Service Flows well
    distinguished by SCN.

    The SCN encoding does not include the null terminated
    octets as DOCSIS specify for other configuration mechanisms
    such as Cable Modem config files encoding.

    This object is applicable to M-CMTS core but not to
    EQAM devices.

    In D-MPT mode no tags are needed since all DOCSIS traffic
    is mapped to same DEPI Flow ID, thus this object is set to
    zero-length string (no tag) or ignored.

    In PSP mode DOCSIS MAPS, DOCSIS MAC messages and PacketCable
    1.0/1.5 voice traffic are mapped to the highest priority DEPI
    Flow ID (lower sequence number in the Resource allocation
    response)

    If this object is empty (no tag), the default policy is
    used.

    In PSP mode the default policy consists to assign the DEPI
    Flow ID of the lowest priority (highest sequence number) to
    the DOCSIS traffic. DOCSIS Traffic not matched to a policy
    Tag is mapped to the default policy Flow ID.

    In PSP mode the docsIfMCmtsDepiRsrcAllocSeq values pointed
```

in a M-CMTS Core Resource Allocation Request has the preconfigured Policy Tags to map DOCSIS traffic to DEPI Flow IDs. When the Resource Allocation response from the EQAM is received, it could have same or less of the PHBIDs requested, and the PHBID references could be in a different order sequence. Therefore, the M-CMTS Core MUST accommodate the policy Tags initial configuration to the EQAM order sequence and number of PHBIDs.

For example:

A Resource Allocation Request:

Seq Num	PHBID	Flow ID	UDP Port	Policy Tags
1	EF			VoiceGold*
2	AF			VideoConference
3	BE			empty - no tag -

* - PCMM voice service based on SCN, no PacketCable 1.0/1.5 voice

The EQAM Resource Allocation response:

Seq Num	PHBID	Flow ID	UDP Port	Policy Tags
1	EF	6	50201	
2	BE	7	50202	

It is vendor specific to re-allocate the policy Tags in the case of less DEPI Flow IDs in the Resource Allocation response than in the requests. In the example PHBID AF policy tag could be assigned to either Flow ID 6 or 7

Final Resource Allocation Tag reordering

Seq Num	PHBID	Flow ID	UDP Port	Policy Tags
1	EF	6	50201	VoiceGold VideoConference
2	BE	7	50202	empty - no tag -

Change of sequence in the response example:

A Resource Allocation Request:

Seq Num	PHBID	Flow ID	UDP Port	Policy Tags
1	0x30			VoiceGold
2	0x20			VideoConference
3	0x10			empty - no tag -

* - PCMM voice service based on SCN, no PacketCable 1.0/1.5 voice

The EQAM Resource Allocation response:

Seq Num	PHBID	Flow ID	UDP Port	Policy Tags
1	0x20	6	50201	
2	0x10	7	50202	
3	0x30	8	50203	

Final Resource Allocation Tag reordering

Seq Num	PHBID	Flow ID	UDP Port	Policy Tags

1	0x20	6	50201	VoiceGold
2	0x10	7	50202	VideoConference
3	0x30	8	50203	empty - no tag -"

```

DEFVAL { " " }
::= { docsIfMCmtsDepsRsrcAllocEntry 6 }

docsIfMCmtsDepsRsrcAllocStorage OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The storage realization of this entry.
        Entries corresponding to a Resource Allocation Response
        are of type 'volatile' and do not persist.
        Entries set as 'permanent' need not write access
        for its read-create type base objects.

        All entries within the same docsIfMCmtsDepsRsrcAllocIndex
        share the same StorageType value."
    DEFVAL { volatile }
    ::= { docsIfMCmtsDepsRsrcAllocEntry 7 }

docsIfMCmtsDepsRsrcAllocRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The status of this conceptual row.
        Administratively created entries need only
        set the value of docsIfMCmtsDepsRsrcAllocPhbId to become
        'active'. All other read-create columnar objects are not
        instantiated or set to default values if not set during
        row creation."
    ::= { docsIfMCmtsDepsRsrcAllocEntry 8 }

docsIfMCmtsDepsRsrcAllocCinPolicyTag OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE (0..32))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A single tag to reference a CIN PHB policy in
        docsIfMCmtsDepsRsrcPolicyTable for this DEPI flow.
        This allows each DEPI flow to be assigned a different
        PHBID across the CIN.

        This object is not meaningful for the EQAM, and reports
        a zero length octet string."
    ::= { docsIfMCmtsDepsRsrcAllocEntry 9 }

--
-- QOS extensions for M-CMTS architecture
-- Policies for mapping PSP packets to SF policies
--

docsIfMCmtsDepsSessionStatsTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsDepsSessionStatsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table provides DEPI Session statistics for the
        M-CMTS Downstream Interface."
    ::= { docsIfMCmtsDepsSessionObjects 4 }

```

```

docsIfMCmtsDepsessionStatsEntry OBJECT-TYPE
    SYNTAX      DocsIfMCmtsDepsessionStatsEntry
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "A conceptual row for this table."
    INDEX { ifIndex }
    ::= { docsIfMCmtsDepsessionStatsTable 1 }

DocsIfMCmtsDepsessionStatsEntry ::= SEQUENCE
{
    docsIfMCmtsDepsessionInfoOutOfSequencePkts    Counter32
}

docsIfMCmtsDepsessionInfoOutOfSequencePkts OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS   read-only
    STATUS      current
    DESCRIPTION
        "The count of DEPI session packets out of sequence.
        It is vendor dependent the re-sequence of DEPI packets.
        EQAM Implementations that do not re-sequence DEPI
        packets also increase the value of ifInDiscards
        for the respective entry.
        This counter is meaningful for M-CMTS Downstream
        interfaces configured in PSP mode. This object
        is not instantiated for D-MPT mode of operation."
    ::= { docsIfMCmtsDepsessionStatsEntry 1 }

--
-- DEPI Latency Measurement (DLM)
--

docsIfMCmtsDepsessionCinLatency OBJECT IDENTIFIER
    ::= { docsIfMCmtsDepsessionObjects 5 }

docsIfMCmtsDepsessionCinLatencyInterval OBJECT-TYPE
    SYNTAX      Unsigned32 (0..420)
    UNITS       "seconds"
    MAX-ACCESS   read-write
    STATUS      current
    DESCRIPTION
        "The time interval used to measure periodically the CIN
        latency per DEPI session.
        Active measurement of CIN latency applies to active DEPI
        sessions only.
        This object is constrained to 420 seconds to prevent
        the Master Clock counter overruns.
        A value zero indicates no CIN latency measurements to be
        performed."
    ::= { docsIfMCmtsDepsessionCinLatency 1 }

docsIfMCmtsDepsessionCinLatencyThreshld OBJECT-TYPE
    SYNTAX      Unsigned32 (0 | 1..4294967295)
    UNITS       "MasterClockTicks"
    MAX-ACCESS   read-write
    STATUS      current
    DESCRIPTION
        "The CIN latency threshold measured in DOCSIS Master clock
        ticks to be reported as an event when exceeded.
        The DOCSIS Master Clock is the 10.24 MHz reference clock."
    ::= { docsIfMCmtsDepsessionCinLatency 2 }

```

```

docsIfMCmtsDepsessionCinEventLevel OBJECT-TYPE
    SYNTAX      INTEGER {
        emergency(1),
        alert(2),
        critical(3),
        error(4),
        warning(5),
        notice(6),
        information(7),
        debug(8)
    }
    MAX-ACCESS   read-write
    STATUS       current
    DESCRIPTION
        "The desired event level to report in case of the CIN
        latency threshold being exceeded."
    ::= { docsIfMCmtsDepsessionCinLatency 3 }

docsIfMCmtsDepsessionCinLastValue OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4294967295)
    UNITS       "MasterClockTicks"
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The CIN latency value measured for the DEPI session
        pointed by docsIfMCmtsDepsessionCinLastValueIfIndex."
    ::= { docsIfMCmtsDepsessionCinLatency 4 }

docsIfMCmtsDepsessionCinLastValueIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The ifIndex of the DEPI Session associated to the CIN
        latency value pointed measured for the DEPI session
        pointed by docsIfMCmtsDepsessionCinLastValue."
    ::= { docsIfMCmtsDepsessionCinLatency 5 }

docsIfMCmtsDepsessionCinLatencyValueLastTime OBJECT-TYPE
    SYNTAX      TimeTicks
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The sysUpTime value of the last time the object
        docsIfMCmtsDepsessionCinLastValue was updated."
    ::= { docsIfMCmtsDepsessionCinLatency 6 }

docsIfMCmtsDepsessionCinLatencyPerfTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsDepsessionCinLatencyPerfEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "This table provides accumulative measurements of the CIN
        latency on the network."
    ::= { docsIfMCmtsDepsessionObjects 6 }

docsIfMCmtsDepsessionCinLatencyPerfEntry OBJECT-TYPE
    SYNTAX      DocsIfMCmtsDepsessionCinLatencyPerfEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "A conceptual row for this table.
        It is a vendor implementation to limit the number

```

```

        of entries per DEPI session (ifIndex) to be stored
        in this table. When the table is full, the oldest
        measurement is replaced with a new one."
INDEX { ifIndex, docsIfMCmtsDepiSessionCinLatencyPerfIntervalSeq }
::= { docsIfMCmtsDepiSessionCinLatencyPerfTable 1 }

DocsIfMCmtsDepiSessionCinLatencyPerfEntry ::= SEQUENCE
{
    docsIfMCmtsDepiSessionCinLatencyPerfIntervalSeq    Unsigned32,
    docsIfMCmtsDepiSessionCinLatencyPerfValue          Unsigned32,
    docsIfMCmtsDepiSessionCinLatencyTime               TimeTicks
}

docsIfMCmtsDepiSessionCinLatencyPerfIntervalSeq OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The interval sequence where the CIN latency
        measurement was taken. It is valid an implementation
        that overrides the oldest sequence number entry with the
        most recent measurement."
    ::= { docsIfMCmtsDepiSessionCinLatencyPerfEntry 1 }

docsIfMCmtsDepiSessionCinLatencyPerfValue OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4294967295)
    UNITS       "MasterClockTicks"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The CIN latency value measured for the DEPI session
        pointed by this entry."
    ::= { docsIfMCmtsDepiSessionCinLatencyPerfEntry 2 }

docsIfMCmtsDepiSessionCinLatencyTime OBJECT-TYPE
    SYNTAX      TimeTicks
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The sysUpTime value of the last time this entry was
        updated."
    ::= { docsIfMCmtsDepiSessionCinLatencyPerfEntry 3 }

--
-- Policies for mapping Service Flows to PSP packets
--
--
-- docsIfMCmtsDepiPhbPolicyTable
-- Applicable to CMTS only

docsIfMCmtsDepiPhbPolicyTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF DocsIfMCmtsDepiPhbPolicyEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The policy rules that apply to DOCSIS traffic (traffic
        profiles) of a DEPI session.
        Traffic Profiles are ways to discriminate specific
        traffic flows for QOS treatment in the CIN and EQAM device.

        The main function of this table is to map the DOCSIS SF
        egress traffic to the Converged Interconnect Network PHB

```

configuration; thus, from the M-CMTS to the EQAM IP host Ingress port, the QOS levels are defined properly.

In D-MPT mode this table is only applicable to PHB egress marking for the CIN.

In PSP mode this table is referenced PHBID CIN (referenced by docsIfMCmtsDepsSessionConfigCinPhbIdPolicy)

The CIN PHBs is operator specific. The CIN per-hub-Behavior of this table accomplishes:

- o DOCSIS MAPs, DOCSIS MAC messages and PacketCable VoIP PHBID are configured in a reserved policy tag 'ExpediteForwardCIN' traffic. This policy has a 'permanent' storage.
- o Data traffic (per DOCSIS Service Flows) is assigned to PBHIDs based on Admission policies rules, e.g., Service Class Name, DOCSIS specific parameters, etc. This table only deals with policies based with SCN. Other traffic descriptor rules are vendor dependent."

```
::= { docsIfMCmtsDepsQosObjects 1 }
```

docsIfMCmtsDepsPhbPolicyEntry OBJECT-TYPE

SYNTAX DocsIfMCmtsDepsPhbPolicyEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The conceptual Table entry.

A consumer of this table uses a lexicographical matching of entries to apply the respective policy, e.g., this table is used for two types of policy assignments:

When referenced by an instance of docsIfMCmtsDepsRsrcAllocCinPolicyTag, the values of docsIfMCmtsDepsPhbPolicyEntry are passed to the CIN PHBID handler to encapsulate DEPI payload with DEPI tunnel PHBID. It means different DEPI flows are assigned to different PHBIDs for the CIN transport."

INDEX { docsIfMCmtsDepsPhbPolicyTag }

```
::= { docsIfMCmtsDepsPhbPolicyTable 1 }
```

DocsIfMCmtsDepsPhbPolicyEntry ::= SEQUENCE

```
{
  docsIfMCmtsDepsPhbPolicyTag          SnmpAdminString,
  docsIfMCmtsDepsPhbPolicyCinVlanState INTEGER,
  docsIfMCmtsDepsPhbPolicyCinPhbId     Unsigned32,
  docsIfMCmtsDepsPhbPolicyStorage       StorageType,
  docsIfMCmtsDepsPhbPolicyRowStatus     RowStatus,
  docsIfMCmtsDepsPhbPolicyCinVlanId     VlanId,
  docsIfMCmtsDepsPhbPolicyCinUserPriority ClDot1dUserPriority
}
```

docsIfMCmtsDepsPhbPolicyTag OBJECT-TYPE

SYNTAX SnmpAdminString (SIZE (1..32))

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The index of the policy."

```
::= { docsIfMCmtsDepsPhbPolicyEntry 1 }
```

docsIfMCmtsDepsPhbPolicyCinVlanState OBJECT-TYPE

```

SYNTAX      INTEGER {
    disabled(0),
    userPriorityOnly(1),
    enabled(2),
    other(3)
}
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "Indicates the layer-2 priority settings assigned to transport
    the DEPI traffic assigned to this docsIfMCmtsDepiPhbPolicyEntry
    for the related DEPI session.
    The value 'disabled' indicates that only transport layer QoS
    settings are in use. DEPI packets for DEPI flows using this
    policy entry will not normally use the 802.1q header.
    The value 'userPriorityOnly' indicates that the
    docsIfMCmtsDepiPhbPolicyCinVlanId object is not in use, but
    the docsIfMCmtsDepiPhbPolicyCinUserPriority is in effect. DEPI
    packets for DEPI flows using this policy entry will normally
    use the 802.1q header with a vlan id of zero and the user
    priority configured by docsIfMCmtsDepiPhbPolicyCinUserPriority.
    The value 'enabled' indicates that values of both the
    docsIfMCmtsDepiPhbPolicyCinVlanId and the
    docsIfMCmtsDepiPhbPolicyCinUserPriority are un use. DEPI
    packets for DEPI flows using this policy entry will use the
    802.1q header with the configured vlan id and user priority.
    The value 'other' indicates that both vlan id and user priority
    are configured by some mechanism other than this MIB."
 ::= { docsIfMCmtsDepiPhbPolicyEntry 2 }

docsIfMCmtsDepiPhbPolicyCinPhbId OBJECT-TYPE
SYNTAX      Unsigned32 (0..63)
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "The CIN PHBID assigned to transport the DEPI traffic assigned
    to this docsIfMCmtsDepiPhbPolicyEntry for the related DEPI
    session."
 ::= { docsIfMCmtsDepiPhbPolicyEntry 3 }

docsIfMCmtsDepiPhbPolicyStorage OBJECT-TYPE
SYNTAX      StorageType
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "The storage realization of this entry
    'permanent' columnar objects allow write access."
 ::= { docsIfMCmtsDepiPhbPolicyEntry 4 }

docsIfMCmtsDepiPhbPolicyRowStatus OBJECT-TYPE
SYNTAX      RowStatus
MAX-ACCESS  read-create
STATUS      current
DESCRIPTION
    "The status of this conceptual table.
    Changes in this columnar objects while this entry is active
    will take effect on new DOCSIS packets being mapped by this
    policy entry."
 ::= { docsIfMCmtsDepiPhbPolicyEntry 5 }

docsIfMCmtsDepiPhbPolicyCinVlanId OBJECT-TYPE
SYNTAX      VlanId

```

```

MAX-ACCESS    read-create
STATUS        current
DESCRIPTION
    "The CIN Vlan ID assigned to transport the DEPI traffic
    assigned to this docsIfMCmtsDepsPhbPolicyEntry for the related
    DEPI session."
::= { docsIfMCmtsDepsPhbPolicyEntry 6 }

docsIfMCmtsDepsPhbPolicyCinUserPriority OBJECT-TYPE
SYNTAX        CldotldUserPriority
MAX-ACCESS    read-create
STATUS        current
DESCRIPTION
    "The 802.1p user priority assigned to transport the DEPI
    traffic assigned to this docsIfMCmtsDepsPhbPolicyEntry for the
    related DEPI session. This only applies to the DEPI session.
    The user priority of DOCSIS frames transported by the DEPI
    session is not affected by the value of this object."
::= { docsIfMCmtsDepsPhbPolicyEntry 7 }

--
-- Extensions for DOCSIS QOS Service Flow Table
--

docsIfMCmtsQosServiceFlowExtTable OBJECT-TYPE
SYNTAX        SEQUENCE OF DocsIfMCmtsQosServiceFlowExtEntry
MAX-ACCESS    not-accessible
STATUS        current
DESCRIPTION
    "This table contains M-CMTS Extensions of the
    DOCSIS Service Flow table to describe DEPI QOS associations
    to Service Flows.

    DEPI Connection Control Table indicates the policies to
    apply any time a new DOCSIS Service Flow is added to the
    M-CMTS Downstream interface."
::= { docsIfMCmtsDepsQosObjects 2 }

docsIfMCmtsQosServiceFlowExtEntry OBJECT-TYPE
SYNTAX        DocsIfMCmtsQosServiceFlowExtEntry
MAX-ACCESS    not-accessible
STATUS        current
DESCRIPTION
    "An entry in the table exists for each
    Service Flow ID of a M-CMTS Downstream Interface type.
    This table is an extension of DocsQosServiceFlowEntry."
INDEX {
    ifIndex,
    docsQosServiceFlowId
}
::= { docsIfMCmtsQosServiceFlowExtTable 1 }

DocsIfMCmtsQosServiceFlowExtEntry ::= SEQUENCE {
    docsIfMCmtsQosServiceFlowExtDepsFlowId  DepsFlowId,
    docsIfMCmtsQosServiceFlowExtCinPhbId    Unsigned32,
    docsIfMCmtsQosServiceFlowExtDepsIfIndex InterfaceIndexOrZero
}

docsIfMCmtsQosServiceFlowExtDepsFlowId OBJECT-TYPE
SYNTAX        DepsFlowId
MAX-ACCESS    read-only
STATUS        current
DESCRIPTION

```

```

        "The DEPI Flow ID associated with this Service Flow."
    ::= { docsIfMCmtsQosServiceFlowExtEntry 1 }

docsIfMCmtsQosServiceFlowExtCinPhbId OBJECT-TYPE
    SYNTAX      Unsigned32 (0..63)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The CIN PHBID associated with this Service Flow."
    ::= { docsIfMCmtsQosServiceFlowExtEntry 2 }

docsIfMCmtsQosServiceFlowExtDepiIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The ifIndex of the M-CMTS DS interface pertaining to
         this Service flow."
    ::= { docsIfMCmtsQosServiceFlowExtEntry 3 }

-- -----
-- Conformance definitions
-- -----

docsIfMCmtsConformance OBJECT IDENTIFIER ::= { docsIfMCmtsMib 2 }
docsIfMCmtsCompliances OBJECT IDENTIFIER ::= { docsIfMCmtsConformance 1 }
docsIfMCmtsGroups      OBJECT IDENTIFIER ::= { docsIfMCmtsConformance 2 }

docsIfMCmtsCoreDeviceCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for M-CMTS Core compliant
         devices."

    MODULE -- this MODULE

-- conditionally mandatory groups

    MANDATORY-GROUPS {
        docsIfMCmtsBaseGroup,
        docsIfMCmtsCoreGroup
    }
::= { docsIfMCmtsCompliances 1 }

docsIfMCmtsEQAMCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for M-CMTS EQAM compliant
         devices."

    MODULE -- this MODULE

-- conditionally mandatory groups

    MANDATORY-GROUPS {
        docsIfMCmtsBaseGroup,
        docsIfMCmtsEqamDevGroup
    }

    ::= { docsIfMCmtsCompliances 2 }

docsIfMCmtsCoreDeviceCompliance2 MODULE-COMPLIANCE
    STATUS      current

```

```

DESCRIPTION
    "The compliance statement for M-CMTS Core compliant
    devices."

MODULE -- this MODULE

-- conditionally mandatory groups

MANDATORY-GROUPS {
    docsIfMCmtsBaseGroup,
    docsIfMCmtsCoreGroup2
}
::= { docsIfMCmtsCompliances 3}

docsIfMCmtsEQAMDeviceCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for M-CMTS EQAM compliant
        devices."

MODULE -- this MODULE

-- conditionally mandatory groups

MANDATORY-GROUPS {
    docsIfMCmtsBaseGroup,
    docsIfMCmtsEqamDevGroup2
}

::= { docsIfMCmtsCompliances 4}

docsIfMCmtsEQAMDeviceCompliance2 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for DOCSIS EQAM compliant
        devices."

MODULE -- this MODULE

-- conditionally mandatory groups

MANDATORY-GROUPS {
    docsIfMCmtsBaseGroup
}

::= { docsIfMCmtsCompliances 5}

docsIfMCmtsBaseGroup OBJECT-GROUP
    OBJECTS {
        docsIfMCmtsDepsessionConfigCableMacIfIndex,
        docsIfMCmtsDepsessionConfigCableMCmtsDownIfIndex,
        docsIfMCmtsDepsessionConfigAddrType,
        docsIfMCmtsDepsessionConfigLocalAddr,
        docsIfMCmtsDepsessionConfigRemoteAddr,
        docsIfMCmtsDepsessionConfigL2TPv3HeaderType,
        docsIfMCmtsDepsessionConfigMethod,
        docsIfMCmtsDepsessionConfigTSID,
        docsIfMCmtsDepsessionConfigDEPIMode,
        docsIfMCmtsDepsessionConfigRsrcAllocReq,
        docsIfMCmtsDepsessionConfigCinPhbIdPolicy,
        docsIfMCmtsDepsessionConfigSyncEnabled,
    
```

```

docsIfMCmtsDepsessionConfigSyncInterval,
docsIfMCmtsDepsessionConfigPhyParamsFlag,
docsIfMCmtsDepsessionConfigChannelFrequency,
docsIfMCmtsDepsessionConfigChannelModulation,
docsIfMCmtsDepsessionConfigChannelInterleave,
docsIfMCmtsDepsessionConfigChannelPower,
docsIfMCmtsDepsessionConfigChannelAnnex,
docsIfMCmtsDepsessionConfigChannelSymbolRateM,
docsIfMCmtsDepsessionConfigChannelSymbolRateN,
docsIfMCmtsDepsessionConfigChannelOutputRate,
docsIfMCmtsDepsessionConfigChannelBurstSize,
docsIfMCmtsDepsessionConfigStorage,
docsIfMCmtsDepsessionConfigRowStatus,
docsIfMCmtsDepsessionConfigChannelId,
docsIfMCmtsDepsessionInfoCfgIndex,
docsIfMCmtsDepsessionInfoUdpPort,
docsIfMCmtsDepsessionInfoMaxPayload,
docsIfMCmtsDepsessionInfoPathPayload,
docsIfMCmtsDepsessionInfoIncludedOCSISMsgs,
docsIfMCmtsDepsessionInfoRsrcAllocResp,
docsIfMCmtsDepsessionInfoConnCtrlID,
docsIfMCmtsDepsessionInfoEQAMSessionID,
docsIfMCmtsDepsessionInfoOwner,
docsIfMCmtsDepsessionInfoState,
docsIfMCmtsDepsessionInfoErrorCode,
docsIfMCmtsDepsessionInfoCreationTime,
docsIfMCmtsDepsessionInfoStorage,
docsIfMCmtsDepsessionInfoRsrcAllocPhbId,
docsIfMCmtsDepsessionInfoRsrcAllocFlowId,
docsIfMCmtsDepsessionInfoRsrcAllocUdpPort,
docsIfMCmtsDepsessionInfoRsrcAllocPolicyScnTags,
docsIfMCmtsDepsessionInfoRsrcAllocStorage,
docsIfMCmtsDepsessionInfoRsrcAllocRowStatus,
docsIfMCmtsDepsessionInfoRsrcAllocCinPolicyTag,
docsIfMCmtsDepsessionInfoOutOfSequencePkts,
docsIfMCmtsDepsessionCinLatencyInterval,
docsIfMCmtsDepsessionCinLatencyThreshld,
docsIfMCmtsDepsessionCinEventLevel,
docsIfMCmtsDepsessionCinLastValue,
docsIfMCmtsDepsessionCinLastValueIfIndex,
docsIfMCmtsDepsessionCinLatencyValueLastTime
}
STATUS      current
DESCRIPTION
    "Group of objects implemented in M-CMTS compliant devices."
 ::= { docsIfMCmtsGroups 1 }

docsIfMCmtsCoreGroup OBJECT-GROUP
OBJECTS {
    docsIfMCmtsCoreDownstreamPhyDependencies,
    docsIfMCmtsCoreDownstreamType,
    docsIfMCmtsQosServiceFlowExtDepsessionFlowId,
    docsIfMCmtsQosServiceFlowExtCinPhbId,
    docsIfMCmtsQosServiceFlowExtDepsessionIfIndex,
    docsIfMCmtsDepsessionCinLatencyPerfValue,
    docsIfMCmtsDepsessionCinLatencyTime,
    docsIfMCmtsDepsessionPhbPolicyCinPhbId,
    docsIfMCmtsDepsessionPhbPolicyStorage,
    docsIfMCmtsDepsessionPhbPolicyRowStatus,
    docsIfMCmtsDepsessionPhbPolicyCinVlanState,
    docsIfMCmtsDepsessionPhbPolicyCinVlanId,
    docsIfMCmtsDepsessionPhbPolicyCinUserPriority
}

```

```

STATUS      deprecated
DESCRIPTION
    "Group of objects implemented in M-CMTS Core compliant
    devices."
::= { docsIfMCmtsGroups 2 }

docsIfMCmtsEqamDevGroup OBJECT-GROUP
OBJECTS {
    docsIfMCmtsEqamDownstreamTSID,
    docsIfMCmtsEqamDownstreamPhyDependencies,
    docsIfMCmtsEqamDownstreamDevicePhyParamLock,
    docsIfMCmtsEqamDownstreamDeviceConfigPhyParamLock,
    docsIfMCmtsEqamDownstreamAllocationType,
    docsIfMCmtsEqamDownstreamAllocationStatus,
    docsIfMCmtsEqamDownstreamAllocationTimeout,
    docsIfMCmtsEqamDownstreamDRRPAdvertizing,
    docsIfMCmtsEqamDownstreamUdpPortMapping,
    docsIfMCmtsEqamDownstreamCapabFrequency,
    docsIfMCmtsEqamDownstreamCapabBandwidth,
    docsIfMCmtsEqamDownstreamCapabPower,
    docsIfMCmtsEqamDownstreamCapabModulation,
    docsIfMCmtsEqamDownstreamCapabInterleaver,
    docsIfMCmtsEqamDownstreamCapabJ83Annex,
    docsIfMCmtsEqamDownstreamCapabConcurrentServices,
    docsIfMCmtsEqamDownstreamCapabServicesTransport,
    docsIfMCmtsEqamDownstreamCapabMuting,
    docsIfMCmtsEqamGroupDependencyGroupID,
    docsIfMCmtsEqamGroupDependencyType,
    docsIfMCmtsEqamGlobCfgDownPhysicalIndex,
    docsIfMCmtsEqamGlobCfgDownBandwidth,
    docsIfMCmtsEqamGlobCfgDownPower,
    docsIfMCmtsEqamGlobCfgDownModulation,
    docsIfMCmtsEqamGlobCfgDownInterleave,
    docsIfMCmtsEqamGlobCfgDownAnnex,
    docsIfMCmtsEqamGlobCfgDownSymbolRateM,
    docsIfMCmtsEqamGlobCfgDownSymbolRateN,
    docsIfMCmtsEqamGlobCfgDownLockParams,
    docsIfMCmtsEqamGlobCfgDownExecutionCode,
    docsIfMCmtsEqamGlobCfgDownErrorsCount,
    docsIfMCmtsEqamGlobCfgDownRowStatus,
    docsIfMCmtsChannelBlockNumberChannels,
    docsIfMCmtsChannelBlockCfgNumberChannels,
    docsIfMCmtsChannelBlockMute,
    docsIfMCmtsChannelBlockTestType,
    docsIfMCmtsChannelBlockTestIfIndex
}
STATUS      deprecated
DESCRIPTION
    "Group of objects implemented in M-CMTS EQAM compliant
    devices."
::= { docsIfMCmtsGroups 3 }

docsIfMCmtsCoreGroup2 OBJECT-GROUP
OBJECTS {
    docsIfMCmtsQosServiceFlowExtDepiFlowId,
    docsIfMCmtsQosServiceFlowExtCinPhbId,
    docsIfMCmtsQosServiceFlowExtDepiIfIndex,
    docsIfMCmtsDepiSessionCinLatencyPerfValue,
    docsIfMCmtsDepiSessionCinLatencyTime,
    docsIfMCmtsDepiPhbPolicyCinPhbId,
    docsIfMCmtsDepiPhbPolicyStorage,
    docsIfMCmtsDepiPhbPolicyRowStatus,
    docsIfMCmtsDepiPhbPolicyCinVlanState,

```

```

        docsIfMCmtsDepsPhbPolicyCinVlanId,
        docsIfMCmtsDepsPhbPolicyCinUserPriority
    }
STATUS      current
DESCRIPTION
    "Group of objects implemented in M-CMTS Core compliant
    devices."
::= { docsIfMCmtsGroups 4 }

docsIfMCmtsEqamDevGroup2 OBJECT-GROUP
OBJECTS {
    docsIfMCmtsEqamDownstreamTSID,
    docsIfMCmtsEqamDownstreamPhyDependencies,
    docsIfMCmtsEqamDownstreamDevicePhyParamLock,
    docsIfMCmtsEqamDownstreamDeviceConfigPhyParamLock,
    docsIfMCmtsEqamDownstreamAllocationType,
    docsIfMCmtsEqamDownstreamAllocationStatus,
    docsIfMCmtsEqamDownstreamAllocationTimeout,
    docsIfMCmtsEqamDownstreamDRRPAdvertizing,
    docsIfMCmtsEqamDownstreamUdpPortMapping,
    docsIfMCmtsEqamGlobCfgDownPhysicalIndex,
    docsIfMCmtsEqamGlobCfgDownBandwidth,
    docsIfMCmtsEqamGlobCfgDownPower,
    docsIfMCmtsEqamGlobCfgDownModulation,
    docsIfMCmtsEqamGlobCfgDownInterleave,
    docsIfMCmtsEqamGlobCfgDownAnnex,
    docsIfMCmtsEqamGlobCfgDownSymbolRateM,
    docsIfMCmtsEqamGlobCfgDownSymbolRateN,
    docsIfMCmtsEqamGlobCfgDownLockParams,
    docsIfMCmtsEqamGlobCfgDownExecutionCode,
    docsIfMCmtsEqamGlobCfgDownErrorsCount,
    docsIfMCmtsEqamGlobCfgDownRowStatus
}
STATUS      deprecated
DESCRIPTION
    "Group of objects implemented in M-CMTS EQAM compliant
    devices."
::= { docsIfMCmtsGroups 5 }

END

```

Annex D Format and Content for Event, SYSLOG, and SNMP Notification (normative)⁷²

This annex contains management events for detection of failures or operational condition changes of relevance for the DEPI interface.

D.1 Event DEPI Process definitions

The events in the Process "DEPI" are indications of error conditions in the DEPI Session or the L2TPv3 control plane. The events on this category are generated as consequences of Stop-CCN or CDN messages delivered or received for the other end of the Connection or Session.

There are 3 Subset sub-processes for the event DEPI process: the first two are related to standard L2TPv3 Stop-CCN and CDN messages. The third sub-process is related to CDN messages, but specific to DOCSIS fault conditions.

D.2 DEPI Events

Table D-1 - DEPI Events

Process	Sub-Process	CMTS & EQAM Priority	Event Message	Message Notes and Details	Error Code Set	Event ID	Trap Name
DEPI L2TP Session Failed (DOCSIS AVPs)							
Depi	DEPI-CDN	Critical	CDN; Result Code = 0;	for syslog & local-log Mandatory Add: ; Error Code = 0; Optional Add: <EC Text> Should Add in <EC Text>: "; PWType = <value>"	M01.1	77000101	
Depi	DEPI-CDN	Critical	CDN; Result Code = 0	for syslog & local-log Mandatory Add: ; Error Code = 3; Optional Add: <EC Text> Should Add in <EC Text>: "; PHBID = <value>"	M01.2	77000102	

⁷² Annex added per DEPI-N-08.0696-2.

Process	Sub-Process	CMTS & EQAM Priority	Event Message	Message Notes and Details	Error Code Set	Event ID	Trap Name
Depi	DEPI-CDN	Critical	CDN; Result Code = 0	for syslog & local-log Mandatory Add: ; Error Code = 4; Optional Add: <EC Text> Should Add in <EC Text>: "; PWType = <value>"	M01.3	77000103	
Depi	DEPI-CDN	Critical	CDN; Result Code = 1	for syslog & local-log Mandatory Add: ; Error Code = 1; Should Add in <EC Text>: "; PHY = <AVP type>; Value = <value>"	M01.4	77000104	
Depi	DEPI-CDN	Critical	CDN; Result Code = 2	for syslog & local-log Mandatory Add: ; Error Code = 2; Optional Add: <EC Text> Should Add in <EC Text>: "; PHY = <AVP type>; Value = <value>"	M01.5	77000105	
DEPI L2TP Connection Control (StopCCN)							
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 1	Optional Add: ; Error Code = <EC>; <EC Text>	M02.1	77000201	
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 2	Mandatory Add: ; Error Code = <EC>; Optional Add: <EC Text>	M02.2	77000202	
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 3	Optional Add: ; Error Code = <EC>; <EC Text>	M02.3	77000203	
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 4	Optional Add: ; Error Code = <EC>; <EC Text>	M02.4	77000204	

Process	Sub-Process	CMTS & EQAM Priority	Event Message	Message Notes and Details	Error Code Set	Event ID	Trap Name
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 5	Mandatory Add: Error Code = <EC>; Optional Add: <EC Text> Note: <EC> indicates Highest Version support Value	M02.5	77000205	
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 6	Optional Add: ; Error Code = <EC>; <EC Text>	M02.6	77000206	
Depi	L2TP-StopCCN	Critical	StopCCN; Result Code = 7	Optional Add: ; Error Code = <EC>; <EC Text>	M02.7	77000207	
DEPI L2TP Session Control (CDN)							
Depi	L2TP-CDN	Critical	CDN; Result Code = 1	Optional Add: ; Error Code = <EC>; <EC Text>	M03.1		
Depi	L2TP-CDN	Critical	CDN; Result Code = 2	Mandatory Add: ; Error Code = <EC>; Optional Add: <EC Text>	M03.2		
Depi	L2TP-CDN	Critical	CDN; Result Code = 3	Optional Add: ; Error Code = <EC>; <EC Text>	M03.3		
Depi	L2TP-CDN	Critical	CDN; Result Code = 4	Optional Add: ; Error Code = <EC>; <EC Text>	M03.4		
Depi	L2TP-CDN	Critical	CDN; Result Code = 5	Optional Add: ; Error Code = <EC>; <EC Text>	M03.5		
Depi	L2TP-CDN	Critical	CDN; Result Code = 13	Optional Add: ; Error Code = <EC>; <EC Text>	M03.1 3		
Depi	L2TP-CDN	Critical	CDN; Result Code = 14	Optional Add: ; Error Code = <EC>; <EC Text>	M03.1 4		
Depi	L2TP-CDN	Critical	CDN; Result Code = 15	Optional Add: ; Error Code = <EC>; <EC Text>	M03.1 5		
Depi	L2TP-CDN	Critical	CDN; Result Code = 16	Optional Add: ; Error Code = <EC>; <EC Text>	M03.1 6		

Annex E DEPI Path Redundancy⁷³

E.1 Introduction

This annex describes DEPI Path Redundancy or DPR. DEPI Path Redundancy is a method for creation and management of redundant DEPI connections between the M-CMTS Core and the EQAM. DPR is defined as a set of DEPI protocol extensions.

E.1.1 Background

DOCSIS technology is frequently deployed in mission critical applications. Applications such as residential voice or business services drive the availability standards for integrated CMTS (I-CMTS) towards what is expected of the traditional voice network. The availability requirements in turn demand that the CMTS's architecture must avoid single points of failure and that the CMTS system must automatically detect and repair failures.

DEPI connections and the components involved in exchange of DEPI data are intended to provide service that is highly reliable. Even though their reliability can be further increased through sophisticated networking techniques, a non-redundant DEPI connection may be perceived as a single point of failure. The M-CMTS system can avoid this single point of failure through support for redundant sub-components involved in DEPI and the ability to operate with redundant DEPI connections.

E.1.2 Assumptions

The following are the prerequisites of the DPR:

- The M-CMTS Core supports multiple output interfaces with the ability to direct the DEPI traffic for a given QAM channel to one of several output interfaces.
- The EQAM includes redundant input interfaces with the ability to receive DEPI traffic for a given QAM channels from one of several input interfaces.
- Each of the input and output interfaces must be independently addressable.

E.1.3 Quality of service goals

The DPR provides protocol mechanisms that can be utilized to enable automatic fail-over around DEPI connection failures when either the M-CMTS Core or the EQAM detect a failure. The redundancy can be implemented in such way that there is minimal loss of end-user service (packet loss). The same protocol mechanisms can be deployed to facilitate operator initiated procedures for servicing components of the M-CMTS Core or the EQAM. An operator may invoke redundancy mechanisms when a component needs to be replaced, when a component is placed in a maintenance mode, or during a software upgrade. The DPR enables a M-CMTS system to implement such maintenance procedures with no or with only momentary loss of service.

E.1.4 General Requirements

The support for DPR is optional. The M-CMTS Core MAY support DPR. The EQAM MAY support DPR.

The requirements listed in this annex (noted by capitalized words “MUST”, etc.), are conditional on whether the M-CMTS Core or the EQAM provide support for DPR. Unless explicitly specified otherwise, the wording in this annex refers to operation when DPR is enabled.

E.2 Architecture

E.2.1 Session Level Redundancy

DPR introduces two types of DEPI data sessions: primary sessions and secondary sessions. DPR provides redundancy at the data session level. The “primary” and “secondary” attributes, which signify the readiness to carry data after a fail-over are applicable to DEPI data sessions but not to control connections. The M-CMTS core permanently assigns these attributes to sessions during session setup.

⁷³ Annex added per DEPI-N-10.0901-5 ON 3/18-10 by JB.

Primary sessions are used to transport encapsulated DOCSIS data under normal conditions. Primary sessions are equivalent to generic DEPI sessions, when DPR is not supported.

A secondary session serves as always-ready substitute for a primary session associated with the same QAM channel. In the control protocol, this association is based on the TSID (Transport Stream Identifier) parameter, which uniquely identifies the target QAM channel. Since a TSID value uniquely identifies a QAM channel, the M-CMTS MUST use the same TSID value when signaling setup of the primary and secondary sessions associated with the same QAM channel. There can be only one primary session associated with a particular QAM channel. There can be more than one secondary session associated with a single QAM channel. A set of sessions established for a particular QAM channel is referred to in this document as a set of corresponding sessions.

A secondary session can be utilized to carry DEPI data when the associated primary session becomes unavailable as result of a failure or an operator action. This includes a situation when the primary session cannot be established. The M-CMTS Core is responsible for determining which sessions to designate as primary and which sessions to designate as secondary. The session type is established during the initial connection setup.

The M-CMTS Core is responsible for switching the output of DEPI traffic from a primary session to a secondary session when it detects a failure, upon an operator action or upon reception of a request from the EQAM. When the data output is moved to a secondary session, all DEPI flows in a particular session must be moved simultaneously. At any time, the M-CMTS Core MUST transmit DEPI traffic intended for a particular QAM channel on only one DEPI session.

E.2 Addressing

The M-CMTS Core MUST support the creation of a single primary session and one or more secondary sessions per QAM channel. The EQAM MUST support a single primary session and one or more secondary sessions per QAM channel. Each DEPI session uses one of the pseudowire types described in Section 7.5.1.1. Per [RFC 3931], both the M-CMTS Core and the EQAM assign a unique L2TPv3 session ID for each session. The M-CMTS Core MUST NOT attempt to create a primary session to a QAM channel for which the M-CMTS Core already has an active primary session. The EQAM MUST reject an attempt to establish a primary session to a QAM channel for which a primary session has already been established.

E.3 Topology

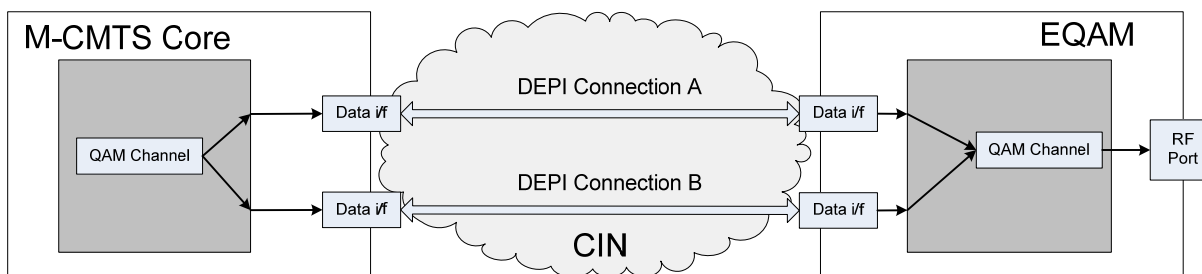


Figure E-1 - Redundant DEPI connections

Figure E-1 shows an example of topology where a single QAM channel can be mapped into one of two redundant DEPI pseudowires. The M-CMTS Core and the EQAM include redundant CIN attachment interfaces and support one or multiple IP addresses which represent LCCEs for L2TPv3 endpoint addressing. **Note:** the mechanism of the mapping between the endpoint IP addresses and the network attachment interfaces or the mechanism in which a QAM channel is mapped to an endpoint IP address are outside of the scope of this specification. The DEPI Connection “A” includes an L2TPv3 control connection and a primary DEPI data session between one pair of LCCEs. The primary session is used to transport encapsulated DOCSIS data under normal conditions.

The DEPI Connection “B” includes an L2TPv3 control connection and a secondary DEPI data session between a second pair of LCCEs. The secondary session included in DEPI Connection “B” is used to transport DEPI traffic when the primary session included in DEPI connection “A” fails or becomes unavailable.

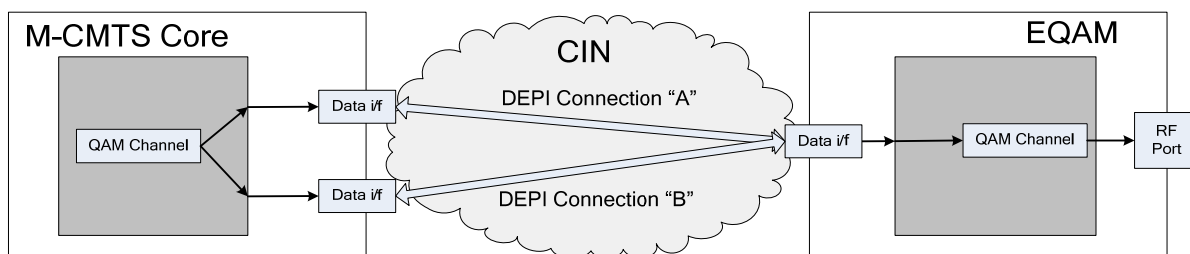


Figure E-2 - Redundant DEPI Connections in Asymmetric Configuration

DPR may be deployed when only one endpoint supports redundant network connectivity. Figure E-2 illustrates such asymmetric configuration, where only the M-CMTS Core includes redundant CIN attachment interfaces and supports multiple IP addresses for LCCEs representation. The EQAM includes a single CIN input interface and supports a single LCCE. Note, that in such asymmetric configuration each of the two DEPI connections can be uniquely identified by a pair of LCCEs.

DPR topology is not limited to the examples presented on Figure E-1 and Figure E-2. While the examples provided above depict 1+1 (one primary plus one secondary) redundancy, DPR supports more diverse configurations. The redundant connections do not need to be created with 1+1 symmetry. For example, a single DEPI connection can include secondary sessions providing backup to primary session included in N DEPI connections. This would create an N+1 scenario. Another possible scenario is when multiple secondary sessions are created for a single primary session.

To avoid a single point of failure the redundant DEPI connection should be created over an independent set of network resources. Those resources include a set of network ports on the M-CMTS Core, a set of network ports on the EQAM, and a fully redundant CIN.

E.4 Signaling

The general rules for signaling with DPR do not differ from the protocol rules described in Section 7.4. Specific modifications to the control protocol for DPR operation are presented below.

E.4.1 Connection Initialization

Figure E-3 shows the typical connection setup sequence when DPR is deployed.

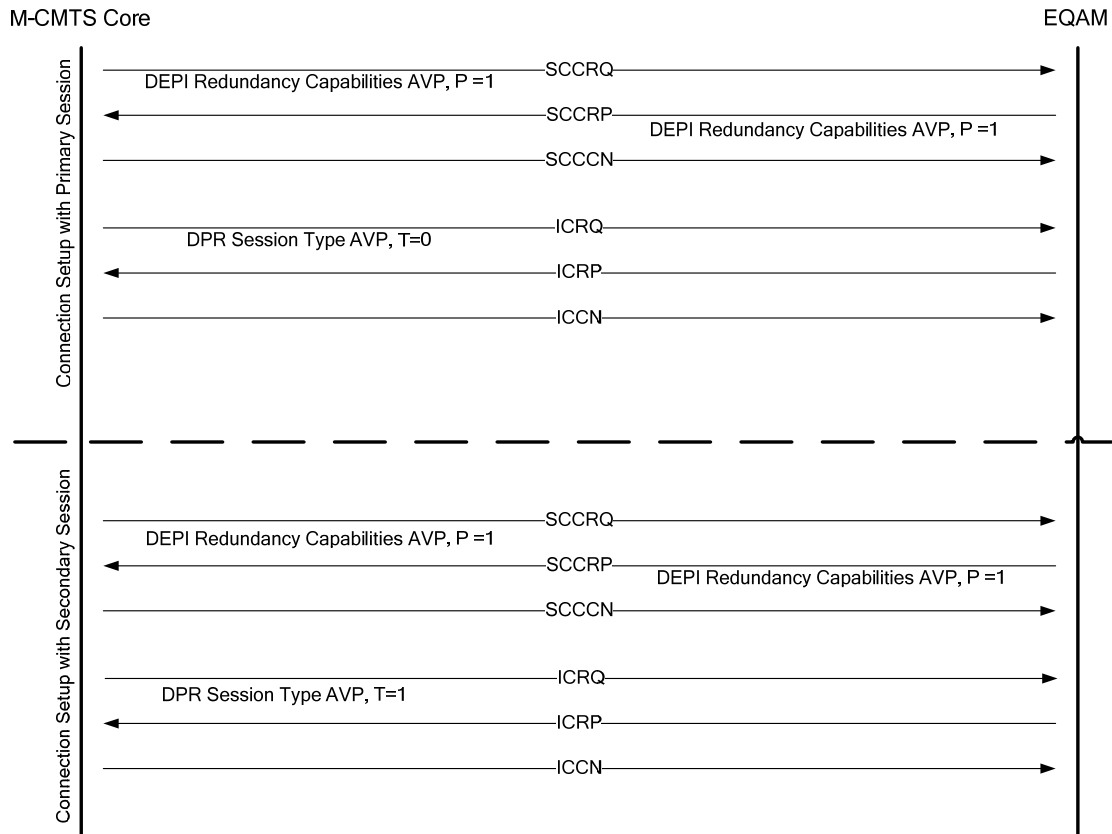


Figure E-3 - Initialization Sequence with DPR

E.4.1.1 Control Connection Setup

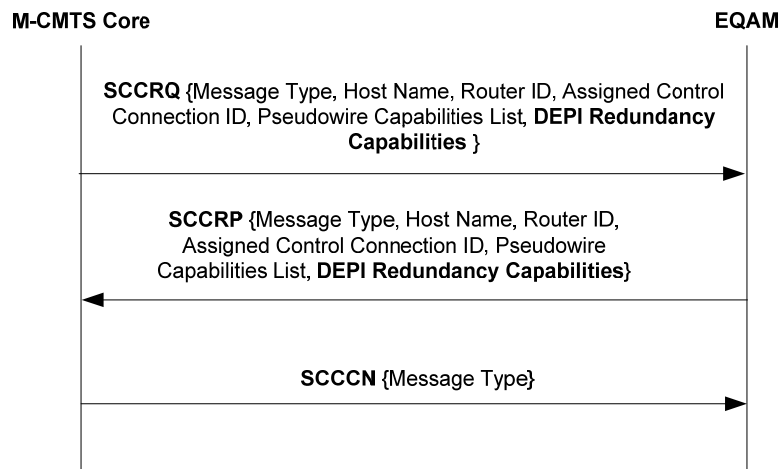


Figure E-4 - DEPI Control Connection Setup

The control connection setup is expanded to include negotiation of the capability to support DPR. For this purpose a new AVP is added: DEPI Redundancy Capabilities (described in Section 7.5.4.1). This AVP is sent in the SCCRQ by the M-CMTS Core with bit “P” set to indicate that the M-CMTS Core supports Path Redundancy. If the EQAM supports Path Redundancy, it includes DEPI Redundancy Capabilities AVP with the “P” bit in the SCCRP. If the

EQAM does not support Path Redundancy, the EQAM may return SCCRP without the DEPI Redundancy Capabilities AVP or return the AVP with the “P” bit set to indicate lack of support for DPR.

The M-CMTS Core determines that the EQAM does not support DPR when the M-CMTS Core receives the SCCRP message with DEPI Redundancy Capabilities AVP with the “P” bit indicating lack of support for DPR, or when the M-CMTS Core receives SCCRP message without DEPI Redundancy Capabilities AVP. When the EQAM does not indicate support for DPR, the M-CMTS Core MUST avoid DPR signaling in session setup by excluding the DPR Session Type AVP from the ICRQ messages.

There are no differences in the protocol setup of control connections used for DEPI control connections which include primary or secondary sessions. Control connection keep-alive and connection teardown protocol does not differ from standard operation.

E.4.1.2 Session Setup

DPR permits for creation of two types of DEPI sessions: primary sessions and secondary sessions. The session type is signaled from the M-CMTS Core to the EQAM during session setup. A new AVP - DPR Session Type AVP is created (defined in Section 7.5.2.9). The M-CMTS Core MUST include DPR Session Type AVP in ICRQ message, when both the M-CMTS Core and the EQAM support DPR. When the DPR is not enabled, then the M-CMTS Core MUST exclude DPR Session Type AVP from ICRQ message.

While the primary session and the corresponding secondary sessions are referring to the same QAM channel, they are independent from the perspective L2TPv3 signaling protocol and general L2TPv3 (non-DEPI specific) AVPs. The only parameter that links primary and corresponding secondary sessions is the value of the TSID of the QAM channel conveyed in Remote End AVP inside of the ICRQ by the M-CMTS Core.

Similarly, the parameters conveyed in the DEPI defined general session AVPs (Table 7–6) can have independent values during the setup of primary and corresponding secondary sessions. The only exception is the Downstream QAM Channel DOCSIS SYNC Control AVP. The M-CMTS Core MUST send identical values of the parameters in the Downstream QAM Channel DOCSIS SYNC Control AVPs when setting up the corresponding primary and secondary sessions.

Conversely, the parameters conveyed in DEPI defined QAM Channel PHY AVPs are common to the primary and the corresponding secondary sessions. This is because they refer to the same QAM channel. When setting up a secondary session, the EQAM MUST set the value QAM Channel PHY Parameters in the ICRP message to values that have been negotiated during the setup of a previously established corresponding primary session.

In a typical deployment scenario, primary sessions are setup before any corresponding secondary sessions are established; however, the protocol does not preclude alternate setup sequence. The M-CMTS Core MUST support setup of a secondary session before the corresponding primary session is established. The EQAM MUST support setup of a secondary session before the corresponding primary session is established.

To address a scenario when a primary session is established after the corresponding secondary session, the DEPI QAM Parameters Write is supported during setup of primary and secondary sessions. The M-CMTS core SHOULD avoid sending DEPI QAM parameters in ICCN message if these parameters have been previously conveyed during a setup of a corresponding session and no change is required.

E.4.1.3 Primary Session Setup

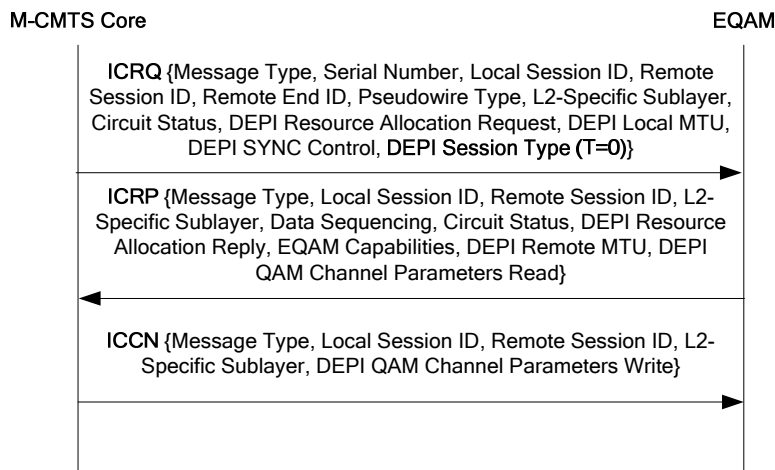


Figure E-5 - Primary Session Setup

The only modification in the protocol for setup of the primary sessions is the addition of the DPR Session Type AVP in ICRQ messages. When sending ICRQ message to create a primary session, the M-CMTS Core **MUST** include DPR Session Type AVP with T bit set to indicate primary session type.

After the setup is complete, the CMTS can start sending DEPI data to the EQAM on the primary session.

E.4.1.4 Secondary Session Setup

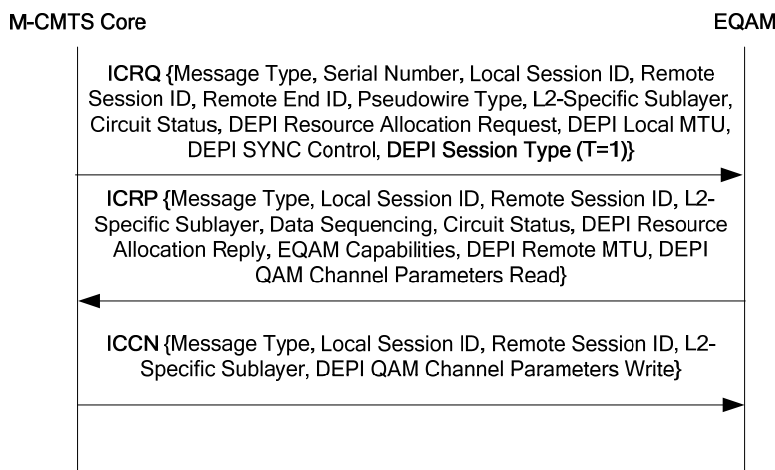


Figure E-6 - Secondary Session Setup

When sending ICRQ message to create a secondary session, the M-CMTS Core **MUST** supply the DPR Session Type AVP with T bit set to indicate the secondary session type. Note that the DEPI QAM channel parameter write is optional in ICCN message. The M-CMTS Core should avoid sending those AVPs if QAM channel PHY parameters have been written during the primary session setup and no changes to the parameters are required during secondary session setup.

After the setup is completed, the secondary session is ready to transport the DEPI data, but remains in a silent or dormant state, where the DEPI data does not flow on the secondary sessions until the fail-over. The M-CMTS Core **MUST** be able to start sending the DEPI data on the secondary session in the event a failure is detected on the

primary session. The EQAM MUST be able to forward DEPI data received on a dormant secondary session without any further protocol interaction in the control plane.

E.4.2 SLI Considerations

The SLI messages can be exchanged in reference to the primary or the secondary sessions. The M-CMTS Core and the EQAM should use the session which is actively carrying DEPI traffic for communication of common parameters such as in DEPI defined QAM Channel PHY AVPs or the Downstream QAM Channel DOCSIS SYNC Control AVP.

E.4.3 Fail-over Scenarios

This specification examines two fail-over scenarios with DPR: M-CMTS Core initiated failover and EQAM initiated failover. Since the DEPI traffic flows unidirectionally from the M-CMTS Core to the EQAM the ultimate decision which of the available sessions to use for active data transport belongs to the M-CMTS Core. When the EQAM initiates the fail-over procedure, the EQAM must notify the M-CMTS Core before the M-CMTS Core can start sending DEPI traffic on an alternate session. When the fail-over is initiated by the M-CMTS Core, it can immediately start sending DEPI data over a secondary session. The transition of traffic generation function must be orderly. The M-CMTS Core MUST ensure that no DEPI data is duplicated during the fail-over. The M-CMTS Core MUST first stop transmitting DEPI traffic on a primary session and subsequently the M-CMTS Core can start sending DEPI traffic on the secondary session. The EQAM MUST be ready to receive DEPI traffic at any time from any secondary DEPI session. This is essential to minimize data outage.

E.4.3.1 M-CMTS Core Initiated Fail-over

The typical fail-over scenario initiated by the M-CMTS Core includes the following two steps:

- 1 The M-CMTS Core stops sending DEPI data on a primary session and starts sending data on a selected corresponding secondary session. If there are multiple secondary sessions corresponding to the primary session it is the responsibility of the M-CMTS Core to determine which corresponding secondary session to select.
- 2 When desirable, the M-CMTS Core may shut down the primary session using the CDN message.

Similar procedure is applicable, when the M-CMTS Core initiates a reverse fail-over from a secondary session to a primary session.

E.4.3.2 EQAM Initiated Fail-over

The EQAM may initiate DPR failover when the EQAM detects an internal failure or when the network operator requests that an EQAM's component needs to be taken out of service, for example when a serviceable module needs to be replaced or when a processor subsystem needs to undergo a software upgrade. In the case of an operator initiated fail-over the EQAM may convey to the M-CMTS Core information about the need to shut down a session (or a group of sessions) before the EQAM's components stops its operation.

The typical session fail-over scenario initiated by the EQAM includes the following three steps:

- 1 The EQAM may signal the request to initiate the fail-over (from a primary session to a secondary session or vice versa) to the M-CMTS Core by tearing down the session via the CDN message. Before issuing the CDN message, the EQAM MAY send an SLI message for the primary session including the DPR Session Status AVP with the T bit set to indicate the intent to shut down the session. In such a case, the EQAM SHOULD send the SLI message at least 500ms before the CDN message is sent. The SLI message is intended to minimize the interruption in the flow of the DEPI traffic when the fail-over request is, for example, a result of operator action at the EQAM. It is anticipated that such operator action can result in the protocol signaling of fail-over requests for a number of sessions that share the same control connection. An early indication of the fail-over request is designed to allow the M-CMTS Core to orderly transition to the transmission of DEPI traffic to a secondary session before the EQAM stops processing data received on the primary session.
- 2 The M-CMTS Core stops sending DEPI data on a primary session and starts sending data on a selected corresponding secondary session. If there are multiple secondary sessions corresponding to the primary session, it is the M-CMTS Core's responsibility to determine which corresponding secondary session to select.

- 3 When desirable, the EQAM may shut down the primary session using the CDN message.

E.4.3.3 DLM Considerations

The DLM exchange can be conveyed on primary and secondary sessions but its scope is dependent on whether the M-CMTS Core is actively sending traffic on particular session. The M-CMTS CORE MUST NOT send DLM-EE (DLM EQAM Egress) on those sessions that are not actively carrying traffic. Without DEPI traffic the DLM-EE measurements are not attainable.

The M-CMTS Core MUST support the sending of a DLM-EI-RQ packet and the receiving of a DLM-EI-RP packet on primary and secondary sessions. The EQAM MUST support the receiving of a DLM-EI-RQ packet and the sending of a DLM-EI-RP packet on primary and secondary sessions.

Appendix I DEPI and DOCSIS System Performance

I.1 Introduction

The M-CMTS architecture provides interoperability among different types of equipment performing various sub-functions of a complete CMTS. In previous architectures, all these functions were contained in a single physical card or chassis, so that the delays in communication between sub-functions were effectively zero. M-CMTS introduces non-zero delays between sub-functions. In some instances these delays may impact system performance. Specifically, interposing a CIN between the M-CMTS Core and the EQAM increases the *round-trip time* of the DOCSIS system.

I.2 Round-Trip Time and Performance

Broadly speaking, round-trip time is the time from a CM's request to the time the CM transmits the data corresponding to that request. The more quickly all this happens, the sooner the CM can transmit another request (e.g., a piggyback request), thereby transmitting more data, etc.

Round-trip time limits the performance of a single modem by limiting the number of grants the modem can receive in a given time. For instance, if the system round-trip time is 10 msec, it is not possible for a modem to receive more than 100 grants per second. If every grant were the size of the modem's allowed maximum burst size (as configured by, e.g., Maximum Concatenated Burst, [RF12.0]), an upper bound on the modem's performance could be found by the following simple calculation:

$$\text{max throughput (bits/sec)} = \text{max burst (bits)} \cdot 1/[\text{round trip time (sec)}]$$

In practice, due to the need to share bandwidth among many users and services, the maximum burst size must be limited to reasonable values, and the CMTS generally cannot grant the maximum burst size in every grant, even if a modem requests it.

A longer round-trip time also increases the access latency seen by a single modem – i.e., the time it takes for a modem to gain access to the upstream to begin transmission of new data after an idle period. Conversely, if reducing round-trip time enables higher throughput to be achieved or speeds the opening of the TCP window, the modem's transactions (e.g., download of an FTP file or HTTP web page) may be completed more quickly (assuming plant bandwidth is available to do so). These factors may in turn affect the overall bandwidth efficiency of the system.

I.3 Elements of Round-Trip Time

It is convenient to begin measurement of round-trip time at the instant when a modem begins transmission of a request. Round-trip time can then be measured as the time from this initial request to the instant when the modem begins transmission of its next request. These events can easily be captured on a network sniffer.

The elements of round-trip time may be categorized as follows:

- *upstream propagation delay*: time occupied by plant delays in the upstream direction.
- *upstream reception and request parsing time*: time from the start of burst arrival at the CMTS until reception and parsing of the request is complete. Some CMTSs require that the entire burst be received before it can be parsed. Others can recognize piggyback requests near the beginning of a burst, even if the end of that burst has not yet arrived. If FEC is enabled for the burst, at least one full FEC block must be received and decoded before any MAC-layer parsing can be performed.
- *scheduler queueing and processing delay*: time from arrival of the request at the scheduler until completion of the MAP message containing a grant for the request. If the request arrives just after the scheduler has finished creating a MAP, the request is delayed by the time interval until the next MAP. On the other hand, if the request arrives just before the scheduler finishes creating a MAP, the request may see nearly zero delay. In general, the actual queueing delay is a random variable between zero and the maximum MAP interval. Under some lab conditions involving only one or a few CMs, this delay may appear to be constant, but this cannot generally be assumed in a real system. Some scheduler implementations may vary the MAP interval to optimize this delay.

The time required for the scheduler to make scheduling decisions and actually create the MAP message is also included here. This factor is highly implementation-dependent.

- *MAP delivery time (to the EQAM DOCSIS PHY layer):* The time from the completion of the MAP message creation, to delivery of the MAP to the PHY layer. This includes any time consumed by the M-CMTS Core's MAC function; encapsulation of the MAP into a DEPI packet; queueing and transmission of the DEPI packet at the egress of the M-CMTS Core; delay and jitter of the CIN; queueing and processing delays inside the EQAM; and any delay in inserting the MAP into the MPEG-encapsulated DOCSIS stream (e.g., due to the need to wait for a previous packet to complete transmission).
- *Downstream physical-layer delays:* This includes the latency of the downstream modulator, downstream interleaver delay, and physical propagation delay between the EQAM and the CM.
- *CM MAP processing time:* The time from arrival of the first bit of the MAP at the CM, until the MAP becomes effective. The minimum value is specified in the Relative Processing Delay section of [RFI2.0]. It accounts for all internal CM processing delays.
- *Time until grant:* If the first grant in the MAP is not to this CM, the CM's actual transmission will be "delayed" until the actual time of the grant.
- *Margin:* In practice, the CMTS cannot precisely control all delays to guarantee that MAPs arrive at the modem at exactly the right instant. Thus, the CMTS must add margin to account for worst-case propagation delays to the farthest modems, variations in MAP creation time and CIN delays, etc.

The following table lists example values for the round-trip time components described above. These values are given ONLY by way of example and should not be interpreted as typical values applying to any particular system and/or implementation.

Table I-1 - DOCSIS Request-Grant Round Trip Worksheet

(All time values in usec)

Delay source:			Remarks
	subtotal	total	
Upstream propagation time		800	
Physical HFC plant delay	800		apprx 100 miles
Upstream reception/parsing time		469	
upstream PHY processing time	369		time for 1 FEC block (236,200) at 5.12 Mbps
upstream MAC processing time	100		
Scheduler queueing and processing		1000	
MAP delivery to PHY layer		1338	
		plus CIN	
DEPI packetization at Core	383		for MPT mode, transmit time of 7 MPEG packets
CIN delay	varies		
EQAM latency	500		per DEPI spec
Queueing behind max-length packet during MPEG encaps.	455		transmit time of 1518 bytes (64QAM Annex B)
Downstream transmission time		1841	
MAP duration on wire	61		200B MAP at QAM64
downstream FEC/interleaver delay	980		(I, J) = (32,4) at QAM64
downstream prop. delay	800		apprx 100 miles
MAP Advance Margin		500	
CM processing time		200	TDMA, no byte interleaving
TOTAL ROUND TRIP TIME		6148	
		plus CIN delay	

I.4 CIN Characteristics

In an M-CMTS system, the CIN adds delay which may be a noticeable contributor to the total system round-trip time. The CIN is configured and managed by the operator. Its extent may vary widely from one system to the next. It may be as simple as a short Ethernet cable between one M-CMTS Core and one EdgeQAM. Alternatively, it may be an IP network consisting of multiple switch and/or router hops which is shared with other (non-DEPI) traffic to and from other nodes (e.g., IP-encapsulated video from VOD servers).

All but the most trivial of packet-based networks will experience variations in delay. These variations arise due to variability in length and arrival time of packets, changes in instantaneous loading, queuing of packets within network elements, differences in QoS parameters applied to different packets, and other factors. Thus, network delay is often modeled as a random variable.

One common way of describing network delay is as a sum of two components: a "typical" delay which is treated as a constant, plus a "jitter" term which may differ from packet to packet. Another approach is to describe the network as having a "minimum" delay and a "maximum" or "worst-case" delay, with delays on individual packets distributed between the two extremes in some way. These approaches are often convenient ways of approximating network behavior.

One approach to rigorously modeling the network involves determining a Cumulative Distribution Function (CDF) of packet delays. This CDF is a function or graph in which the x-axis shows delay D_0 , while the y-axis shows the probability that the actual delay D on any particular packet is less than D_0 . To be useful, this CDF may be limited in scope: for example, it may be for from some specified source node to a particular destination node and for a particular class of traffic. It can then be stated that a certain fraction of applicable packets will experience delay less than a particular amount (e.g., "99.995% of packets will experience delay less than 2 msec," or some similar statement). In some networks, it may be impossible to guarantee an upper bound on delay for 100% of all packets.

In addition to the CIN itself, the "network" may include switching and/or queuing that occurs inside an M-CMTS Core or an EQAM. For example, an M-CMTS Core supporting multiple downstream QAM channels may have multiple Gigabit Ethernet output ports, and thus might include an internal "switch" to connect various DEPI flows to different output ports. If present, this switching function could also add implementation-dependent queuing delays which could be modeled as part of the CIN.

To aid in characterizing the CIN, DEPI specifies the Latency Measurement Subheader (Section 8.4). This subheader takes advantage of the fact that both the M-CMTS Core and the EQAM contain a DTI interface which provides a common, high precision clock. The M-CMTS Core transmits a Latency Measurement Packet, on any given DEPI session, containing its current timestamp value. Upon receipt of this message, the EQAM adds its own timestamp value and returns both values to the M-CMTS Core. The result is a single measurement of CIN delay (plus any M-CMTS Core egress and EQAM input queueing delays in the path between timestamp insertion points) between the CMTS and the EQAM. The CMTS may make use of this information in several different ways including CDF calculations or adjusting specific DOCSIS network parameters.

Oftentimes the design of the CIN is the one variable in the M-CMTS architecture that the MSO has complete control over. Decisions made here regarding the size and number of network hops will have a direct effect on overall performance of the DOCSIS network.

1.5 Queueing Delays in Network Elements

Many layer 2 and layer 3 switch products today support line-rate switching in a non-blocking fashion. "Non-blocking" means that packets being switched across particular source and destination ports will not interfere with packets being switched across different source and destination ports. If all traffic within the switch is non-blocking (as is typically the case in laboratory tests per IETF RFCs), switching will be very fast. (Exact values for this "intrinsic switch delay" are implementation-specific.) However, if packets simultaneously arriving from several different source ports are directed to a single destination port, these packets will suffer queueing delay within the switch.

For very simple switched topologies where only DEPI traffic is present, worst-case queueing delay at a given destination port may be calculated as a function of packet size and number of source ports switching to that destination port. This calculation only applies to a single node within the network. If every source port delivered a packet to the destination port at the same instant, the last of these packets to actually exit the destination port would be delayed by the time required to transmit all preceding packets. The calculation is as follows:

$$\text{Max delay (sec)} = (\# \text{ of source ports} - 1) \cdot \text{packet size (bits)} / \text{line rate (bits/sec)}$$

The result of this calculation plus the intrinsic switch delay (which may, by way of example, be on the order of 10-100 usec) gives a reasonable upper bound on the total worst-case delay through the switch when the traffic at the source ports is rate-limited by the M-CMTS Core. As a result, the aggregate traffic out the destination port of the switch does not exceed the port's capacity. This would typically be the case for a switch internal to a CMTS or EQAM, or one that carries only DEPI traffic in a one- or two-hop network. For more complex systems, additional queue build-up could occur and the latency through the switch could easily exceed 1 msec. As such, it is important to apply QoS policies to any traffic that is latency sensitive so that it might bypass queue build-ups. More

information on the use of QoS in the CIN is provided in the sections below on "Traffic Prioritization" and "PSP Mode."

In recent years products have evolved so that the distinction between a "switch" and a "router" is not always clear. A "switch" may incorporate extensive QoS functionality, while a "router" may perform large amounts of processing in hardware and be as fast as some switches. Thus, in more complex CIN topologies, delays may vary widely and do not readily lend themselves to calculation. Even routers or switches capable of line-rate performance are subject to congestion and internal queueing and processing delays which may vary depend on load, traffic type, QoS functions supported, and many other conditions.

I.6 Traffic Prioritization and Network Delays

In general, it is possible to reduce network delay for certain packets by instructing routers and/or switches to give these packets higher priority than other packets. The mechanism for accomplishing this is usually the IEEE 802.1Q VLAN tag for Ethernet, or the DSCP field and associated per-hop behavior for IP.

In the simplest case, packets tagged as high priority are sent by the router or switch ahead of all other packets of lower priority which may already be queued within the device. More complex behaviors also exist, but fundamentally, they all reduce delay on the high-priority packets at the expense of lower-priority packets. In order for this to be effective, high-priority packets must represent a relatively small fraction of the total traffic on the network.

In a CIN, traffic prioritization may be useful for reducing round-trip time when PSP mode is in use by prioritizing DEPI flows containing MAPs ahead of flows containing other types of data. This concept may be extended to add more priority levels (e.g., for voice vs. best-effort data) if the M-CMTS Core and EQAM both support the desired number of PSP flows. In MPT mode, this approach cannot be used since all data for a given QAM channel, regardless of type or priority, are carried in a single flow.

If the CIN also carries non-DEPI traffic, it may be possible to reduce DEPI delays by giving DEPI higher priority. However, this will result in increased delay on the non-DEPI packets. The consequences of this should be carefully considered by the operator.

I.7 Queue Persistence in a DEPI Flow

DEPI requires the M-CMTS Core to rate-shape its output to match the rate of the EQAM's RF output. If the path between the two devices had fixed delay (i.e., zero jitter), DEPI data arriving at the EQAM would immediately be transmitted on the HFC network. In practice, a real DEPI path will always contain variable delays (i.e., jitter). The presence of jitter in this path requires data to be queued inside the EQAM.

To see this, consider a simple example involving a single MPT-mode DEPI flow. Suppose that packets are being sent on a 1 Gbps Ethernet network. The flow itself occupies only about 40 Mbps and is rate-shaped, so there will be "space" on the network between packets. The interval on the CIN between the start of one packet and the start of the next packet will correspond to the same interval on the EQAM's RF output. As long as every packet is being delivered from M-CMTS Core to EQAM with constant delay D , each packet will arrive at the EQAM just as the EQAM completes transmission of the previous packet. However, suppose a single packet P_0 experiences higher-than-normal delay $D+J$. The time on the network between this packet and the previous one (packet P_{-1}) is extended, while the time between this packet and the following one (packet P_1) is compressed (since P_1 experiences only delay D). Thus, the EQAM completes transmission of P_{-1} before P_0 arrives. Since the EQAM now has no DOCSIS data to send, it must transmit MPEG Null packets until P_0 arrives. At that time, it must complete the MPEG Null packet it is currently transmitting and then begin transmission of P_0 . However, since the time between P_0 and P_1 has been shortened, P_1 will arrive at the EQAM before transmission of P_0 has completed. P_1 must now be queued by the EQAM and will experience queueing delay J' , where:

$$J' = \text{ceiling}(J/T_{\text{MPEG}}), \text{ where } T_{\text{MPEG}} = \text{duration of one MPEG packet}$$

i.e., the amount of delay that was added to P_0 due to jitter on the network rounded up to the next MPEG packet boundary. In addition, as long as the M-CMTS Core continues to output data at the exact rate of the EQAM's RF output, all subsequent packets in the flow will also experience queueing delay J' . This can be a serious problem for an M-CMTS system, since even if jitter J occurs very infrequently, once it does occur, the additional queueing delay could persist indefinitely.

To prevent this infinite queue persistence, DEPI requires that the M-CMTS Core be capable of rate-shaping its output to some configurable fraction of the EQAM's actual output data rate. This does not prevent queueing delays from occurring due to network jitter events, but it does mean that, in the aggregate, the EQAM can drain the queue (by transmitting data) faster than it fills.

It is possible to calculate the time T required for the queue depth to return to zero after a jitter event increases the delay on a single packet from D to $D+J$. Suppose that the CMTS is rate-shaping to a rate r which is some "rate-shaping ratio" ρ of the EQAM's output rate R (*i.e.*, $\rho = r/R$). During time J' , it will send MPEG Null packets when, had the jitter event not occurred, it would have ordinarily received from the M-CMTS Core and immediately transmitted on the wire $J' \cdot r$ bits of data. This number of bits will instead be queued inside the EQAM and, once available, transmitted and hence removed from the queue at rate R . Meanwhile, data continues to arrive and be added to the queue at rate r . Thus, over a time interval T , the total queue size decreases by $T \cdot (R - r)$. The queue size will return to zero when:

$$J' \cdot r = T \cdot (R - r)$$

Solving for T and expressing in terms of ρ (the ratio configured in the M-CMTS Core) gives:

$$T = J' \cdot \rho / (1 - \rho)$$

For example, if network jitter on a single packet results in 2 msec of queueing delay (J), and the M-CMTS Core continues to send traffic at a rate equal to 98% of the EQAM's actual output rate, the time to drain the resulting queue at the EQAM will be (2 msec) $[0.98/(1 - 0.98)]$, or 98 msec. This time will be reduced if the CMTS does not have enough downstream traffic available during this period to "fill the pipe" to 98% of nominal. Conversely, if another network jitter event occurs before this time has elapsed, the queue size will again suddenly increase. The impacts of continuous jitter is not additive. Rather, the worst case queue build up will equal the worst case jitter. If network jitter events are frequent enough and traffic load remains relatively high, the queue may never completely drain.

For MPT operation, a single flow contains all DOCSIS data for a given QAM channel, including MAP messages. The above calculation of T can be useful in estimating how many MAP messages will experience increased delay due to network jitter events. If a MAP interval is typically 2 msec, then during time $T = 98$ msec, 49 MAP messages on each upstream channel will see increased delay as a result of each network jitter event adding $J = 2$ msec delay to a single DEPI packet (whether or not that packet contains a MAP message). Note that this calculation may not be exact, since the CMTS may vary the MAP interval.

Depending on how much MAP Advance margin the CMTS has provided (see round-trip time calculations in Section I.3), some of these 49 MAPs may still be usable by CMs. To account for this, the amount of margin provided may be subtracted from J and the result used to calculate T , *i.e.*, if margin is represented by μ , then when a jitter event occurs which adds jitter J , the number of MAPs on each upstream channel which are delayed enough to be lost is given by:

$$\# \text{ MAPs lost} = [(J - \mu) \cdot \rho / (1 - \rho)] / (\text{MAP interval})$$

In the current example, if the CMTS has added 500 usec of MAP Advance margin to each MAP, the queue would drain to the point where MAPs are usable by CMs after $(J - 500 \text{ usec}) \cdot [\rho/(1 - \rho)] = (1.5 \text{ msec}) (49) = 73.5 \text{ msec}$. If the MAP interval is 2 msec, only 37 MAPs would be lost for each such network jitter event, as opposed to the 49 MAPs that would be lost if zero margin had been provided. These 37 lost MAPs translate into $(37 \cdot 2 \text{ msec}) = 74 \text{ msec}$ of time during which CMs cannot transmit as a result.

To minimize the number of MAPs lost due to network jitter when MPT mode is in use, the scheduler should add margin sufficient to give the desired reliability level, based on the CDF describing the network. For instance, suppose it has been determined that 99.9999% of the time (*i.e.*, $1 - 10^{-6}$), the network delay will be less than D_1 . the scheduler could then add a margin of D_1 when creating MAPs. It could then be said that an event resulting in lost MAPs will occur once for every 10^6 packets sent. On a relatively loaded downstream carrying *e.g.*, 50,000 packets

per second, this would result in a "lost MAP event" about once every 20 seconds. The number of MAPs lost for each event, and the corresponding time for which CMs cannot transmit due to missing MAPs, would depend on the amount by which the actual delay exceeded D_1 . In the previous example, if the MAP Advance margin had been set to 2 ms to account for the worst case CIN jitter, then the 49 MAP messages that were delayed would all still be usable.

The effect of this added margin is to increase system round-trip time by D_1 for all packets. However, it helps to minimize the negative system impacts of frequently lost MAPs.

I.8 PSP Mode

DEPI provides PSP mode as a way of mitigating CIN delays affecting round-trip time. PSP mode does not reduce the delay of the network itself. Instead, it separates MAP messages into a separate DEPI flow and uses traffic prioritization (Section I.6) to minimize delay on this flow. PSP mode also allows the EQAM to transmit MAP messages ahead of lower-priority DOCSIS data, even if the lower-priority data is already queued within the EQAM. These two modifications in turn mean that, in PSP mode, (a) MAP messages are only delayed in the network by jitter events directly affecting packets containing MAPs; and (b) MAP messages can only be queued behind (and hence delayed by) other MAPs. Thus, the CDF for network delay for MAP messages in PSP mode may show significantly lower delays than a similar CDF for MPT mode on the same network.

Use of PSP mode should be considered by the operator whenever the impact of the CIN on system round-trip time is a concern. More specifically, PSP mode should be considered if the amount of margin which must be added to round-trip time to give a low enough rate of lost MAPs is unacceptably large. What exactly constitutes "unacceptably large" depends on many factors and may be subjective. For example, a system in which the plant is physically short has less propagation delay and therefore may tolerate larger CIN delays. As another example, on a plant where high modem performance is desired but the presence of UGS traffic or other factors compel the use of a small maximum burst size, even relatively small CIN delays may degrade performance.

In general, a very small CIN (one or possibly two switch hops) probably has little impact on system round-trip time, while a CIN which has multiple hops and/or on which non-DEPI traffic is present probably has a much more significant impact on system round-trip time. To accurately predict the actual improvement in round-trip time that can be gained by using PSP mode on a given CIN, it is necessary to characterize the delays of that CIN for different DSCPs.

Appendix II Early Adoption and Evolving Use of EQAM Devices

Prior to the development of the M-CMTS specifications, EQAM devices in existing HFC digital CATV systems were responsible for video processing functions such as multiplexing and modulation (QAM). The M-CMTS specifications place additional requirements on EQAM devices to support DOCSIS functionality.

It is possible that certain EQAM devices may be able to support a subset of the DOCSIS functionality by adhering to parts of the M-CMTS specifications (including DEPI). These devices would not be considered M-CMTS compliant EQAMs, but nonetheless might be a valuable component of a transition strategy for MSOs.

The development of initial M-CMTS EQAM devices that are first on the market (early adopters) will be divided into two categories. The first category (category A) is EQAM vendors with existing video-only EQAM products (no support for the DTI). These vendors may want to offer their customers a software upgrade path for already deployed EQAM products to support bonded DOCSIS channels that do not contain timing information (no SYNC messages). The second category (category B) is EQAM vendors that intend to initially offer new EQAM products that have fully M-CMTS capable hardware including the DTI, but where full support for M-CMTS features is not offered initially. In both categories, support for additional M-CMTS features would typically be added via software upgrade using a phased approach.

II.1 EQAM Development: Category A (no DTI)

Vendors falling into Category A will provide software upgrades to allow their existing deployed video EQAM products to be upgraded in the field to support bonded DOCSIS channels that do not contain DOCSIS timing information (no SYNC messages). This provides a level of investment protection for MSOs with already deployed EQAM products in the field. These upgraded video EQAM products would not support the DTI and would thus not be M-CMTS compliant, but they could be leveraged by MSOs when deploying DOCSIS channel bonding. This would help to minimize the number of new EQAM devices that the MSOs would be required to purchase when upgrading their systems to support DOCSIS channel bonding.

Upgrade Phases for Category A (no DTI)

- Phase 1: S/W upgrade existing "video" EQAM to support {L2TP control plane and DEPI MPT mode}
- Phase 2: Add (to phase 1) support for L2TP data plane.
- Phase 3: Add (to phase 2) support for ERMI.

II.2 EQAM Development: Category B (with DTI)

Vendors falling into Category B will initially develop EQAM devices with hardware that has the capability of achieving full M-CMTS compliance. This mainly includes the physical DTI interface hardware. Support for M-CMTS features will then be phased in by the vendor over time by offering software upgrades. This allows MSOs to purchase M-CMTS EQAM devices up front knowing that only software upgrades are required to eventually achieve full M-CMTS compliance. An EQAM with M-CMTS compliant hardware would support the DTI allowing it to operate in either SCDMA mode or ATDMA mode.

Upgrade Phases for Category B (with DTI)

- Phase 1: Support DTI, L2TP control plane, and DEPI MPT mode.
- Phase 2: Add (to phase 1) support for L2TP data plane.
- Phase 3: Add (to phase 2) support for ERMI.
- Phase 4: Add (to phase 3) support for DEPI: PSP mode.

II.3 Possible M-CMTS Feature Phasing

In order to minimize time to market, EQAM vendors will likely add in support for M-CMTS system features using a phased approach by offering software upgrades. In both development categories described above (A and B), the software upgrade path towards full M-CMTS compliance may be very similar.

Development: Phase 1

The initial M-CMTS products will support the L2TP control plane, and they will likely support the DEPI MPT mode only (not DEPI PSP mode). EQAMs with DTI hardware may or may not support the DTI. If the DTI is not supported, the EQAM can only be used for video applications and or to support DOCSIS bonded channels with no DOCSIS timing information.

The L2TP control plane is required to allow the M-CMTS core to provision and configure the EQAM, so support for the L2TP control plane is mandatory. It is assumed that the L2TP control plane can be developed in software with no required hardware changes to either an existing "video" EQAM or an EQAM with M-CMTS capable hardware.

Support for the L2TP data plane may require hardware assistance or more extensive software development than the L2TP control plane, so it is likely that EQAM vendors would defer support of the L2TP data plane until later phases. Existing network processors typically do not support the L2TP, so any L2TP data plane processing in early adopter EQAM products would require custom software development. It should also be noted that the M-CMTS core will always include the L2TP data plane, but since the L2TP layers are fixed length, an early adopter EQAM product could be designed to simply skip over the L2TP headers when receiving DEPI data. In this case the UDP layer is required to support the routing of data packets to the appropriate QAM channel outputs.

It is likely that the early adopter EQAM devices will initially support the DEPI MPT mode, but not the DEPI PSP mode. The DEPI MPT mode delivers MPEG packets to the EQAM, and requires processing in the EQAM that is similar to the processing that is performed on video MPEG packets. The DEPI PSP mode requires the EQAM to perform additional functions such as transmission convergence (MPEG packetization) and DOCSIS SYNC insertion so it will likely be deferred to a later phase.

Development: Phase 2

It is likely that the next step (phase 2) after offering initial EQAM products as described above in phase 1 would be to offer support for the L2TP data plane. Support of the L2TP data plane could be realized in software, or network processors that support the L2TP could be leveraged if available. The use of L2TP capable network processors could be achieved via software upgrade and or an FPGA firmware upgrade, or hardware changes could be required.

Development: Phase 3

Support for the M-CMTS ERMI will also be phased in via software upgrade. The M-CMTS system is designed to function without an ERM (without the use of the ERMI) by relying on the L2TP control plane and static system configuration. In this case EQAM resources are manually (and statically) assigned to the M-CMTS core. As a result, support for the ERMI in the EQAM can be deferred until a later phase.

Development: Phase 4

The final phase of M-CMTS EQAM development is likely to be software upgrades to support the DEPI PSP mode. The DEPI PSP mode requires the EQAM to perform DOCSIS specific functions such as transmission convergence (MPEG packetization) and DOCSIS SYNC insertion. In addition, the data plane processing for PSP mode is more complex than MPT mode in that it requires support of variable size PDUs with multiple DOCSIS frames per PDU. As a result, it is likely that support for DEPI PSP mode will be offered by EQAM vendors in late or final phases of development. Support for DEPI PSP mode would only be applicable to EQAM products that support the DTI (category B EQAM products).

II.4 Optional UDP Layer

The UDP layer is optional in the L2TP. It is desirable to use the L2TP protocol without the UDP layer since the L2TP provides built in mechanisms (session IDs) to bind payload data to software functions analogous to the use of a UDP port. If two devices that fully support the L2TP are communicating with each other (using L2TP), then there is no need to use a UDP layer below the L2TP layer since the session ID field provides the necessary data routing

function. If one of the devices does not support the L2TP in the data plane, then the UDP layer can be used to provide the data routing function.

Since off-the-shelf network processors that support the L2TP will likely not be available when EQAM vendor begin M-CMTS development, early adopter EQAM products will likely not support the L2TP in the data plane. As a result, early adopter EQAM products will likely make use of the UDP layer to provide the data routing function since existing network processors are capable of parsing packets up to and including the transport layer in hardware.

Eventually, if/when L2TP capable network processors become available, or alternatively if EQAM vendors develop support for the L2TP layer in the data plane, the devices communicating via L2TP can stop using the UDP layer if desired.

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Appendix IV Revision History (Informative)

IV.1 Engineering Changes for CM-SP-DEPI-I02-051209

ECN	ECN Date	Summary
DEPI-N-05.0243-1	9/21/05	Clarification of wording regarding the use of the UDP layer in DEPI.
DEPI-N-05.0246-3	10/19/05	Clarification of Latency Measurement AVP
DEPI-N-05.0256-4	11/16/05	Correction of MTU usage
DEPI-N-05.0257-2	11/16/05	Specification of PW-types, and addition of L2 Specific Sublayer and Data Sequencing Mandatory AVPs
DEPI-N-05.0258-1	11/9/05	Timeliness of Application of DTI Conveyed Time at an M-CMTS Entity
DEPI-N-05.0259-3	11/9/05	Editorial fixes; Clarification of DLM packet format.

IV.2 Engineering Change for CM-SP-DEPI-I03-060728

ECN	ECN Date	Summary
DEPI-N-06.0273-1	6/7/2006	IANA official PW-Type Assignments and L2-Specific Sublayer Type Assignments

IV.3 Engineering Changes for CM-SP-DEPI-I04-061222

ECN	ECN Date	Summary
DEPI-N-06.0300-2	11/8/2006	DEPI Editorial QoS changes
DEPI-N-06.0305-2	11/8/2006	DEPI Appendix A
DEPI-N-06.0306-1	11/15/2006	DEPI Circuit Status
DEPI-N-06.0307-1	11/8/2006	DEPI Editorial II
DEPI-N-06.0308-1	11/15/2006	DEPI M-bits
DEPI-N-06.0309-2	11/15/2006	DEPI RF Block Mute
DEPI-N-06.0310-2	11/15/2006	DEPI UDP Checksum
DEPI-N-06.0311-2	11/15/2006	DEPI UDP Optional
DEPI-N-06.0347-1	12/13/2006	DEPI reference correction

IV.4 Engineering Changes for CM-SP-DEPI-I05-070223

ECN	ECN Date	Summary
DEPI-N-06.0332-1	12/13/2006	Move timestamp jitter specification and test case from DEPI to DRFI.
DEPI-N-06.0349-2	12/27/07	DEPI bit order

IV.5 Engineering Change for CM-SP-DEPI-I06-081209

ECN	ECN Date	Summary
DEPI-N-08.0696-1	12/3/2008	Relocate DEPI MIB from M-OSSI.

IV.6 Engineering Change for CM-SP-DEPI-I07-100115

ECN	ECN Date	Summary
DEPI-N-09.0860-3	11/04/09	DEPI Control Connection Teardown Following Reboot

IV.7 Engineering Changes for CM-SP-DEPI-I08-100611

ECN	ECN Date	Summary
DEPI-N-10.0901-5	3/17/2010	DEPI Path Redundancy
DEPI-N-10.0916-1	5/5/10	DEPI Omnibus, including addition of Annex E
