Data-Over-Cable Service Interface Specifications DOCSIS® 4.0

CCAP™ Operations Support System Interface Specification

CCAP-OSSIv4.0-I12-250703

ISSUED

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1 SCOPE

1.1 Introduction and Purpose

This specification is part of the DOCSIS family of specifications developed by Cable Television Laboratories (CableLabs). In particular, this specification is part of a series of specifications that define the sixth generation of high-speed data-over-cable systems, commonly referred to as the DOCSIS 4.0 specifications. This specification was developed for the benefit of the cable industry and includes contributions by operators and vendors from North and South America, Europe, China, and other regions.

This generation of the DOCSIS specifications builds upon the previous generations of DOCSIS specifications (commonly referred to as the DOCSIS 3.1 and earlier specifications), leveraging the existing Media Access Control (MAC) and Physical (PHY) layers. It includes backward compatibility for the existing PHY layers in order to enable a seamless migration to the new technology. Further, the DOCSIS 4.0 specifications introduce Full Duplex (FDX) DOCSIS PHY layer technology as an expansion of the OFDM PHY layer introduced in the DOCSIS 3.1 PHY specification to increase upstream capacity without significant loss of downstream capacity versus DOCSIS 3.1 networks. The DOCSIS 4.0 specification also builds upon DOCSIS 3.1 OFDM and OFDMA technology with an extended Frequency Division Duplex (FDD) DOCSIS alternative. DOCSIS 4.0 FDD supports legacy mid split and high split and also provides extended splits up to 684 MHz in an operational band plan that is referred to as ultra-high split (UHS). DOCSIS 4.0 FDD also introduces the expansion of usable downstream spectrum up to 1794 MHz. Both the FDX and FDD DOCSIS 4.0 alternatives are based on OFDM PHY.

This document includes requirements and the information model for the management of the Cable Modem Termination System (CMTS) and the Converged Cable Access Platform (CCAP) system. The intent of this specification is to define a common, cross-vendor set of functionalities, information models, and data models for the configuration and management of CMTSs and CCAPs. In addition to supporting DOCSIS 3.1 and earlier devices, the requirements and management information models are defined for a DOCSIS 4.0 CMTS/CCAP.

1.2 Background

1.2.1 Broadband Access Network

A coaxial-based broadband access network is assumed. This may take the form of either an all-coax or hybrid-fiber/coax (HFC) network. The generic term "cable network" is used here to cover all cases.

A cable network uses a tree-and-branch architecture with analog transmission. The key functional characteristics assumed in this document are the following:

- Two-way transmission.
- A maximum optical/electrical spacing between the CMTS and the most distant CM of 100 miles (160 km) in each direction, although typical maximum separation may be 10–15 miles (16–24 km).

1.2.2 Network and System Architecture

1.2.2.1 The DOCSIS Network

The elements that participate in the provisioning of DOCSIS services are shown in Figure 1.

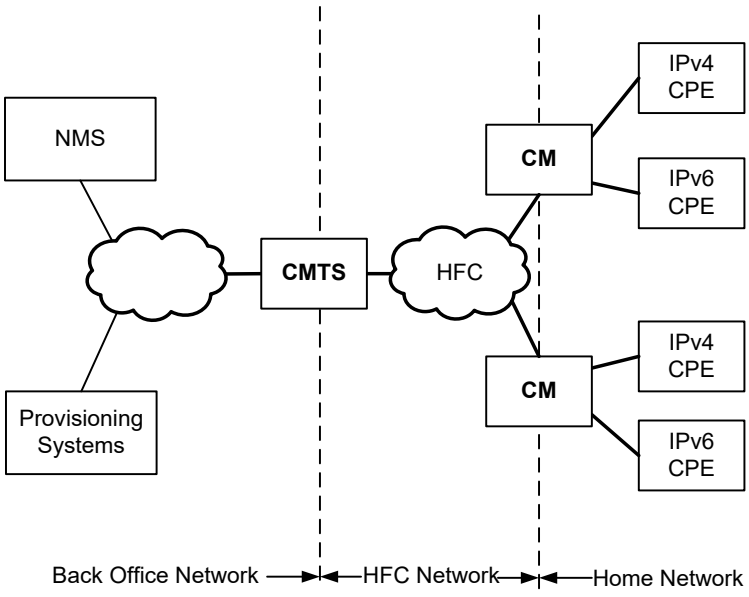

Figure 1 - The DOCSIS Network

The CM connects to the operator's HFC network and to a home network, bridging packets between them. Many CPE devices can connect to the CMs' LAN interfaces. CPE devices can be embedded with the CM in a single device, or they can be separate standalone devices (as shown in Figure 1). CPE devices may use IPv4, IPv6 or both forms of IP addressing. Examples of typical CPE devices are home routers, set-top devices, and personal computers.

The CMTS connects the operator's back office and core network with the HFC network. Its main function is to forward packets between these two domains, and optionally to forward packets between upstream and downstream channels on the HFC network. The CMTS performs this forwarding with any combination of link-layer (bridging) and network-layer (routing) semantics.

Various applications are used to provide back office configuration and other support to the devices on the DOCSIS network. These applications use IPv4 and/or IPv6 as appropriate to the particular operator's deployment. The following applications include:

Provisioning Systems

- The CM provisioning systems are discussed in [CM-OSSIv4.0].
- Command Line Interface applications that are vendor-proprietary.
- The Time Protocol server provides Time Protocol clients with the current time of day.
- Certificate Revocation server provides certificate status.
- Optionally supported NETCONF client supports CMTS/CCAP device provisioning.

Network Management System (NMS)

- The SNMP Manager allows the operator to configure and monitor SNMP Agents which reside within the CMTSs/CCAPs.
- The syslog server collects messages pertaining to the operation of devices.
- The IPDR Collector server allows the operator to collect bulk statistics in an efficient manner.

1.2.2.2 CMTS Reference Architecture

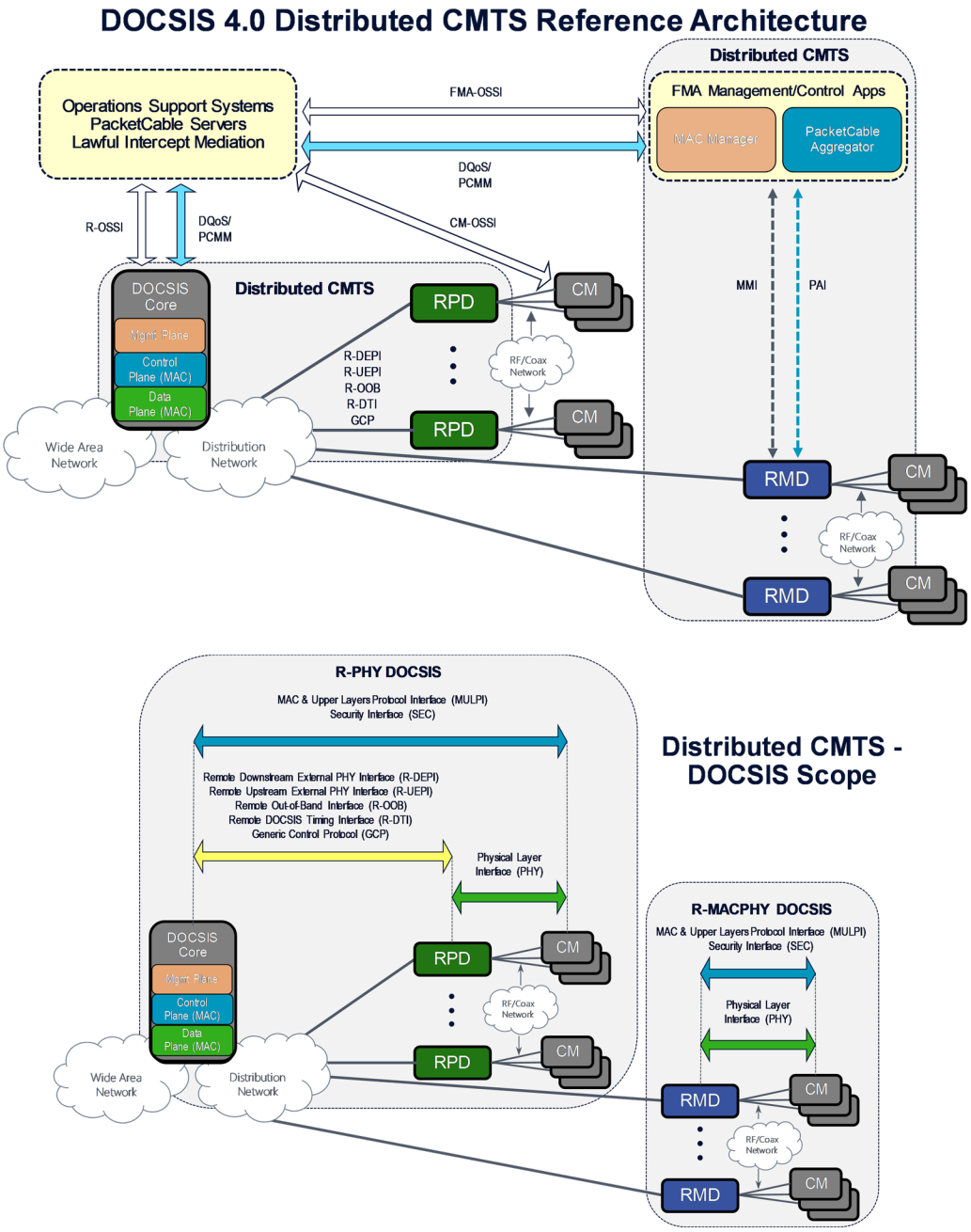

Figure 2 - Data-Over-Cable Reference Architecture

The reference architecture for data-over-cable services and interfaces is shown in Figure 2.

1.2.2.3 CCAP Data Reference Architecture

The following diagram, Figure 3, displays the interfaces used for the CCAP. This specification will focus on the Operations Support System Interface (OSSI) between the CCAP and the Operations Support System (OSS). The interfaces between the OSS and the eSAFE and Cable Modems are out of scope for this specification.

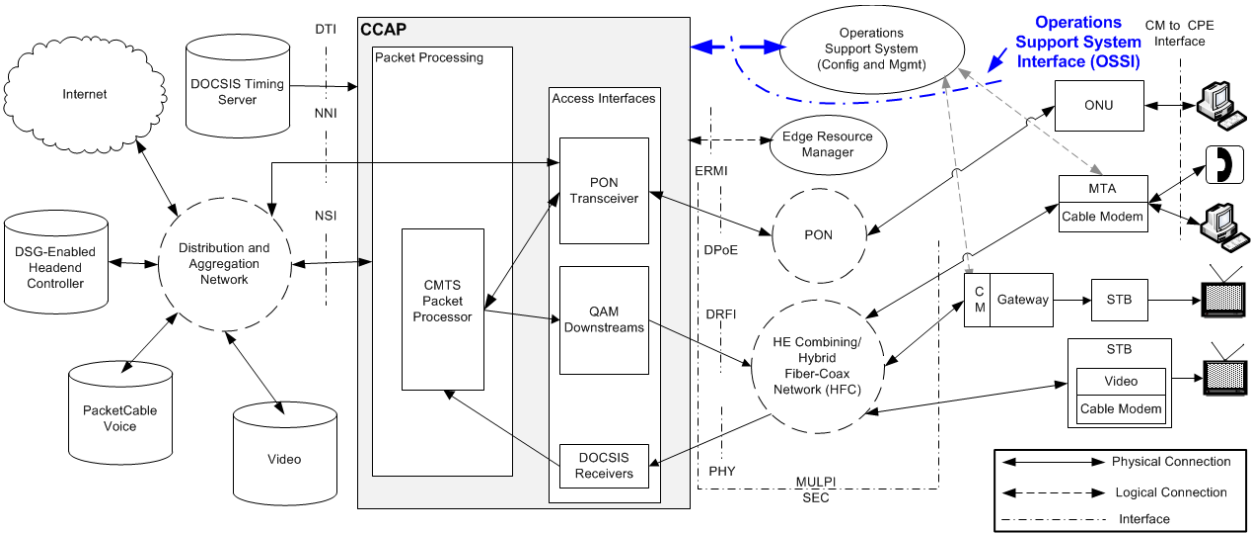

Figure 3 - CCAP Interface Reference Architecture

Within a CCAP implementation, logical interface connectivity is from the OSSI to the packet processing function of the CCAP. This logical interface connection allows for the configuration and management of the CCAP infrastructure. The packet processing function will receive its OSS content through the Network Side Interface (NSI), consisting of at least 160 Gbps of data on one or more physical interfaces.

For additional information about the CCAP data reference architecture, see [CCAP TR].

1.2.3 Service Goals

As cable operators have widely deployed high-speed data services on cable television systems, the demand for bandwidth has increased. Additionally, networks have scaled to such a degree that IPv4 address constraints are becoming a burden on network operations. To this end, CableLabs' member companies have decided to add new features to the DOCSIS® specification for the purpose of increasing channel capacity, enhancing network security, expanding addressability of network elements, and deploying new service offerings.

The DOCSIS system allows transparent bi-directional transfer of Internet Protocol (IP) traffic, between the cable system headend and customer locations, over an all-coaxial or hybrid-fiber/coax (HFC) cable network. This is shown in simplified form in Figure 4.

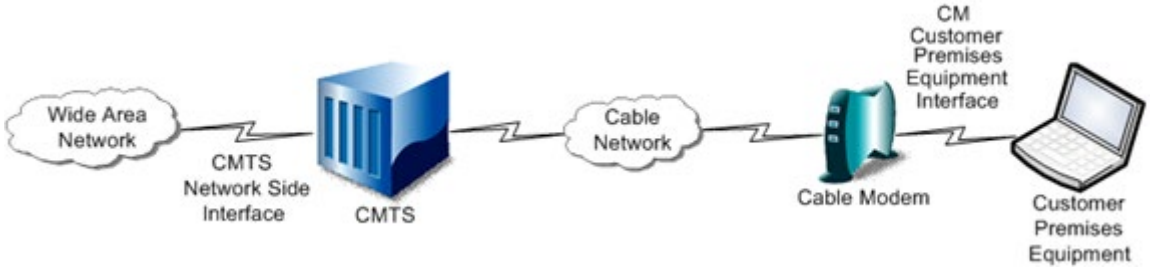

Figure 4 - Transparent IP Traffic Through the Data-Over-Cable System

1.2.4 Statement of Compatibility

This specification defines the DOCSIS 4.0 interface. Prior generations of DOCSIS were commonly referred to as the DOCSIS 1.0, 1.1, 2.0, 3.0, and 3.1 interfaces. DOCSIS 4.0 is backward-compatible with some equipment built to the previous specifications. DOCSIS 4.0-compliant CMTSs and CCAPs seamlessly support DOCSIS 4.0, DOCSIS 3.1, DOCSIS 3.0, DOCSIS 2.0, and DOCSIS 1.1 CMs.

1.2.5 DOCSIS 4.0 Documents

A list of the specifications in the DOCSIS 4.0 series is provided in Table 1. For further information, please refer to http://www.cablemodem.com.

Table 1 - DOCSIS 4.0 Series of Specifications

Designation	Title
CM-SP-PHYv4.0	Physical Layer Specification
CM-SP-MULPIv4.0	Media Access Control and Upper Layer Protocols Interface Specification
CM-SP-CM-OSSIv4.0	Cable Modem Operations Support System Interface Specification
CM-SP-CCAP-OSSIv4.0	Converged Cable Access Platform Operations Support System Interface Specification
CM-SP-SECv4.0	Security Specification

This specification is defining the interface for the Operations Support Systems Interface (OSSI), specifically for the Cable Modem Termination System and Converged Cable Access Platform.

Refer to [MULPIv4.0] for a list of related DOCSIS specifications.

1.3 Requirements

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

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

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

1.4 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.

```
MIB syntax, XML Schema and YANG module syntax are represented by this code sample font.
```

NOTE: Notices and/or Warnings are identified by this style font and label.

1.5 Organization of Document

Section 1 provides an overview of the DOCSIS 4.0 CCAP/CMTS specification including the reference architecture and statement of compatibility.

Section 2 includes a list of normative and informative references used within this specification.

Section 3 defines the terms used throughout this specification.

Section 4 defines the acronyms and XML namespaces used throughout this specification.

Section 5 provides an introduction to the FCAPS Network Management Model, which forms the organizational structure of this specification. In order to provide a more logical flow, one that mirrors processes in place at MSOs, the order of functions has been shifted, and is organized as CPAF:

- Configuration Management
- Performance Management
- Accounting Management
- Fault Management

Note that Security Management topics are covered in context of these topics.

Key feature and Use Cases for each management function are provided along with a high-level CCAP management architectural view. An introduction to the concept of Information Models and Data Models is also provided.

Section 6 defines the Configuration Management functions of the CCAP, including theory of operation, network management protocols and Information Models.

Section 7 defines the Performance Management functions of the CCAP, including network management protocols, Information Models and Data Model requirements.

Section 8 defines the Accounting Management functions of the CCAP, including IPDR network management protocols, SAMIS and Data Model requirements.

Section 9 defines the Fault Management functions of the CCAP including network management protocols, event reporting requirements and Information Models.

1.5.1 Annexes (Normative)

Annex A includes a detailed list of MIB object requirements for the CMTS and CCAP.

Annex B describes the IPDR for DOCSIS Cable Data Systems Subscriber Usage Billing Records.

Annex C describes the Auxiliary Schemas for DOCSIS IPDR Service Definitions.

Annex D describes the format and content for Event, SYSLOG, and SNMP Notification.

Annex E describes how vendors can extend the configuration data model.

Annex F describes the CCAP Data Type Definitions used in both the Information Models and data models.

Annex G describes the Diagnostic Log network management feature including Information Models.

1.5.2 Appendices (Informative)

Appendix I contains information relevant to example NETCONF message exchanges.

Appendix II contains a method for identifying replicated QAMs.

Appendix III contains DOCSIS IPDR sample instance documents.

Appendix IV contains spectrum analysis use cases.

Appendix V contains sequence diagrams.

Appendix VI lists the acknowledgments for authoring this specification.

Appendix VII contains the revision history of this specification.

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.

All references are subject to revision, and parties to agreement based on this specification are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

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3 TERMS AND DEFINITIONS

This specification uses the following terms and definitions.

advanced band plan	A generic term for DOCSIS 4.0 FDD and FDX spectrum resources.
aggregation	A special type of object association for configuration information models in which objects are assembled or configured together to create a more complex object.
asynchronous operation	Operation that returns data for requests at a later time. An asynchronous operation provides a way to make scheduled requests for resources, data, or services when available. The availability of a resource, service, or data store may not be immediate. An asynchronous operation may provide a callback to the requester when the requested resource is ready.
base overlap channel	The overlap channel that covers the entire spectrum of and uses the same DOCSIS channel ID as the physical OFDMA channel in an overlapping OFDMA channels configuration.
bridging CMTS	A CMTS that makes traffic forwarding decisions between its network systems interfaces and MAC domain interfaces based upon the Layer 2 Ethernet MAC address of a data frame.
cable modem (CM)	A modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system.
cable modem termination system	An access-side networking element or set of elements that includes one or more MAC domains and one or more network system interfaces. This unit is located at the cable television system headend or distribution hub and provides data connectivity between a DOCSIS radio frequency interface and a wide area network.
cable modem termination system—network side interface (CMTS-NSI)	The interface, defined in [NSI], between a CMTS and the equipment on its network side.
carrier-to-noise plus interference ratio (CNIR)	The ratio of the expected commanded received signal power at the CMTS input to the noise plus interference in the channel.
channel	The frequency spectrum occupied by a signal. Usually specified by center frequency and bandwidth parameters.
CM-to-CM co-channel interference	Interference caused by two or more different transmitters operating in the same channel, without proper channel access control or scheduling, leading to decreases in throughput for devices operating in the channel.
command line interface	A mechanism used to interact with the CCAP by typing text-based commands into a system interface.
complete transmit channel set	This is defined for a CM as the combination of upstream channels in its transmit channel set and in its extended transmit channel set. Pre-DOCSIS 4.0 CMs do not have an extended transmit channel set. In other words, their complete transmit channel set consists only of upstream channels in their transmit channel set. A CM's upstream service flows may be associated with some or all of the channels in the complete transmit channel set.
configuration objects	Managed objects in the CCAP configuration that support writability. The CCAP is configured by specifying the attributes of these objects.
Converged Cable Access Platform	An access-side networking element or set of elements that combine the functionality of a CMTS with that of an Edge QAM, providing high-density services to cable subscribers.
customer premises equipment	Equipment at the end user's premises; may be provided by the end user or the service provider.
data model	A data model (as opposed to an information model) is defined at a lower level of abstraction. It is intended for implementations and includes protocol-specific constructs. Because conceptual models can be implemented in different ways, multiple data models can be derived from a single information model. Data models are technology specific. The CM has defined data models for SNMP as SNMP MIB modules.
datastore	A collection of configuration objects used by the CCAP to define its configuration.
DOCSIS 4.0 cable modem	A device that supports DOCSIS 4.0 requirements and reports FDD capability, FDX capability, or both these capabilities.
downstream	Transmissions from CCAP to CM/CPE. Also, RF spectrum used to transmit signals from a cable operator's headend or hub site to subscriber locations.
echo cancellation	A process by which an FDX CM receiver's performance is improved by canceling out adjacent leakage interference (ALI) and adjacent channel interference (ACI) resulting from concurrent upstream transmissions.

edge QAM	A headend or hub device that receives packets of digital video or data. It repacketizes 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).
extended transmit channel set	The set of extended upstream channels that a DOCSIS 4.0 CM is configured to use for upstream transmission. The extended transmit channel set (TCS_EXT) is alternatively referred to as the FDX transmit channel set (TCS_FDX) for FDX CMs in an FDX band plan and as the FDD transmit channel set (TCS_FDD) for FDD CMs in an FDD band plan. See also *transmit channel set* and *complete transmit channel set*.
extended upstream channel	An OFDMA upstream channel present above 108 MHz in an FDX band plan or in an FDD UHS band plan. In an FDX band plan, extended upstream channels exist only in the FDX allocated spectrum of the 108 MHz to 684 MHz FDX band. In an FDD band plan, extended upstream channels exist only between 108 MHz and the UHS upstream upper band edge. An extended upstream channel's bandwidth is always 96 MHz, as specified in [PHYv4.0]. Extended upstream channel only has meaning when the plant is operating with a UHS or FDX band plan. Otherwise, channels used for upstream transmission are referred to as upstream channels.
extensible markup language	A universal file format for storing and exchanging structured data.
FCAPS	A set of principles for managing networks and systems wherein each letter represents one principle. F is for fault, C is for configuration, A is for accounting, P is for performance, and S is for security.
FDD extended upstream channel	An extended upstream channel in an FDD band plan.
FDD mode	See *frequency division duplex mode*.
FDX extended upstream channel	An extended upstream channel in an FDX band plan.
FDX mode	See *full duplex mode*.
flow	A stream of packets used to transport data of a certain priority from the source to the sink.
frequency division duplex (FDD)	A band plan where a given band of spectrum is used for either upstream or downstream transmission.
frequency division duplex band plan	A band plan with an upstream/downstream split as per the ultra-high split or high split band plans. The upstream (lower frequencies) and downstream (higher frequencies) are typically separated by a diplexer.
frequency division duplex cable modem	A DOCSIS 4.0 CM that is designed to operate in an FDD band plan. An FDD CM can access upstream channels below the upstream/downstream split and downstream channels above the upstream/downstream split. An FDD CM can access all such upstream channels and downstream channels in a high-split band plan. An FDD CM can access all such upstream and downstream channels in a UHS band plan, with the exception that the FDD CM is not required to be able to access upstream channels between 85 MHz and 108 MHz.
frequency division duplex cable modem termination system	A DOCSIS 4.0 CMTS that is designed to operate in an FDD band plan. An FDD CMTS can access all upstream channels below the upstream/downstream split, and all downstream channels above the upstream/downstream split. An FDD CMTS supports mid-split, high-split, and UHS band plans.
frequency division duplex mode	A DOCSIS 4.0 mode of operation in which a frequency division duplex cable modem is configured to operate on a frequency division duplex plant.
full duplex (FDX)	A mode of operations within the DOCSIS 4.0 specification that is targeted at significantly increasing upstream capacity by using the spectrum currently used for downstream transmission for simultaneous upstream and downstream communications via full duplex communications.
full duplex allocated spectrum	The portion of the full duplex band that the access network allocates for FDX operation, whether that spectrum is currently in use or not by the FDX node receiver or any full duplex cable modems. Five values are defined for FDX allocated spectrum: 96 MHz, 192 MHz, 288 MHz, 384 MHz, and 576 MHz.
full duplex band	Always 108 to 684 MHz. Contiguous range of RF spectrum defined in [PHYv4.0] and configured for full duplex operation. Any given access network may operate only a strict subset of the full duplex band in full duplex operation (see also *full duplex allocated spectrum*).
full duplex band plan	A band plan where only upstream channels are present up to an 85 MHz upstream upper band edge, the full duplex band exists from 108 to 684 MHz (which can have upstream and downstream channels), and only downstream channels exist above 684 MHz.
full duplex cable modem	A cable modem compliant to the full duplex specific requirements of the DOCSIS 4.0 specifications. A full duplex cable modem can access the full duplex channel when it is used in the upstream direction or when it is used in the downstream direction.

full duplex cable modem termination system	A DOCSIS 4.0 CMTS that is designed to operate in an FDX band plan. An FDX CMTS is compliant with all FDX-specific requirements of the DOCSIS 4.0 specifications. An FDX CMTS can access upstream channels below the FDX band, full duplex channels within the full duplex allocated spectrum of the FDX band, and downstream channels above the FDX allocated spectrum.
full duplex capable cable modem	Full duplex capable (FDX-capable) cable modem refers to both the full duplex cable modem and the full duplex limited cable modem.
full duplex channel	A downstream OFDM channel or upstream OFDMA channel within the full duplex band configured for full duplex operation.
full duplex DOCSIS	A mode of operations within the DOCSIS 4.0 specification that is targeted at significantly increasing upstream capacity by using the spectrum currently used for downstream transmission for simultaneous upstream and downstream communications via full duplex communications.
full duplex downstream channel	An OFDM channel in the occupied full duplex band. A full duplex downstream channel's bandwidth can be 96 MHz or 192 MHz, as specified in [PHYv4.0].
full duplex limited cable modem	A DOCSIS 3.1 cable modem compliant to all of the requirements in the DOCSIS 3.1 specification and full duplex requirements in the DOCSIS 4.0 specification that support transmit only on a specified full duplex sub-band and/or receive only on different specified full duplex sub-bands.
full duplex mode	A DOCSIS 4.0 mode of operation in which a full duplex cable modem is configured for full duplex operation on a full duplex plant.
full duplex node	An optical node compliant to the full duplex specific requirements of the DOCSIS 4.0 specifications. A full duplex node can access any full duplex channel when it is used in the upstream direction or when it is used in the downstream direction.
full duplex sub-band	A portion of the electromagnetic spectrum within the occupied full duplex band that contains only full duplex channels. An FDX duplex sub-band always contains a single full duplex downstream channel. An FDX duplex sub-band always contains either one or two full duplex upstream channels.
full duplex upstream channel	An OFDMA channel in the occupied full duplex band. A full duplex upstream channel's bandwidth is 96 MHz, as specified in [PHYv4.0].
generalization	A relationship in which one configuration model element (the child) is based on another model element (the parent). A generalization relationship indicates that the child receives all of the attributes, operations, and relationships that are defined in the parent.
gigabits per second	1 billion bits per second.
gNMI connection	Refers to the establishment of a communication link between a client and a network device (server) over which network management operations can be performed. This connection leverages the gRPC (Google Remote Procedure Call) protocol for communication. The connection to a gNMI server is typically represented by a gRPC channel. This channel serves as the conduit for invoking RPCs provided by the gNMI server.
gRPC channel	Provides the connection for making remote procedure calls (RPCs) in gRPC. It is a concept that represents a logical connection between the client and the server, allowing them to communicate. The client can use this channel to call the server's methods directly as if they were local methods.
gRPC network management interface	An open-source network management protocol that is developed by OpenConfig. It is based on gRPC and is designed to be a flexible, extensible alternative to traditional network management protocols like SNMP. gNMI is used for telemetry and uses data models defined in YANG.
gRPC remote procedure call	A high-performance, open-source framework designed to handle remote procedure calls (RPCs), providing a way for client and server applications to communicate transparently. gRPC uses HTTP/2 as its transfer protocol and includes protocol buffers (protobuf) as one supported interface definition language.
gRPC tunnel	A mechanism to allow a gRPC server to initiate a connection with a gRPC client, such as in the gNMI dial-out scenario. NOTE: There is no mechanism built into the gRPC library that supports this type of reverse connection.
high split	A band plan where there is an upstream/downstream split at a 204 MHz upstream upper band edge (and a 258 MHz lower downstream band edge).
hybrid fiber/coax system	A broadband bidirectional shared-media transmission system using optical fiber trunks between the headend and the fiber nodes, and coaxial cable distribution from the fiber nodes to the customer locations.

information model	An information model (as opposed to a data model) is an abstraction and only provides a high-level view of things of interest (e.g., information) to the business. It aids in understanding the scope and breadth of the business, rather than the depth. An information model is a way of representing and structuring information that has advantages over other common artifacts such as a glossary, descriptive document, database, or source code. A common information model will streamline the processes associated with information exchange, both within a business (e.g., enterprise) and between a business and its external stakeholders.
Institute of Electrical and Electronics Engineers	A voluntary organization that, among other things, sponsors standards committees and is accredited by the American National Standards Institute (ANSI). For more information, refer to www.ieee.org.
interference group	A group of cable modems with active channels in the full duplex band that are susceptible to interfering with one another. The CMTS uses sounding to determine interference groups that are, in turn, mapped into transmission groups for resource block assignment. An interference group is part of a transmission group that non-overlapping downstream and upstream channels are allocated to avoid the upstream-to-downstream interference among cable modems in the same interference group.
Internet Engineering Task Force	A body responsible for, among other things, developing standards used on the Internet.
Internet Protocol	An Internet network-layer protocol.
Internet Protocol detail record	Provides information about Internet Protocol (IP)-based service usage and other activities that can be used by operational support systems (OSS) and business support systems (BSS).
IPDRDoc	Master IPDR Schema Document [IPDR/BSR].
kilobits per second	1 thousand bits per second.
Low Latency DOCSIS	A set of tools for providing control, status and statistics of packet queuing delays incurred by the processing of packets through the forwarding plane of the system referred to as Low Latency Support as defined in [MULPIv3.1] and [MULPIv4.0].
low split	A band plan where there is an upstream/downstream split at a 42 MHz upstream upper band edge (and a 54 MHz lower downstream band edge). This is also referred to as the extended-subsplit in [DOCSIS PHYv4.0].
MAC domain	A grouping of Layer 2 devices that can communicate with each other without using bridging or routing. In DOCSIS, it is the group of CMs that are using upstream and downstream channels linked together through a MAC forwarding entity.
MAC domain cable modem service group	The subset of a CM-SG that is confined to the DCs and UCs of a single MAC domain. An MD-CM-SG differs from a CM-SG only if multiple MAC domains are assigned to the same CM-SGs.
management	Functions on the CCAP that monitor for faults and for overall system performance, including traps and alarms.
management information base	A database of device configuration and performance information that is acted upon by SNMP.
media access control	Used to refer to the Layer 2 element of the system, which would include DOCSIS framing and signaling.
megabits per second	1 million bits per second.
mid split	A band plan where there is an upstream/downstream split at an 85 MHz upstream upper band edge (and a 108 MHz lower downstream band edge).
multimedia terminal adapter	A combination cable modem and telephone adapter.
multiple system operator	A corporate entity that owns and/or operates more than one cable system.
Network Configuration Protocol	An IETF network management protocol that provides mechanisms to manipulate the configuration of a device, commonly referred to as NETCONF. NETCONF executes YANG-based XML files containing configuration objects.
non-extended upstream channel	An upstream channel present below 108 MHz in an FDD UHS band plan or in an FDX band plan. An FDD CM is not required to support upstream channels between 85 MHz and 108 MHz in a UHS band plan. An FDX CM is not required to support upstream channels between 85 MHz and 108 MHz. Non-extended upstream channel only has meaning when the plant is operating with a UHS or FDX band plan. Otherwise, channels used for upstream transmission are referred to as upstream channels.
non-primary downstream channel	A downstream channel received by a cable modem that is not its primary downstream channel.
occupied full duplex band	This term is used interchangeably with FDX allocated spectrum and defines the spectrum in an access network that is allocated to an FDX band, including guard bands, whether it is used for full duplex or not.

Open Systems Interconnection (OSI)	A framework of ISO standards for communication between different systems made by different vendors in which the communications process is organized into seven different categories that are placed in a layered sequence based on their relationship to the user. Each layer uses the layer immediately below it and provides a service to the layer above. Layers 7 through 4 deal with end-to-end communication between the message source and destination, and layers 3 through 1 deal with network functions.
overlap channel	A portion of a physical OFDMA channel used to support the overlapping OFDMA channels feature. Overlap channels each have their own DOCSIS channel ID and upper boundary frequency, which are independent from the DOCSIS channel ID and upper boundary frequency of the physical OFDMA channel.
overlapping OFDMA channels	A CMTS feature that supports sharing of overlapping frequency sub-bands of an OFDMA channel by cable modems with differing diplexer settings.
partial service	A modem is in a partial service mode of operation any time it is operating with a subset of the channels in the RCS and/or TCS because a channel has become unusable, either because of an inability to acquire a channel or because communication on a channel was lost during normal operation.
physical (PHY) layer	Layer 1 in the Open System Interconnection (OSI) architecture; the layer that provides services to transmit bits or groups of bits over a transmission link between open systems and that entails electrical, mechanical, and handshaking procedures.
physical OFDMA channel	The OFDMA channel that provides the physical resources (e.g., PHY burst receiver) used to support the overlapping OFDMA channels feature.
PNM server	One or more software application(s) for initiating PNM tests and queries involving network elements, acting as a server from the perspective of other PNM and OSS applications, but acting as a client for network elements and measurement devices providing PNM and OSS results.
primary-capable downstream channel	A downstream channel that carries timestamp information (SYNC messages for SC-QAM or timestamp message block and explicit primary-capability indicator for OFDM), MDD messages containing ambiguity resolution TLVs, as well as UCD and MAP messages for at least one upstream channel in each of the MD-CM-SGs that the downstream channel reaches.
primary downstream channel	Prior to registration, a primary-capable downstream channel on which the CM has achieved timing lock and successfully received an MDD message containing ambiguity resolution TLVs. After registration, the channel on which the CM acquires timing from the assigned list of primary downstream channels in the simplified RCC encodings.
primary service flow	All CMs have a primary upstream service flow and a primary downstream service flow. They ensure that the CM is always manageable, and they provide a default path for forwarded packets that are not classified to any other service flow.
proactive network maintenance	The process and mechanism of measuring and assessing network conditions of the cable plant to determine error or fault conditions before becoming service impacting.
proto3	Protocol buffers version 3. See *protocol buffers*.
protocol buffers (protobuf)	A language-neutral, platform-neutral, extensible mechanism for serializing structured data (https://developers.google.com/protocol-buffers).
QAM channel	An analog RF channel that uses quadrature amplitude modulation (QAM) to convey information.
quadrature amplitude modulation	A modulation technique in which an analog signal's amplitude and phase vary to convey information, such as digital data.
query	A synchronous request-response for data (including measurements and-or statistics) that is expected to be available on request for a polling model. A query does not apply to streaming telemetry. A PNM query is distinguished from a PNM test (see *test*).
radio frequency	In cable television systems, this refers to electromagnetic signals in the range of 5 to 1000 MHz.
RBA sub-band direction set	The set of all active FDX sub-bands and the associated direction for those sub-bands. Because of RBA expiration times, there may be RBA messages with sequential change counts that specify the same set of sub-band directions. The term RBA sub-band direction set is used to describe the directions contained in an RBA message to distinguish those directions from the RBA message. The CM and CMTS maintain ECT state on a per RBA sub-band direction set basis. The RBA sub-band direction set is independent of the assigned TG ID.
receive channel set	The set of downstream channels assigned to an individual CM is called its receive channel set, and is explicitly configured by the CMTS using the RCC encodings.
remote authentication dial in user service	A networking protocol that provides centralized authentication, authorization, and accounting (AAA) management for computers to connect and use a network service.
request for comments	A technical policy document of the IETF; these documents can be accessed at http://www.rfc-editor.org/.

resource block	The set of sub-bands of the full duplex active spectrum assigned to a transmission group of FDX-capable cable modems. A resource block has fixed configured boundaries and the capability to be dynamically assigned by the CMTS to any of a set of upstream or downstream combinations to satisfy network traffic demand and the service provider's business objectives.
resource block assignment	Assignment of a resource block to upstream or downstream operation.
RESTCONF	An HTTP-based protocol that provides a programmatic interface for accessing data defined in YANG, using the datastore concepts defined in the Network Configuration Protocol (NETCONF).
routing CMTS	A CMTS that makes traffic forwarding decisions between its network system interfaces and MAC domain interfaces based upon the Layer 3 (network) address of a packet.
running-config	Configuration objects that control CCAP behavior, along with any vendor-proprietary configurations.
Secure Copy Protocol	A secure file transfer protocol based on Secure Shell (SSH).
Simple Network Management Protocol	Allows a host to query modules for network-related statistics and error conditions.
sounding	Sounding is a testing process performed by the FDX CMTS to assess the Co-Channel Interference (CCI) level between any CM pair that may share the same spectrum for FDX operation and is performed during Interference Group (IG) Discovery.
specialization	A relationship in which one configuration model element (the parent) is used to model another element (the child). The specialized child element receives all of the attributes, operations, and relationships that are defined in the parent and defines additional attributes, operations, and relationships that enable its specialized behavior.
startup-config	The configuration objects stored in non-volatile memory.
streaming telemetry	The transmission of telemetry via a streaming transport protocol from remote points or systems to receiving systems.
streaming telemetry client	The gNMI streaming telemetry application that subscribes to elements of a YANG datastore maintained by a telemetry server.
streaming telemetry server	The gNMI streaming telemetry network function that maintains a YANG datastore and provides the gNMI telemetry service to the telemetry client.
synchronous operation	Operation that returns data in direct responses to requests. A synchronous operation provides a way to make requests for resources, data, or services when available. The expectation is that there will be an immediate return of data. Using a synchronous operation, the application requests data and waits for it until a value is returned.
telemetry	The automatic recording and transmission of measurements/data from remote points/systems to receiving systems (in different locations) for monitoring and analysis.
Terminal Access Controller Access-Control System Plus	Protocol that provides access control for routers, network access servers, and other networked computing devices via one or more centralized servers.
test	An asynchronous data request-response from the network element, initiated by a command, and is usually accompanied by specific parameters for execution of the request. A test is always accompanied by a "Test ID", end point, or other method to align the request and response, and sometimes answered with a file output response of a measurement or statistic. A PNM test is distinguished from a PNM query (see *query*).
transmission group	A logical grouping of cable modems using the full duplex band that is formed by the CMTS for the purpose of preventing transmissions from a cable modem from interfering with cable modems receiving in a downstream channel at the same time.
transmit channel set	The set of upstream channels that a pre-DOCSIS 4.0 CM is configured to use for upstream transmission. The set of upstream channels that an FDD CM is configured to use for upstream transmission in a non-UHS band plan. The set of non-extended upstream channels that an FDD CM is configured to use for upstream transmission in a UHS band plan. The set of non-extended upstream channels that an FDX CM is configured to use for upstream transmission in an FDX band plan. See also *extended transmit channel set* and *complete transmit channel set*.
ultra-high split	A band plan where there is an upstream/downstream split at a 300, 396, 492, or 684 MHz upstream upper band edge. (The typical maximum corresponding downstream lower band edges are at 372, 492, 588, or 834 MHz respectively).
upstream	Transmissions from CM to CCAP. Also, RF spectrum used to transmit signals from a subscriber location to a cable operator's headend or hub site.

video-on-demand system	System that enables individuals to select and watch video.
X.509	ITU-T recommendation standard for a public key infrastructure (PKI) for single sign-on (SSO) and privilege management infrastructure (PMI).
YANG	A data modeling language used to model configuration data, state data, remote procedure calls, and notifications for network management protocols.

4 ABBREVIATIONS AND NAMESPACES

This specification uses the following abbreviations.

AAA	(network) authentication, authorization, and accounting
ACK	acknowledge
ACL	access control list
ANSI	American National Standards Institute
API	application programming interface
AQM	active queue management
ASCII	American Standard Code for Information Interchange
ASF	aggregate service flow
ASM	any source multicast
A-TDMA	Advanced Time Division Multiple Access
BPI	Baseline Privacy Interface
BPKM	Baseline Privacy Key Management
bps	bits per second
BSR	business solution requirements
BSS	business support systems
C	Celsius (temperature)
CA	certificate authority
CAS	conditional access system
CAT	conditional access table
CATV	cable television
CCAP	Converged Cable Access Platform
CCF	common collection framework
CCI	copy control information
CLI	command line interface
CM	cable modem
CMTS	cable modem termination system
CoS	class of service
CP	cyclic prefix
CPAF	configuration, performance, accounting, fault management
CPE	customer premises equipment
CRANE	Common Reliable Accounting for Network Element
CRL	certificate revocation list
CW	control word
CWT	continuous wave tone
dB	decibel
DBC	dynamic bonding change
DBG	downstream bonding group
DC	downstream channel
DCC	dynamic channel change
DCID	downstream channel identifier
DCS	downstream channel set
DES	Digital Encryption Standard
DHCP	Dynamic Host Configuration Protocol
DLC	downstream line card
DLS	DOCSIS Light Sleep (mode)

DPD	downstream profile descriptor
DPoE	DOCSIS Provisioning of EPON
DS	downstream
DSAP	destination service access point
DSCP	differentiated services (DiffServ) code point
DSG	DOCSIS Set-top Gateway
DSID	downstream service identifier
DST	Daylight Saving Time
DTD	document type definition
DTI	DOCSIS Timing Interface
EAE	early authentication and encryption
ECM	entitlement control message
ECMD	ECM decoder
ECMG	ECM generator
EM	event message OR energy management
EM-ID	energy management identifier
EMM	entitlement management message
EPON	Ethernet Passive Optical Network
EQAM	Edge QAM
ERM	Edge Resource Manager
ERMI	Edge Resource Manager Interface
ERRP	Edge Resource Registration Protocol
ETV	enhanced television
ETVBIF	Enhanced Television Binary Interchange Format
FCAPS	Fault, Configuration, Accounting, Performance, and Security
FDD	frequency division duplex
FDX	full duplex or full duplex DOCSIS
FDX-L	full duplex limited
FEC	forward error correction
FFT	fast Fourier transform
FQDN	fully qualified domain name
FRU	field replaceable unit
FSM	finite state machine
FTP	File Transfer Protocol
Gbps	gigabits per second
GC	group configuration
GCR	group classifier rule
GLBG	general load balancing group
GMT	Greenwich Mean Time
gNMI	gRPC network management interface
GPB	Google Protocol Buffers
GQC	group QoS configuration
gRPC	gRPC Remote Procedure Calls
GSF	group service flow
HCS	header check sequence
HFC	hybrid fiber-coax
HMAC	hash-based message authentication code
HQoS	hierarchical quality of service
HTTP	Hypertext Transfer Protocol

HTTP/2	Hypertext Transfer Protocol version 2
HTTPS	Hypertext Transfer Protocol Secure
IATC	interface aggregate traffic class
ID	identifier
IDL	interactive data language
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFFT	inverse fast Fourier transform
IG	interference Group
IGMP	Internet Group Management Protocol
INIT	initialize or initialization
IP	Internet Protocol
IPDR	Internet Protocol Detail Record
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IR	Internet Protocol Detail Record recorder
IS	Internet Protocol Detail Record store
ISO	International Organization for Standardization
IT	Internet Protocol Detail Record transmitter
ITU	International Telecommunication Union
IUC	interval usage code (has iterations of 1,2, and 3)
J2EE	Java 2 Platform, Enterprise Edition
JSON	JavaScript Object Notation
kbps	kilobits per second
kHz	kilohertz
L2VPN	Layer 2 virtual private network
LAN	local area network
LLD	Low Latency DOCSIS
log	logarithm
LSB	least significant bit
LTE	long-term evolution
MAC	Media Access Control
MAP	bandwidth allocation map
Mbps	megabits per second
M-CMTS	modular cable modem termination system
MD-CM-SG	Media Access Control domain cable modem service group
MDD	MAC domain descriptor
MD-DS-SG	Media Access Control domain downstream service group
MDF	multicast DSID forwarding
MD-US-SG	Media Access Control domain upstream service group
MER	modulation error ratio
MGMD	multicast group membership discovery
MHz	megahertz
MIB	management information base
MIC	message integrity check
MLD	multicast listener discovery
MPD	message processing and dispatching
MPTS	multi-program transport stream

MSB	most significant bit
MSO	multiple system operator
MTA	multimedia terminal adapter
MTC	multiple transmit channel
MULPI	MAC and Upper Layer Protocols Interface
NETCONF	Network Configuration Protocol
NMS	network management system
NOC	network operations center
NSI	network side interface
OCD	OFDM Channel Descriptor
OCSP	Online Certificate Status Protocol
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiplexing with multiple access
OMG	object management group
ONU	optical network unit
OOC	overlapping OFDMA channels
OSS	Operations Support System
OSSI	Operations Support System Interface
OUI	organizationally unique identifier
PAT	program association table
PCMM	PacketCable Multimedia
PE	physical and environmental
PEN	private enterprise number
PHY	Physical Layer
PID	packet identifier
P-IE	probe information element
PMT	program map table
PNM	Proactive Network Maintenance
PON	Passive Optical Network
PS	CableHome Portal Services
PSD	power spectral density
QAM	quadrature amplitude modulation
QoS	quality of service
QPSK	quadrature phase shift keying
RADIUS	Remote Authentication Dial In User Service
RB	resource block
RBA	resource block assignment
RCC	receive channel configuration
RCP	receive channel profile
RCP-ID	receive channel profile identifier
RCS	receive channel set
RCT	redistribution control trigger
REG	registration
REST	representational state transfer
RF	radio frequency
RFC	request for comments
RFI	radio frequency interface
RKS	record keeping server
RPC	remote procedure call

RTSP	Real Time Streaming Protocol
RxMER	receive (channel) modulation error ratio
SA	security association
SAID	security association identifier
SAMIS	Subscriber Accounting Management Interface Specification
SAV	source address verification
SC	service consumer
S-CDMA	synchronous code division multiple access
SCN	service class name
SCP	Secure Copy Protocol
SC-QAM	single-carrier quadrature amplitude modulation
SDV	switched digital video
SE	service element
SEC	security
SF	service flow
SFID	service flow identifier
SID	service identifier
SLA	service-level agreement
SMIv1	Structure of Management Information version 1
SMIv2	Structure of Management Information version 2
SNAP	Subnetwork Access Protocol
SNMP	Simple Network Management Protocol
SNMPv1	Simple Network Management Protocol version 1
SNMPv2	Simple Network Management Protocol version 2
SNMPv2c	community-based Simple Network Management Protocol version 2
SNMPv3	Simple Network Management Protocol version 3
SP	Streaming Protocol
SRE	system route engine
SSH	secure shell
SSM	source specific multicast
STP	Spanning Tree Protocol
SW	software
SYNC	synchronize or synchronization
TACACS+	Terminal Access Controller Access-Control System Plus
TCP	Transmission Control Protocol
TCS	transmit channel set
TCS_EXT	extended transmit channel set
TDMA	time division multiple access
TEK	traffic encryption key
TFTP	Trivial File Transfer Protocol
TG	transmission group
TLS	transport layer security
TLV	type-length-value
ToD	time of day
ToS	terms of service
TS	transport stream
TSID	transport stream identifier
UBG	upstream bonding group
UC	upstream channel

UCC	upstream channel change
UCID	upstream channel identifier
UDC	upstream drop classifier
UDP	User Datagram Protocol
UHS	ultra-high split
ULC	upstream line card
UML	Unified Modeling Language
URL	uniform resource locator
US	upstream
UTC	Coordinated Universal Time
UUID	universally unique identifier
VACM	view-based access control model
VIVSO	vendor-identifying vendor-specific options
VLAN	virtual local area network
VOD	video on demand
WAN	wide area network
XDR	external data representation
XML	Extensible Markup Language
XSD	XML Schema Definition

4.1 XML Namespaces

This specification uses the following XML namespace prefixes to indicate the corresponding public XML namespaces.

Table 2 - Public XML Namespaces

Prefix	XML Namespace	Specification Reference
xsd	http://www.w3.org/2001/XMLSchema	[W3XSD1.0]
xsi	http://www.w3.org/2001/XMLSchema-instance	[W3XSD1.0]
ipdr	https://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr	[IPDR/SSDG]

This specification defines the following XML namespaces for DOCSIS IPDR Service Definitions.

Table 3 - IPDR Service Definition Namespaces

Prefix	XML Namespace
DOCSIS-SAMIS-TYPE-1	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-1
DOCSIS-SAMIS-TYPE-2	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-2
DOCSIS-CMTS-CM-US-STATS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-US-STATS-TYPE
DOCSIS-CMTS-CM-REG-STATUS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-REG-STATUS-TYPE
DOCSIS-CMTS-TOPOLOGY-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-TOPOLOGY-TYPE
DOCSIS-CPE-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CPE-TYPE
DOCSIS-DIAG-LOG-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-TYPE
DOCSIS-DIAG-LOG-EVENT-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-EVENT-TYPE

Prefix	XML Namespace
DOCSIS-DIAG-LOG-DETAIL-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-DETAIL-TYPE
DOCSIS-CMTS-US-UTIL-STATS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-US-UTIL-STATS-TYPE
DOCSIS-CMTS-DS-UTIL-STATS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-DS-UTIL-STATS-TYPE
DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE
DOCSIS-IP-MULTICAST-STATS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-IP-MULTICAST-STATS-TYPE
DOCSIS-CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE
DOCSIS-CMTS-CM-DS-OFDM-STATUS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-DS-OFDM-PROFILE-TYPE
DOCSIS-CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE
DOCSIS-CMTS-CM-US-OFDMA-STATUS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-US-OFDMA-STATUS-TYPE
DOCSIS-DS-OFDM-PROFILE-STATS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-DS-OFDM-PROFILE-STATS-TYPE
DOCSIS-US-OFDMA-PROFILE-STATS-TYPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-US-OFDMA-PROFILE-STATS-TYPE"

This specification defines the following XML namespaces for DOCSIS auxiliary schemas.

Table 4 - Auxiliary Schema Namespaces

Prefix	XML Namespace
DOCSIS-CMTS	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS
DOCSIS-CM	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM
DOCSIS-CPE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CPE
DOCSIS-QOS	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-QOS
DOCSIS-REC	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC
DOCSIS-CMTS-CM-US	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-US
DOCSIS-CMTS-CM-NODE-CH	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-NODE-CH
DOCSIS-MD-NODE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-MD-NODE
DOCSIS-DIAG-LOG	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG
DOCSIS-DIAG-LOG-DETAIL	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-DETAIL
DOCSIS-CMTS-US-UTIL	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-US-UTIL
DOCSIS-CMTS-DS-UTIL	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-DS-UTIL
DOCSIS-SERVICE-FLOW	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-SERVICE-FLOW
DOCSIS-IP-MULTICAST	https://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-IP-MULTICAST
DOCSIS-CMTS-CM-DS-OFDM	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-DS-OFDM
DOCSIS-CMTS-CM-PARTIAL	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-PARTIAL
DOCSIS-CMTS-CM-US-OFDMA	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-US-OFDMA
DOCSIS-OFDM-PROFILE	https://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-OFDM-PROFILE

5 OVERVIEW

5.1 FCAPS Network Management Model

The International Telecommunication Union (ITU) Recommendation defines a set of management categories, referred to as the FCAPS model, represented by the individual management categories of Fault, Configuration, Accounting, Performance and Security. Telecommunications operators, including MSOs, commonly use this model to manage large networks of devices. This specification uses these management categories to organize the requirements for the configuration and management of the CCAP platform.

Fault management seeks to identify, isolate, correct and record system faults. Configuration management modifies system configuration variables and collects configuration information. Accounting management collects usage statistics for subscribers, sets usage quotas and bills users according to their use of the system. Performance management focuses on the collection of performance metrics, analysis of these metrics and the setting of thresholds and rate limits. Security management encompasses identification and authorization of users and equipment, provides audit logs and alerting functions, as well as providing vulnerability assessment.

Each of these management categories is discussed in further detail in the following sections.

5.1.1 Fault Management

Fault management is a proactive and on-demand network management function that allows non-standard/abnormal operation on the network to be detected, diagnosed, and corrected. A typical use case involves network elements detecting service-impacting abnormalities; when detected, an autonomous event (often referred to as an alarm notification) is sent to the network operations center (NOC) to alert the MSO of a possible fault condition in the network affecting a customer's service. Once the MSO receives the event notification, further troubleshooting and diagnostics can be performed by the MSO to correct the fault condition and restore the service to proper operation.

5.1.2 Configuration Management

Configuration Management provides a set of network management functions that enables system configuration building and instantiating, installation and system turn up, network and device provisioning, auto-discovery, backup and restore, software download, status, and control (e.g., checking or changing the service state of an interface).

Configuration Management is primarily concerned with network control via modifying operating parameters on network elements such as the CCAP. Configuration parameters could include both physical resources (for example, an Ethernet interface) and logical objects (for example, QoS parameters for a given service flow).

While the network is in operation, Configuration Management is responsible for monitoring the configuration state and making changes in response to commands by a management system or some other network management function.

For example, a performance management function may detect that response time is degrading due to a high number of uncorrected frames, and may issue a Configuration Management change to modify the modulation type from 16-QAM to QPSK. A Fault Management function may detect and isolate a fault and may issue a configuration change to mitigate or correct that fault.

5.1.3 Accounting Management

Accounting Management is a network management function that allows MSOs to measure the use of network services by subscribers for the purposes of cost estimation and subscriber billing. The CCAP is the network element that is responsible for providing the usage statistics to support billing. Subscriber Accounting Management Interface Specification (SAMIS) is an example of an implemented Accounting Management function. Billing is outside the scope of this specification.

5.1.4 Performance Management

Performance Management is a proactive and on-demand network management function. The ITU Recommendation defines its role as gathering and analyzing "statistical data for the purpose of monitoring and correcting the behavior

and effectiveness of the network, network equipment, or other equipment and to aid in planning, provisioning, maintenance and the measurement of quality." A Performance Management use case might include the NOC performing periodic (15 min, for example) collections of QoS measurements from network elements to perform monitoring and identification of any potential performance issues that may be occurring with the service being monitored. With the historical data that has been collected, trending analysis can be performed to identify issues that may be related to certain times of day or other corollary events. The MSO can run reports on the data to identify suspect problems in service quality, or the NOC application can be provisioned, so that when certain performance thresholds are violated, the MSO is automatically notified that a potential service quality problem may be pending. Significant intelligence can be integrated into the NOC application to automate the ability to detect the possible degradation of a customer's service quality and take actions to correct the condition. Service level agreement compliance is not possible without strong performance management.

Performance Management functions include collecting statistics of parameters such as number of frames lost at the MAC layer and number of codeword errors at the PHY layer. These monitoring functions are used to determine the health of the network and whether the offered Quality of Service (QoS) to the subscriber is met. The quality of signal at the PHY layer is an indication of plant conditions.

Additional Performance Management functions include Proactive Network Maintenance to enable measurement and reporting of network conditions such that undesired impacts such as plant equipment and cable faults, interference from other systems and ingress can be detected and measured. With this information, cable network operations personnel can make modifications necessary to improve conditions and monitor network trends to detect when network improvements are needed.

DOCSIS 4.0 introduces a new Performance Management function for Streaming Telemetry. Telemetry is the automatic recording and transmission of measurements/data from remote points/systems to receiving systems (in different locations) for monitoring and analysis. Sensors in remote systems measure physical (e.g., temperature) or electrical data (e.g., current). These measurements form a data stream sent to a collection/receiving system. The receiver disaggregates the data stream into the original data set for processing/display/etc. While Telemetry is used across many different industries, Telemetry specific to communication networks is referred to as Network Telemetry. Network Telemetry describes how information from various network data sources can be collected using a set of automated communication processes and transmitted to one or more receiving equipment for analysis tasks. Analysis tasks may include event correlation, anomaly detection, performance monitoring, metric calculation, trend analysis, and other related processes.

5.1.5 Security Management

Security Management provides for the management of network and operator security, as well as providing an umbrella of security for the telecommunications management network functions. Security Management functions include authentication, access control, data confidentiality, data integrity, event detection, and reporting. A Security Management use case might include providing authentication and data confidentiality when transferring a configuration file that contains the entire configuration data set for the device to a network element. These functions are covered in context within this specification.

5.2 Management Architectural Overview

Figure 5 illustrates the DOCSIS CCAP management architecture including management interfaces and logical components of the MSO Back Office, CCAP, and Cable Modem. Refer to the following sections for descriptions of the architectural components and interfaces.

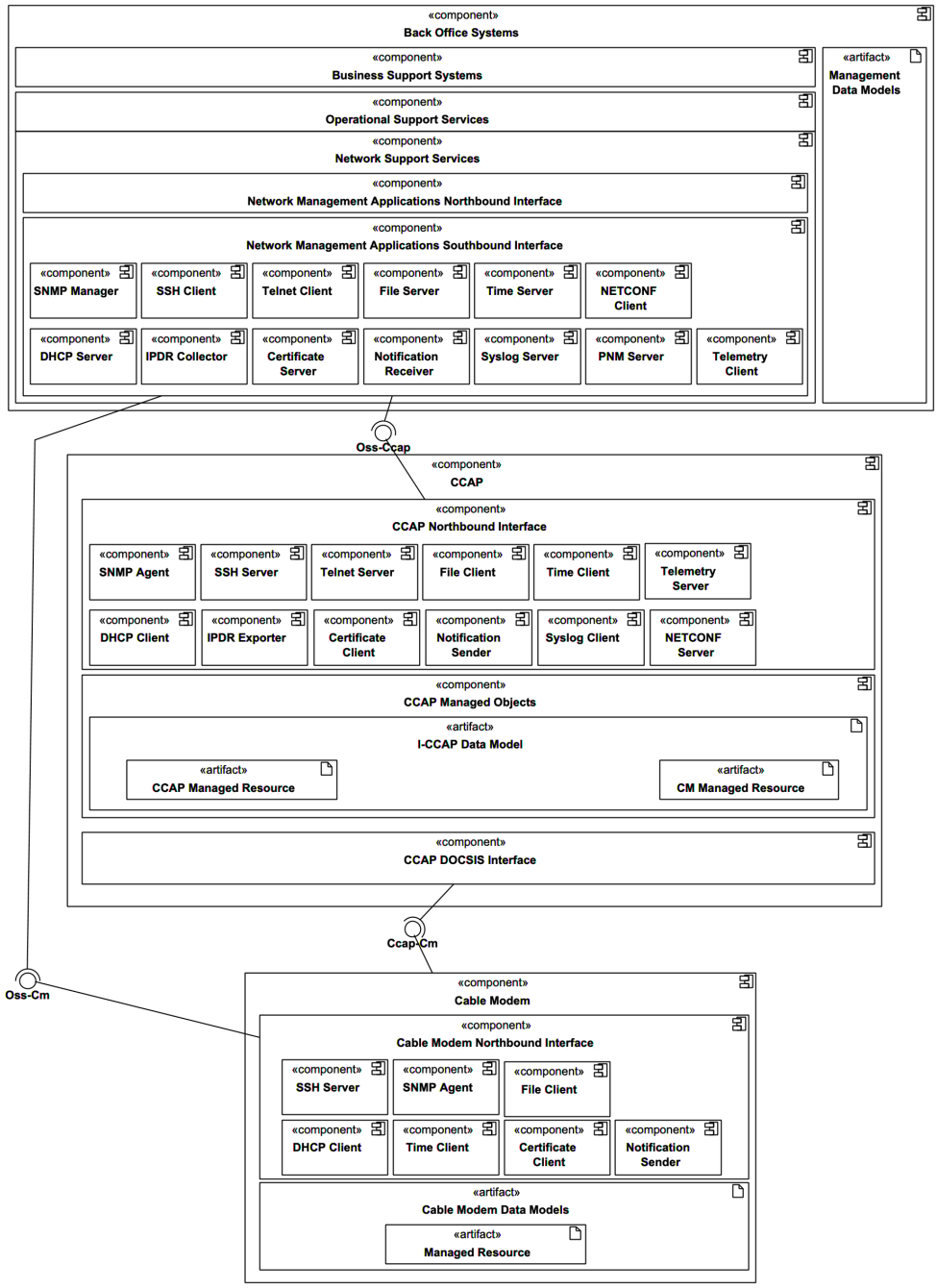


Figure 5 - CMTS and CCAP Management Architecture

5.2.1 Back Office Systems

MSO back office systems support the delivery of their subscriber services. This is generally represented as a layered model:

- Business Support Services

  Business Support Services (BSSs) include business and commercial level systems for customer management, revenue management, billing, etc.

- Operational Support Services

Operational Support Services (OSSs) include service-level systems for service delivery and orchestration and service monitoring.

- Network Support Services

Network support services, including Network Management Systems (NMSs) and Element Management Systems (EMSs) include network facing systems for network management, monitoring, administration and control. This is often referred to as the Network Management Layer. Network Support Services provide an abstraction layer to the Operational Support Services via a Network Management Applications Northbound Interface.

- Management Data Models

In a model-driven architecture, each layer in the Back Office contains an abstracted view of the underlaying layer below it. management data models provide implementation-specific programmable models which can be used by all applications in each layer. This specification uses UML to model protocol-agnostic Information Models as described in Section 5.4.

5.2.2 Network Management Applications

Various management applications and servers, including Network Management Stations, reside in the Network Management Layer within the MSO back office to provision, monitor, and administer the Network Elements or network functions within the Network Layer.

The following set of network management applications are supported in the architecture:

- SNMP Manager – performs SNMP queries against a CCAP's SNMP Agent.
- SSH Client – provides secure access to the CCAP.
- Telnet Client – provides Telnet capabilities into the CCAP.
- File Server – provides a file transfer mechanism for the CCAP.
- Time Server – provides a CCAP with current Time of Day (ToD).
- DHCP Server – has the responsibility of assigning a CCAP its IPv4 and/or IPv6 addresses as well as other DHCP parameters.
- IPDR Collector – primary and secondary - collect bulk data statistics, such as usage metrics, via the IPDR/SP protocol.
- Certificate Server – provides information and status for security certificates.
- Notification Receiver – receives autonomous SNMP and optional NETCONF notifications and Syslog messages from a CCAP.
- Syslog Server – provides the ability to receive SYSLOG messages from the CCAP.
- NETCONF Client – performs provisioning for CCAP's supporting NETCONF Servers.
- PNM Server – provides an interface to triggering PNM tests in the CCAP and collecting PNM measurements.
- Telemetry Client – provides a Streaming Telemetry data collection subscription-based interface.

The Business and Service Management Layer, which sits north of the Network Management Layer, is where higher-level MSO business processes are implemented via BSS/OSS systems (Business Support Services and Operational Support Services). These BSS/OSS systems utilize the data and information from the Network Management Layer (via the Network Management Applications Northbound Interface) that interrogate data from the Network Layer. Figure 5 illustrates components and their respective resource artifacts that reside at the Network Layer and Network Management Layer, which include the CCAP and Cable Modem and their respective Network Management Applications.

5.2.3 Common Collection Framework

The CableLabs Common Collection Framework (CCF) [CCF] represents a data collection framework which enables abstraction of the network layer for BSS applications. BSS applications utilize a RESTful API layer provided by CCF and CCF implements the network layer protocol specific interfaces to collect network layer datasets, such as Proactive Network Maintenance measurement data. Within the context of DOCSIS, the CCF includes component functions (e.g., PNM Servers) to collect PNM data using DOCSIS OSSI interfaces including SNMP and TFTP. With the introduction of future OSSI interfaces, the BSS applications would not need to be redesigned to support these new interfaces, the CCF would simply introduce additional protocol interface support and provide the models in the RESTful APIs to the BSS application clients.

Figure 6 represents the CCF applicable to DOCSIS OSS PNM. A PNM Application resides in the Application Plane within the back office. The PNM Application functionality is left to vendor implementation. The PNM Server resides at the CCF plane within the back office. The PNM Server provides an abstraction of the network elements to the PNM Application via a REST API interface. The PNM Application is able to retrieve PNM-centric data from the PNM Server via a set of REST APIs from the PNM Server NBI. The CCAP provides the PNM data collected from CCAP measurements to the PNM Server over the CCAP NBI using existing DOCSIS OSS protocols (SNMP, TFTP). In addition, the PNM Server SBI communicates directly with Cable Modems to retrieve PNM measurement data using the same DOCSIS OSS interfaces.

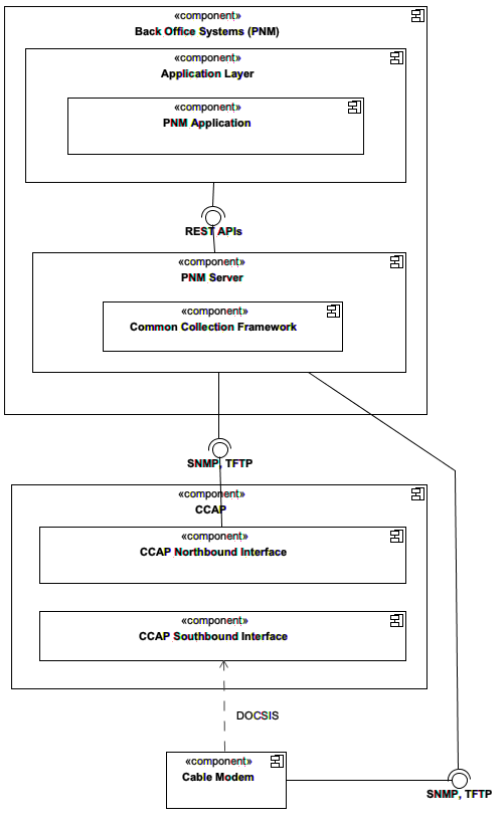


Figure 6 - Common Collection Framework for DOCSIS PNM

5.2.4 CCAP

The CMTS is an access-side networking element or set of elements that includes one or more MAC Domains and one or more Network System Interfaces. This device is located at the cable television system headend or distribution hub and provides data connectivity between a DOCSIS Radio Frequency Interface and a wide-area network.

The CCAP is an access-side networking element or set of elements that combines the functionality of a CMTS with that of an Edge QAM, providing high-density services to cable subscribers.

The CMTS/CCAP and Cable Modems reside within the Network Layer where services are provided to end Subscribers and various metrics are collected about network and service performance, among other things.

5.2.4.1 CCAP Northbound Interface

The CCAP Northbound Interface ("Oss-Ccap interface") provides a standardized set of management and operations protocols to enable back office management of DOCSIS components. In addition, this interface provides an abstracted model view of the DOCSIS system components to the back office management applications.

The following set of network management protocols are supported by the architecture:

- SNMP Agent
- SSH Server
- Telnet Server
- File Client
- Time Client
- DHCP Client
- IPDR Exporter
- Certificate Client
- Notification Sender
- Syslog Client
- NETCONF Server
- Telemetry Server

These represent client or server applications that enable communication with the back office network management applications via the Oss-Ccap interface.

5.2.4.2 CCAP Managed Objects

This represents the set of data models, containing groupings of managed objects, which enables the back office to manage, administer, monitor and provision the CCAP component. In this specification, this information is specified in a protocol-neutral UML modeling language and then translated into the required protocol specific data models based on each type of network management interface and its requirements for data encoding and associated messaging protocols. There are two basic types of managed objects, CCAP managed resources, which enable the back office to manage aspects of the CCAP component, and CM managed resources, which enable the back office to manage aspects of Cable Modems via the DOCSIS protocol over the Ccap-Cm interface. Refer to Section 5.4 for additional details.

5.2.4.3 CCAP Southbound Interface

The CCAP Southbound Interface ("Ccap-Cm interface") represents the interface between the CCAP and CM. This interface communicates with the southbound CMs in the Network Layer to manage MAC and PHY level characteristics.

5.2.5 Cable Modem

The Cable Modem is a modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system. The Cable Modem also contains a set of Information Models and associated protocol specific data models as specified in [CM-OSSIv4.0]. The back office CM management interface is referred to as the "Oss-Cm interface".

5.3 DOCSIS 4.0 OSSI Key Features

DOCSIS 4.0 introduces a number of features that build upon features introduced in previous versions of DOCSIS, including Low Latency DOCSIS support (LLD). This specification includes new features for the Operations Support System Interface (OSSI) based on requirements established to support the introduction of new DOCSIS 4.0 features and provides enhancements to management capabilities that will further improve operational efficiencies for the operator.

The DOCSIS 4.0 specification includes Full Duplex (FDX) operation as well as Frequency Division Duplex (FDD) operation to facilitate increased capacity for providing multigigabit services in the upstream and downstream. FDX significantly increases upstream capacity over DOCSIS 3.1 networks and allows for the same spectrum to be used as downstream or upstream. FDX CMTS will simultaneously receive and transmit in the same FDX spectrum, while FDX CMs can only receive or transmit at any one time in the same FDX spectrum.

FDD supports significant increases in upstream and downstream capacity by extending the DOCSIS downstream upper band edge to 1794 MHz and introduces ultra-high split (UHS) alternatives for the upstream with 300, 396, 492, or 684 MHz upstream upper band edges to provide flexibility in upstream channel placement.

Support for Modular YANG further enhances the DOCSIS 4.0 OSSI specification. In addition, DOCSIS 4.0 technology introduces an updated Baseline Privacy Interface Plus version (i.e., BPI+V2), which provides perfect forward secrecy, algorithm agility, stronger authorization and traffic encryption keys, downgrade protection, and mutual authentication, as defined in the [SECv4.0] specification.

Table 5 - Management Feature Requirements for DOCSIS 4.0

Features	Management Functional Area	OSI Layer	Description
Legacy OFDM downstream signals, OFDMA upstream signals, advanced band plan downstream signals, and extended spectrum upstream signals	Configuration	PHY	Provisioning physical downstream and upstream transmitters and receivers according to their capabilities
Plant topology	Configuration	PHY, MULPI, (Data Link)	Provisioning flexible arrangements of US/DS channels for channel bonding configuration to reflect plant topology
Enhanced diagnostics	Fault	PHY, MULPI, network	Expanded metrics for Proactive Network Maintenance, including DOCSIS 4.0 extended channel metrics
Enhanced performance data collection	Performance	PHY, MULPI, network	Collection of large statistical data sets for DOCSIS 4.0 feature sets
Enhanced signal quality monitoring	Performance	PHY	Gathers information on narrow-band ingress and distortion affecting the quality of the RF signals in the extended spectrum
BPI+ V2	Configuration	SEC	Provides perfect forward secrecy, encryption algorithm agility, stronger authorization and traffic encryption keys, downgrade protection, and mutual authentication
Modular YANG		OSSI	Replaces monolithic YANG
Streaming telemetry		OSSI	gNMI/gRPC-based telemetry interface as an alternative to IPDR and SNMP-based data collection

5.3.1 Fault Management Features

The DOCSIS 4.0 Fault Management features include all DOCSIS 3.1 fault management features plus those specific to FDX and FDD events and alarms. This also includes additional DOCSIS 4.0 security events and alarms.

5.3.2 Configuration Management Features

The configuration of the DOCSIS protocols for CM/CCAP interactions for configuring features in support of PHY MULPI/QoS and Security (BPI) uses the CM configuration file and CMTS policies via MAC messages exchange.

The reporting of configuration state and status information is done via SNMP MIB objects, in addition to YANG nodes, via NETCONF if NETCONF is supported. Configuration of features and functions of the CCAP is performed via a vendor-proprietary mechanism or via NETCONF (using modular YANG data models) if NETCONF is supported.

DOCSIS 4.0 Full Duplex DOCSIS (FDX) configuration requirements include configuration of extended upstream channels at the optical fiber node for FDX channels.

DOCSIS 4.0 Frequency Division Duplex (FDD) configuration requirements include configuration of extended upstream channels at the optical fiber node for an FDD band plan.

5.3.3 Performance Management Features

The DOCSIS 4.0 performance management requirements include an efficient mechanism for collecting large Proactive Network Maintenance data sets for granular plant status. While DOCSIS 4.0 continues to support the file-based Bulk Data transfer mechanisms described in this specification, new methods are introduced for streaming of Telemetry.

Additional status objects manage the operation and status monitoring of DOCSIS 4.0 cable modems configured for the FDX band plan or FDD band plan.

5.4 Information Models

The Information Model approach is based on an object-oriented modeling approach well known in the industry for capturing requirements and analyzing the data in a protocol independent representation. This specification uses the Unified Modeling Language (UML) to graphically represent the various elements composing the Information Model. This approach defines requirements with use cases to describe the interactions between the operations support systems and the network element. Use Case diagrams illustrate the ways in which the user or actor, which can be an external system, can interact with the system under design (i.e., CCAP). Sequence diagrams model the sequence of exchanged messages (e.g., SNMP, NETCONF, etc.) and actions for a specific operation and are often used to define specific scenarios for the defined Use Cases. The management information is represented in terms of classes or objects along with their attributes and the interactions between these encapsulated objects (or also referred to as entities in some representations). Class diagrams provide this conceptual, static model of the structure of the system (i.e., CCAP OSS Interface). Class diagrams organize attributes into related groups or classes, model relationships between the classes including inheritance, and define the operations (e.g., CRUD) each class can execute. Component diagrams model the components of a system and the interactions between the components. These define specific interfaces (i.e., CCAP OSSI) and the information that flows through the interface. Typically, one component provides the interface realization (the Server) while other component(s) utilize ("<<use>>") the interface (the Client(s)) to interact with the other component. Component diagrams effectively define interfaces and the operations which can be performed on the interface. The collection of UML diagrams are referred to as the DOCSIS 4.0 Information Models. With the introduction of several new, complex features in DOCSIS 4.0 and the operator needs for a more proactive and efficient approach to management information, information modeling methodologies offer the ability to reuse the same definitions when new protocols are introduced in the future.

The managed objects, operations, and notifications are then represented in a protocol specific form referred to as a management data model. The management data models when using SNMP are described using the Structure of Management Information Version 2 (SMIv2) [RFC 2578] and the design of these models is determined by the capabilities of the protocol. The management data models when using NETCONF are described using the YANG data modeling language [RFC 6020]. The management data models when using IPDR/SP are described using the IPDR Service Definition Schemas [IPDR/SSDG].

Refer to [UML Guidelines] for information modeling concepts used throughout this specification.

5.4.1 Attribute Multiplicities in Class Diagrams

While a multiplicity is often defined for an association between two classes, a multiplicity can also be defined for an attribute within a class definition. This is further explained in the Attributes section of [UML Guidelines].

Class object attributes tables can include a column labeled "Multiplicity." The multiplicity for an attribute can be represented in a UML Class Diagram by placing the value or range of values within square brackets following the attribute name and attribute type.

If the multiplicity for an attribute is not defined or specified, the default multiplicity is '1,' which represents a single value or single instance for the attribute when the class is instantiated. Non-default attribute multiplicities require the UML class diagram and object attributes table to define the multiplicity.

An attribute with a multiplicity defined to include zero (e.g., 0..1) indicates the attribute is not required when the class is instantiated.

An attribute with a multiplicity defined to include a value greater than 1 (e.g., 0..* or 1..*) indicates the attribute is a list or array with 1 or more values.

The following examples highlight the multiplicity rules.

Class: DocsisGlobalCfg

Attribute: ChannelUtilizationInterval: UnsignedInt [1]

Attribute: L2VpnGlobalEnabled: Boolean [0..1]

In this example, there is a single instance or value for the ChannelUtilizationInterval attribute when the DocsisGlobalCfg class is instantiated. The L2VpnGlobalEnabled attribute is optional and may be omitted when the DocsisGlobalCfg class is instantiated. If L2VpnGlobalEnabled attribute is included, there is a single instance or value present when the class is instantiated.

Class: ServiceClass

Attribute: LatencyHistBinEdges: UnsignedShort [0..15]

In this example, there can be zero to 15 instances or values for the LatencyHistBinEdges attribute when the ServiceClass class is instantiated. In this case, the LatencyHistBinEdges attribute is implemented as a list or array in the data model.

5.5 CCAP Use Cases

The following Use Cases represent example FCAPS operations for managing the CCAP.

5.5.1 Fault Management Use Cases

The following represents a set of Fault Management Use Cases for the CCAP.

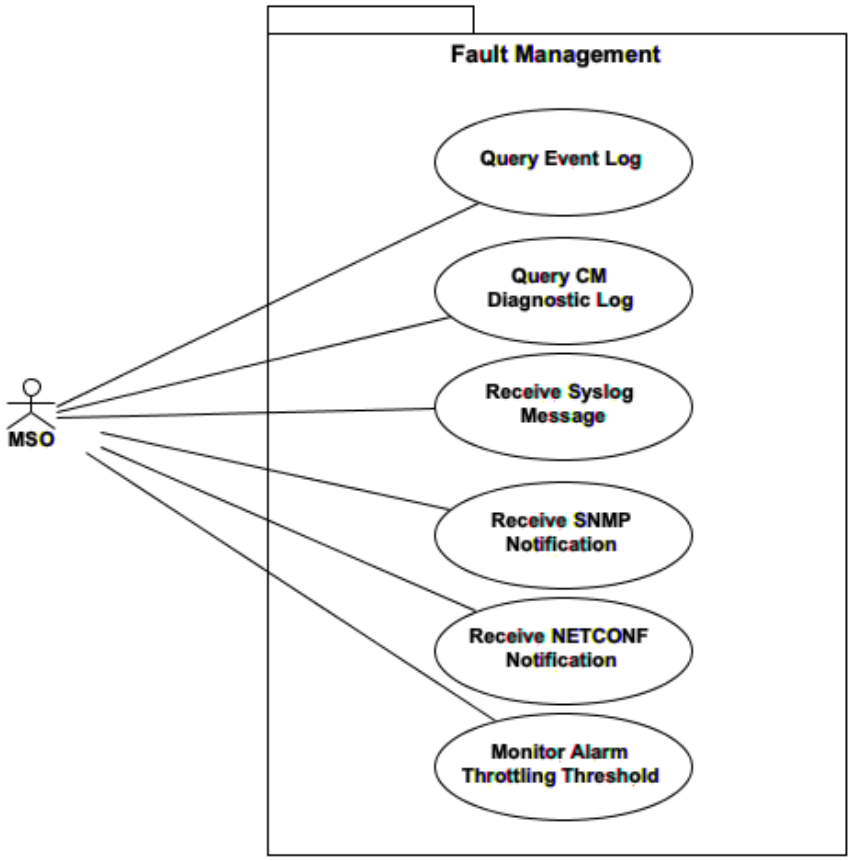


Figure 7 - Fault Management Use Cases

5.5.1.1 Monitoring Downstream Channel Faults and Events

The following is an example Use Case which illustrates an MSO monitoring/querying events specific to a downstream OFDM channel via the Northbound OSSI interface by receiving a SNMP notification, receiving a Syslog message, and querying the CCAP event log. An example OFDM channel event, event ID 74001000, is included, which represents a profile failure event. NETCONF notifications are optionally supported and are not illustrated in Figure 8.

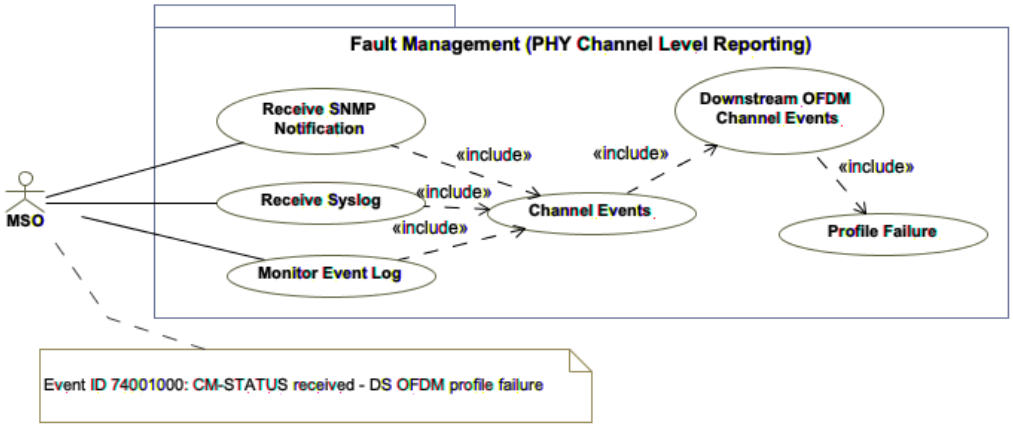


Figure 8 - Downstream Channel Fault Monitoring Use Case

5.5.2 Configuration Management Use Cases

The following represents a set of Configuration Management Use Cases for the CCAP.

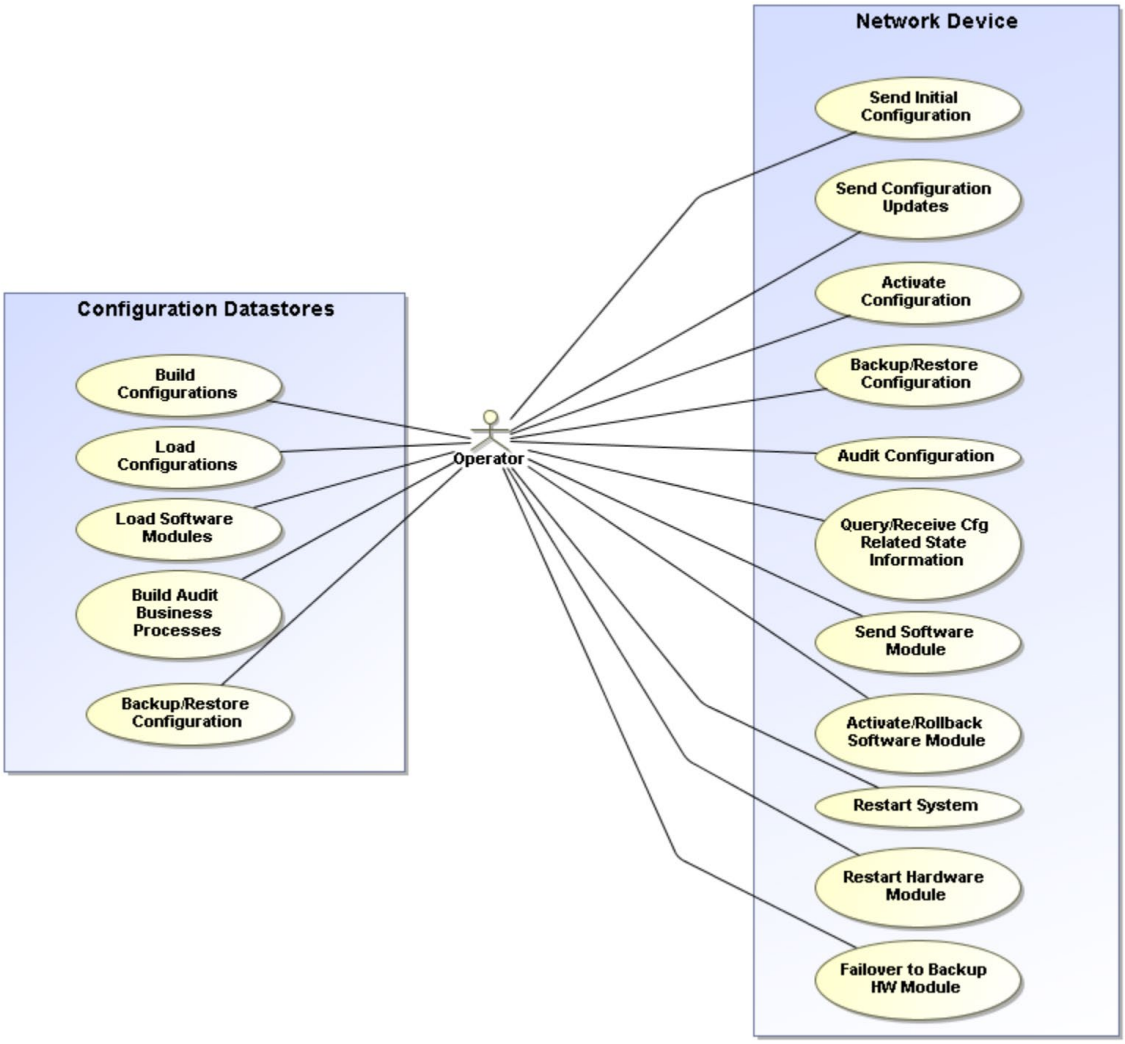


Figure 9 - Configuration Management Use Cases

5.5.2.1 Downstream RF Port Configuration

The following is an example Use Case for configuration of attributes for a downstream RF port on one of the line cards on the I-CCAP chassis modeled by the MAC Manager. As Figure 10 shows, this Use Case includes configuration of downstream RF port attributes such as Base Power, Tilt, Maximum Tilt Frequency, and RF Mute. Example CLI commands for such provisioning operations are also included.

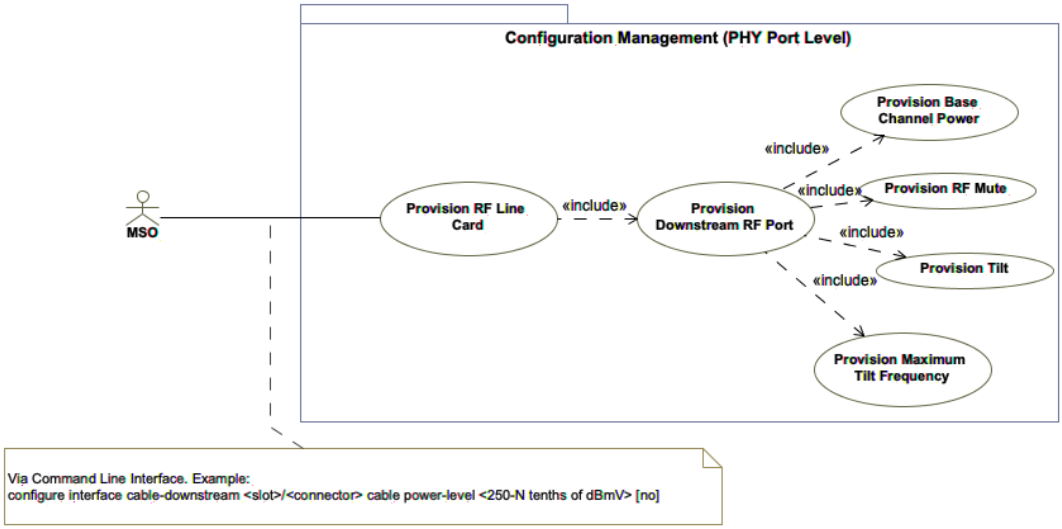


Figure 10 - Downstream RF Port Configuration Use Case

5.5.2.2 Downstream RF Channel Configuration

The following is an example Use Case for configuration of attributes for a downstream OFDM channel on one of the downstream RF ports of a linecard on the I-CCAP chassis modeled by the MAC Manager. As Figure 11 shows, this Use Case includes configuration of OFDM channel attributes such as Power Adjust. Example CLI commands for such provisioning operations are also included.

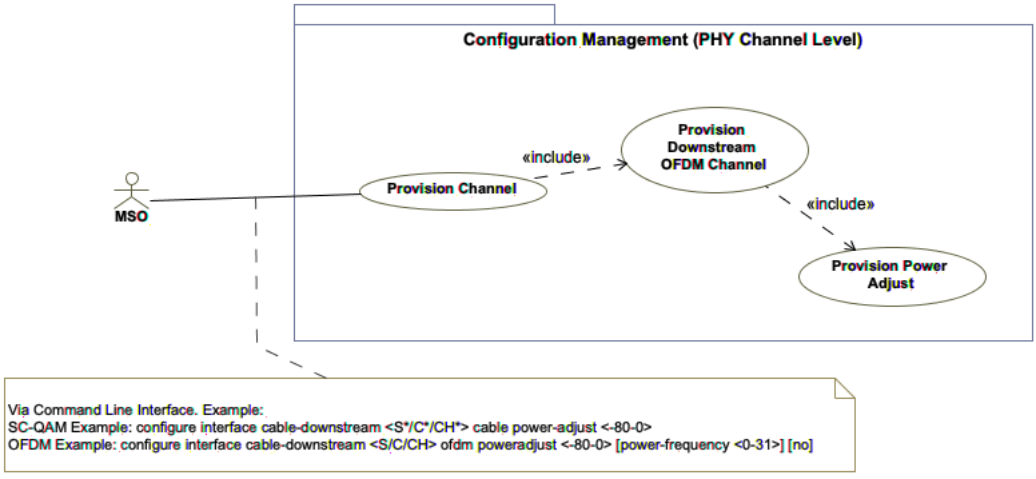


Figure 11 - Downstream RF Channel Configuration Use Case

5.5.2.3 MAC Domain-Level Configuration

The following is an example Use Case for configuration of attributes for a MAC Domain on the I-CCAP chassis modeled by the MAC Manager. As Figure 12 shows, this Use Case includes configuration of MAC Domain attributes such as MDD Interval. Example CLI commands for such provisioning operations are also included.

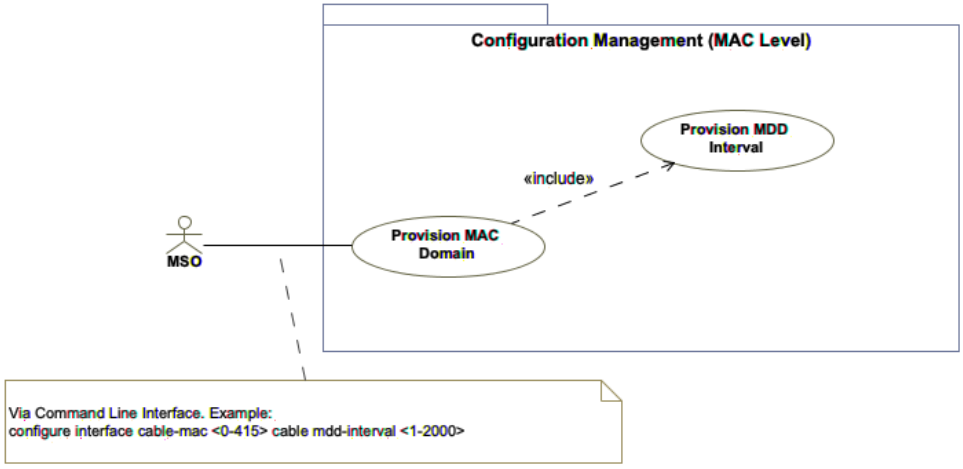


Figure 12 - MAC Domain-Level Configuration Use Case

5.5.3 Performance Management Use Cases

The following represents a set of Performance Management Use Cases for the CCAP.

5.5.3.1 Monitoring Downstream Channel Performance

The following is an example Use Case which illustrates an MSO monitoring/querying the count of MAC-layer octets transmitted by the MAC Manager using the profile specified for a downstream OFDM channel via the Northbound OSSI interface using SNMP. An example SNMP GET operation is included which represents querying a specific channel profile, identified by OFDM channel index and profile id, for the count of out octets.

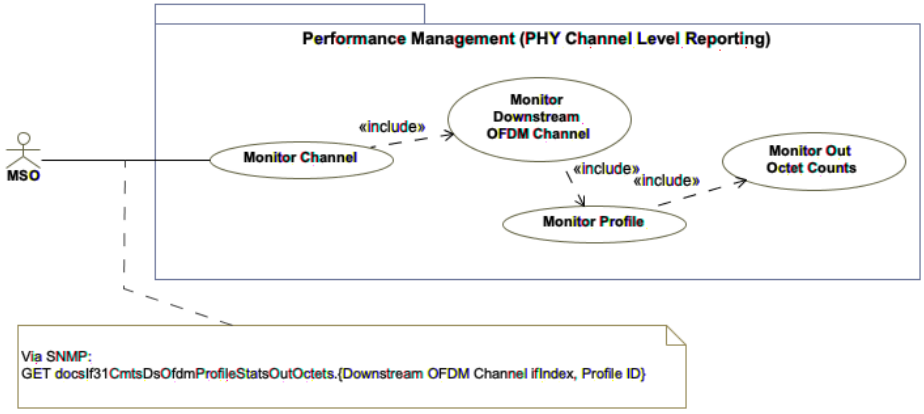


Figure 13 - Downstream Channel Performance Monitoring Use Case

5.5.3.2 Monitoring Downstream Channel Status

The following is an example Use Case illustrating an MSO monitoring/querying the channel utilization for a downstream OFDM channel via the Northbound OSSI interface using SNMP. An example SNMP GET operation is included which represents querying a specific OFDM channel index for the utilization on that interface.

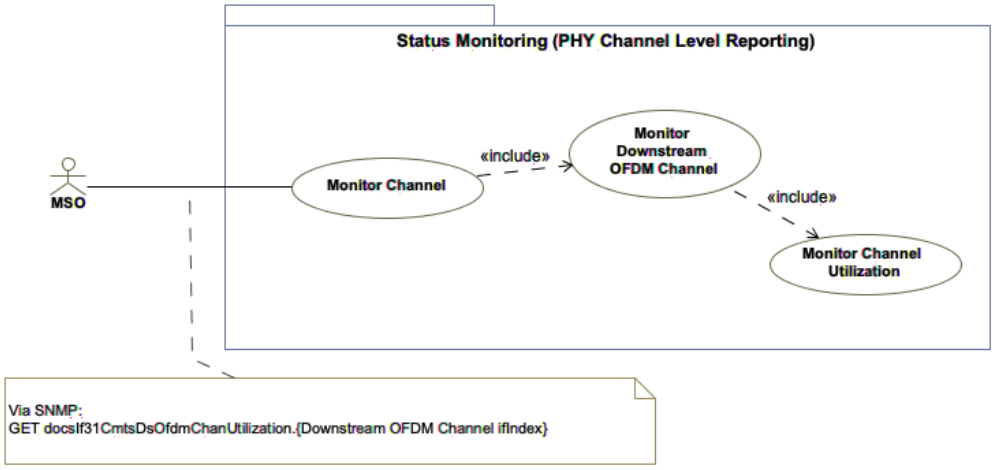


Figure 14 - Downstream Channel Status Monitoring Use Case

5.5.3.3 Downstream Proactive Network Maintenance

The following is an example set of Use Cases which illustrates an MSO/PNM Server monitoring/querying/triggering downstream PNM measurements and statistics via the Northbound OSSI interface using SNMP and TFTP.

MSOs have the ability to:

- Provide partial functionality of a network analyzer to analyze the response of the cable plant via Downstream OFDM Symbol Capture. Capturing the input and output of the cable plant is equivalent to a wideband sweep of the channel, which permits full characterization of the linear and nonlinear response of the downstream plant.
- View the noise, interference and intermodulation products underlying a portion of an OFDM signal with the Downstream Noise Power Ratio measurement.
- Perform Downstream OFDM Profile Tests and retrieve per-subcarrier MER values, codeword statistics, and NCP Field and CRC failure counts from a CM.

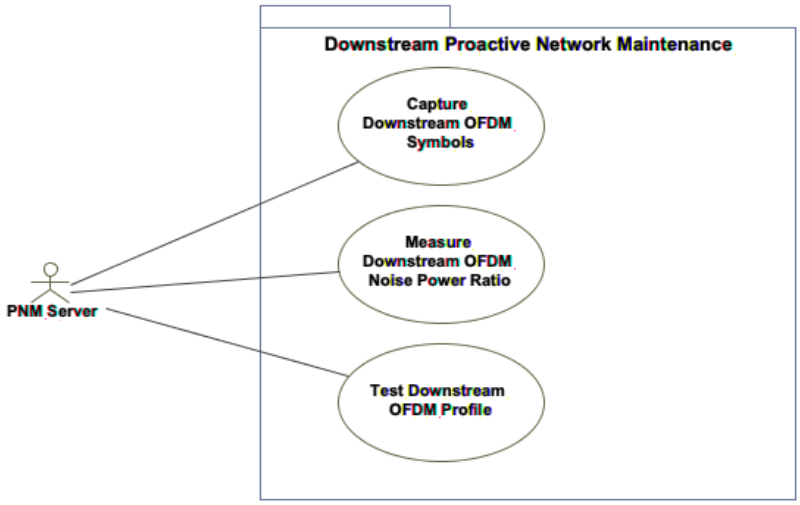


Figure 15 - Downstream Proactive Network Maintenance Use Cases

5.5.3.4 Upstream Proactive Network Maintenance

The following is an example set of Use Cases which illustrates an MSO/PNM Server monitoring/querying/triggering upstream PNM measurements and statistics via the Northbound OSSI interface using SNMP and TFTP.

MSOs have the ability to:

- Measure plant response and view the underlying noise floor by capturing at least one OFDM symbol during a scheduled active or quiet probe with Upstream Capture for Active and Quiet Probe. An active probe provides the partial functionality of a network analyzer since the input is known and the output is captured. This permits full characterization of the linear and nonlinear response of the upstream cable plant. A quiet probe provides an opportunity to view the underlying noise and ingress while no traffic is being transmitted in the OFDMA band being measured.
- Provide a wideband spectrum analyzer function with Capture Upstream Spectrum which can be triggered to examine desired upstream transmissions as well as underlying noise and interference during a quiet period.
- Gather statistics of burst/impulse noise occurring in a selected narrow band with Upstream Impulse Noise Statistics.
- Retrieve Upstream FEC Statistics to monitor upstream link quality via FEC and related statistics taken on codeword error events.
- Gather a measurement of nonlinear effects in the channel such as amplifier compression with Upstream Histogram.
- Estimate the total received power in a specified OFDMA channel at the F connector input of the CCAP, or other agreed measurement point, for a given user with Upstream OFDMA Rx Power. The measurement is based on upstream probes, which are typically the same probes used for pre-equalization adjustment.
- Retrieve measurements of the Upstream Receive Modulation Error Ration (RxMER) for each subcarrier of an OFDMA channel.

Figure 16 - Upstream Proactive Network Maintenance Use Cases

5.5.3.5 Common Proactive Network Maintenance

The following is an example set of Use Cases which illustrates an MSO/PNM Server performing common PNM testing functions via the Northbound OSSI interface using SNMP and TFTP.

MSOs have the ability to:

- Provide PNM test configuration prior to triggering a test to run on the CCAP.
- Trigger or start a PNM test to run on the CCAP. Note that this could be performed during the configuration step in a one-shot action.
- Monitor a PNM test while it is running to determine the test status.
- Stop a free run PNM test that is current running on the CCAP.
- Query test results from a completed PNM test, or test which provides run-time measurements.
- Receive measurement results when a PNM capture tests has completed execution. This can include:

- Receiving a PNM results capture file via a file transfer mechanism such as TFTP. This method uses a CCAP Bulk Data File transfer.
- Receiving PNM measurement captures real-time via a MDT Subscription Interface.

- Retrieving real-time PNM-related measurements which may or may not include triggering a test to perform such measurements.

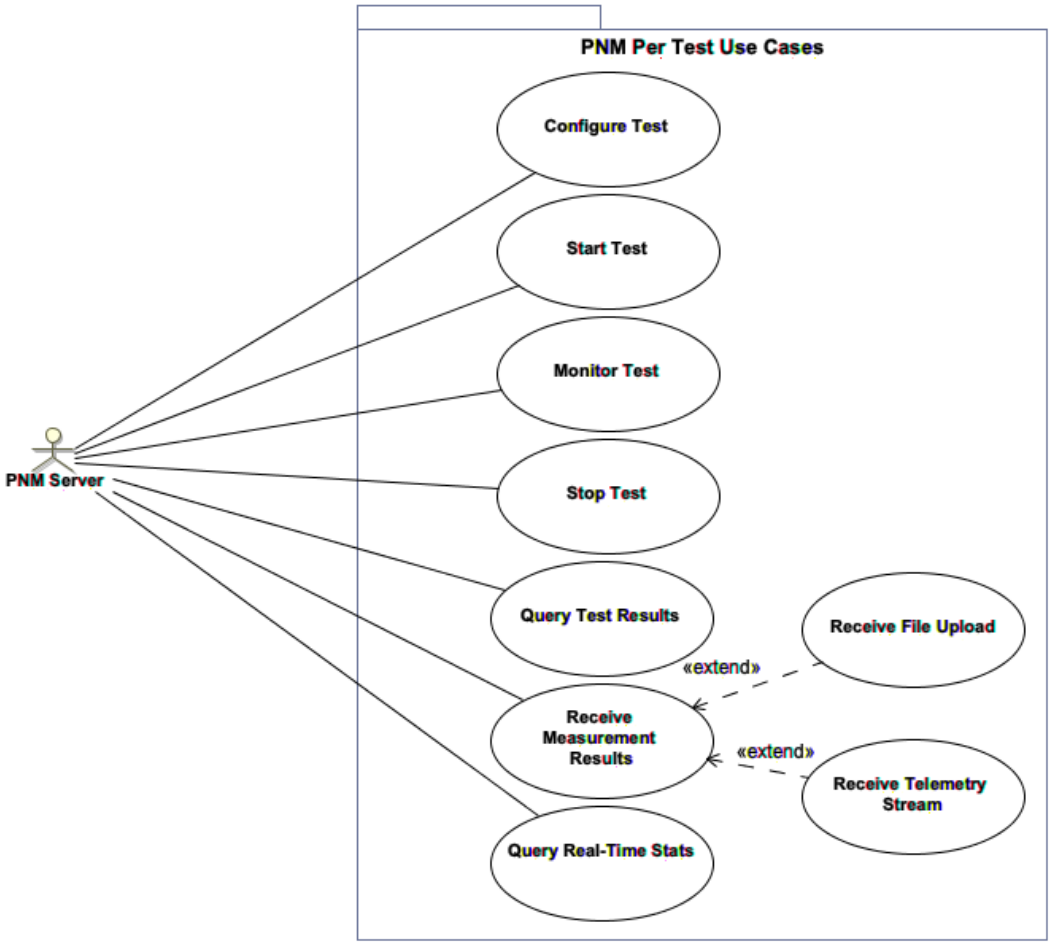


Figure 17 - Common Proactive Network Maintenance Test Use Cases

5.5.3.6 Streaming Telemetry

The following is an example set of Use Cases which illustrates a Telemetry Client (a Network Support Services layer application) performing Streaming Telemetry functions via the Northbound OSSI interface using Streaming Telemetry interface. There are also Use Cases which illustrate a provisioning and/or monitoring application (also, a Network Support Services layer application) configuring and monitoring the Streaming Telemetry interface using existing OSSI management interfaces.

Provisioning and Monitoring Applications have the ability to:

- Configure Telemetry Server parameters on the CCAP, such as Telemetry Client access lists.
- Collect metrics related to the Streaming Telemetry interface operation and status, such as Telemetry Client connection status.

- Receive alarms or events relating to the CCAP Streaming Telemetry interface, such as Telemetry Client connection failures.

Telemetry Clients have the ability to:

- Subscribe to Telemetry data within the device (e.g., CCAP) data model hierarchy of performance management statistics, status or state information.
- Once subscribed, receive Telemetry data over the CCAP Streaming Telemetry interface.
- Upon receiving Telemetry data over the Streaming Telemetry interface, cancel the subscription to suspend further data from being sent by the CCAP.

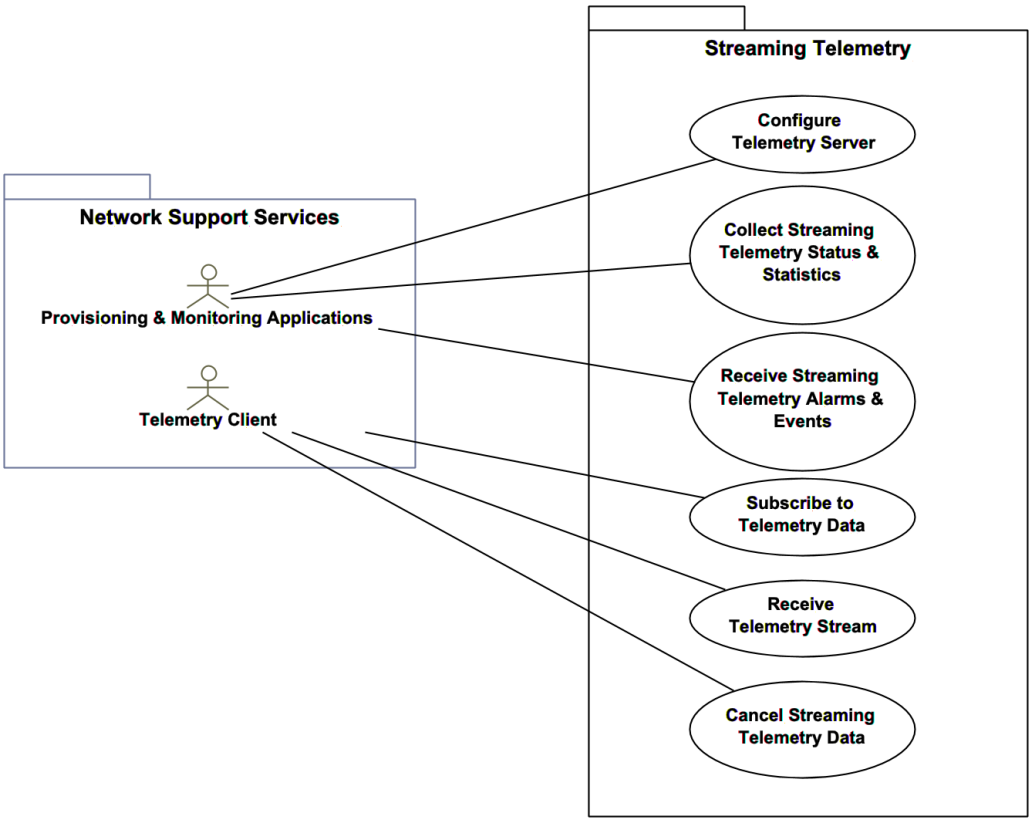


Figure 18 - Streaming Telemetry Use Cases

5.5.4 Security Management Use Cases

Security management provides support to configure security functions of the CCAP and implements key functions at the CCAP to execute security management of CMs. This includes the implementation of SSH, secure configuration, and certificate management.

5.5.4.1 Secure Shell

Operators require secure remote access to CCAPs for activities such as maintenance and troubleshooting. The CCAP provides a Secure Shell (SSH) server that allows secure remote access including for vendor-specific command line interface.

MSOs have the ability to:

- Remotely and securely access CCAPs for CLI operations.

- Remotely and securely execute automated management, for example using NETCONF.
- Add, change, or update files on CCAPs.

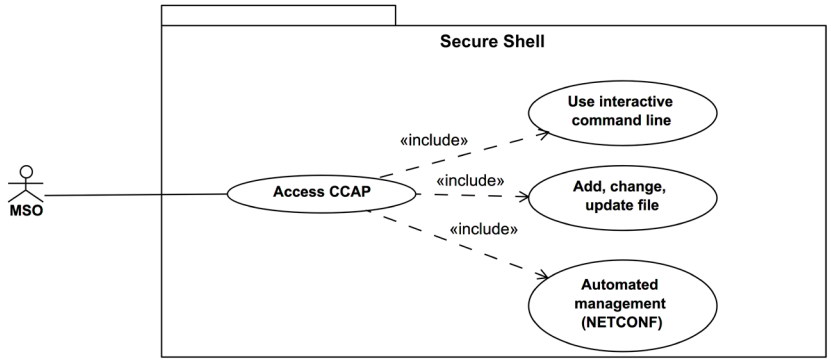


Figure 19 - Secure Shell Use Cases

5.5.4.2 Secure Controls and Tools Management

The CCAP is required to provide several provisioning and monitoring capabilities securely. This includes providing appropriate configuration files, setting key security settings, and implementing and configuring secure channels.

MSOs have the ability to:

- Configure TLS parameters.
- Configure SSH parameters.
- Configure and utilize a secure channel to configure additional security settings for Source Address Verification, Early Authentication and Encryption and BPI+.

This specification only provides details necessary for configuration and control of these Security features.

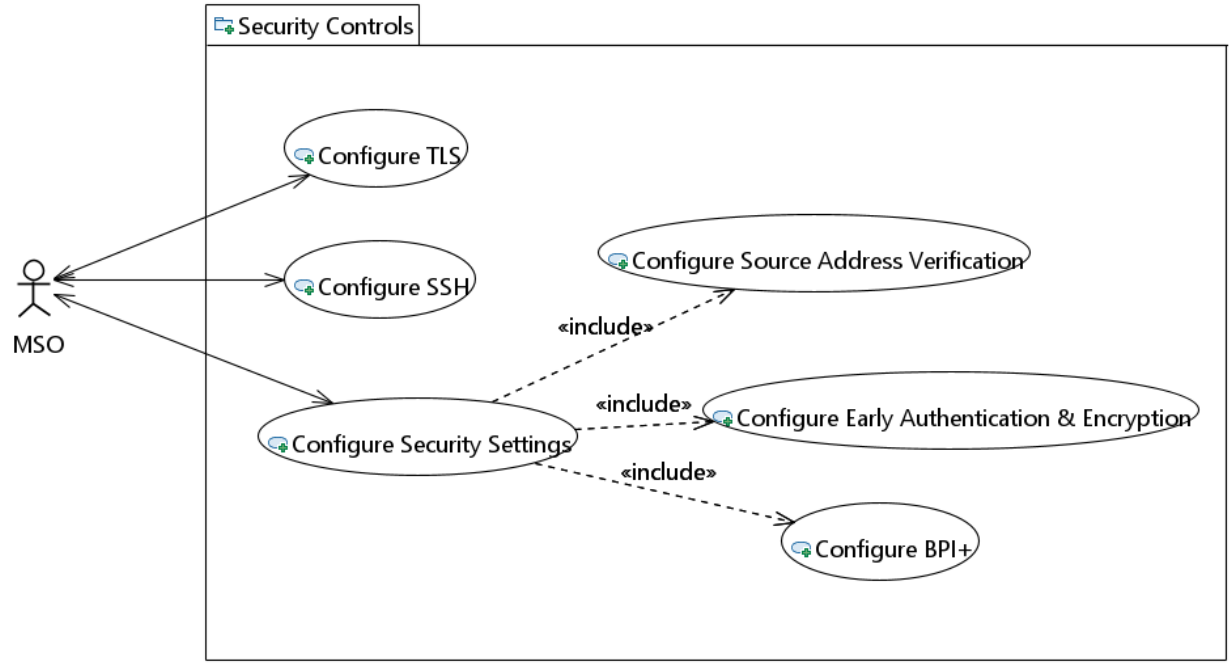


Figure 20 - Security Controls Use Cases

5.5.4.3 Certificate Management

CCAP uses X.509 certificates for device authentication between the CMs and back-office server, as well as between the CMs and the CCAP. The X.509 certificates are also used to validate secure software download images as specified in [SECv4.0] and this specification. The CCAP provides the requisite messaging and server support to ensure CMs are able to validate certificates and determine revocation status.

MSOs have the ability to:

- Manage certificates on CMs and the CCAP.
- Manage the trust stores used for validated certificates on CMs and the CCAP.
- Configure and execute certificate validation on CMs and the CCAP.
- Assign the certificates revocation method used by CMs as either Certificate Revocation List (CRL), Online Certificate Status Protocol (OCSP), both, or neither.
- Maintain and distribute a certificate revocation list for CM devices if Certificate Revocation List (CRL) is used.
- Ensure connectivity to an OCSP responder if OCSP is used.

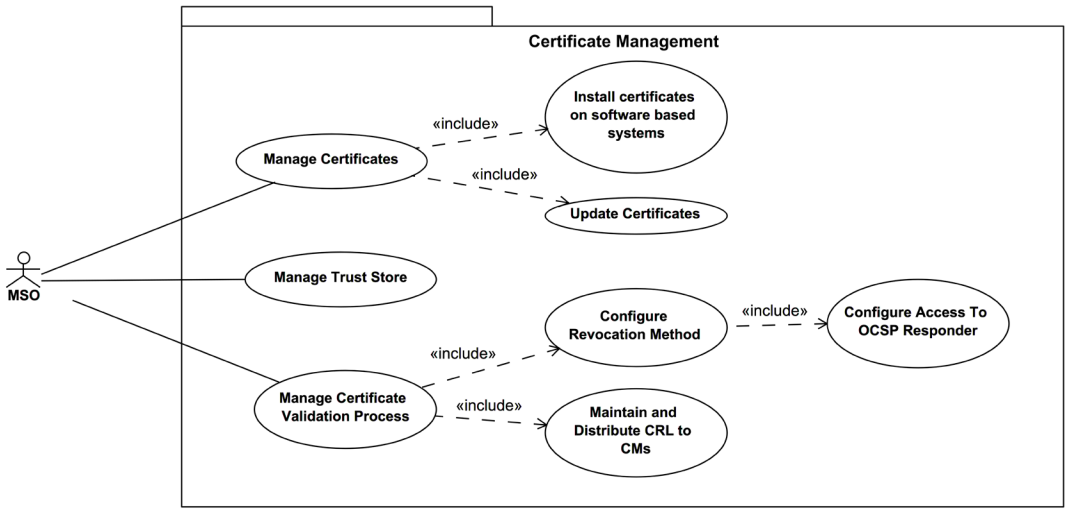


Figure 21 - Certificate Management Use Cases

6 CONFIGURATION MANAGEMENT

DOCSIS 3.0 technology introduced a new methodology and approach for configuration management in the CCAP by moving away from using the SNMP interface to using the NETCONF protocol as described in this section.

In addition to the NETCONF approach to modify the attribute values stored in the CCAP, vendor-specific methods such as a Command Line Interface (CLI) or an HTTP interface could be present. Irrespective of the method used, it is necessary to assure the data integrity as a result of changes performed using different interfaces. For example, when the attribute value is modified using one management interface, this changed value is reported when that attribute is accessed from any of the other interfaces. When a change in the value of the attribute does not succeed, requesting the same change from another interface also results in failure (assuming the same level of access control for all those interfaces for the specific operation). If an event is generated as a result of making the change in one management interface, this is reported independent of how the change was initiated.

6.1 CCAP Configuration Theory of Operation

The CCAP combines the functionality of an EQAM with a CMTS. While these are distinct functions, the configuration of the CCAP will treat these functions in a consolidated way. To facilitate the configuration of such a complex and dense device, this specification describes a method for configuring the device via the NETCONF protocol:

Aspects of CCAP configuration include:

- Standard YANG data model for configuration, with vendor-specific extensions for the inclusion of proprietary features
- Ability to configure a full set of standardized and vendor-proprietary configuration elements
- Ability to configure a partial set of standardized and vendor-proprietary configuration elements
- NETCONF options to manage the CCAP configuration

It is anticipated that the CCAP will contain only basic default settings in its startup configuration when initially powered on, and the operator will begin configuration of the CCAP via serial console connection. Basic default settings are vendor-specific. The following sections define standardized CCAP configuration mechanisms and processes.

6.2 CCAP Configuration and Transport Protocol Requirements

6.2.1 Configuration Object Datastore

The CCAP implements the standard configuration objects defined by this specification.

These configuration objects control CCAP behavior and, along with any vendor-proprietary configurations, are referred to as the "running-config".

The CCAP MUST provide a method for saving the state of the running-config to non-volatile memory. For NETCONF-based configuration, the NETCONF "copy-config" operation protocol provides this mechanism.

The configuration objects stored in non-volatile memory are referred to as the "startup-config".

6.2.2 DHCP Relay Agent Requirements

The CCAP MUST support the configuration of the relay function of the Dynamic Host Configuration Protocol, as specified in [MULPIv4.0].

The CCAP MUST support the ability to be configured with multiple concurrent DHCPv6 server addresses for routing mode operation.

The CCAP MUST support configuration of at least four distinct DHCP helper addresses, so that devices such as CMs, MTAs, and CPE can be directed to separate DHCP servers by a CCAP operating in non-routing mode.

The CCAP MUST support the configuration of relay agent and VIVSO options. This does not imply that all DOCSIS features of the CCAP need to be governed by this setting.

The CCAP MUST support the CableLabs DHCPv6 VIVSO option for CM MAC address in RELAY-FORW. This is the equivalent of DHCPv4 option 82 remote-id for both CM and CPE.

The CCAP MUST support the ability to configure the throttling rate of DHCP renews (unicast) to abate flooding of the DHCP server for routing mode operation.

6.2.3 Dynamic Management of QAMs

When the CCAP configuration based on the YANG model contains updates to the QAM channel parameter configuration, the CCAP can send an ERMI-1 UPDATE message with a Service Status indicating "maintenance mode" for the particular QAM channel(s) affected. Once there are no active dynamic sessions and no traffic on the static UDP ports for each QAM channel, the channel is taken down, updates made, and then brought up and advertised with a new UPDATE.

For details, refer to the EQAM Dynamic Provisioning section of [PMI].

There can be a minimum number of preconfigured QAMs for DOCSIS and an additional set of channels that are demand based. When demand is low, those additional channels are available for other services. Conversely, when demand is high, more of these resources are assigned to DOCSIS, up to a configurable limit.

6.2.3.1 Dynamic Assignment of SDV/VOD QAMs

The ERM will control QAMs for SDV and VOD.

6.2.4 Video Configuration Requirements

The CCAP MUST enable adjustability of the size of the de-jitter buffer.

6.2.5 DOCSIS Configuration Requirements

The CCAP MUST support the configuration of blocked bandwidth limits.

The CCAP MUST support the ability to configure Concatenation (configurable on/off for each MAC domain, for pre-DOCSIS 3.0 modems, MAC wildcard).

The CCAP MUST support the ability to configure Fragmentation (configurable on/off for each MAC domain, for pre-DOCSIS 3.0 modems, MAC wildcard).

The CCAP MUST support the ability to configure enabling/disabling IPv6 provisioning mode via the DOCSIS MDD message.

The CCAP MUST support the ability to configure steering a modem to a different CMTS or CCAP based on TLV 43.11 - Service Type Identifier per [MULPIv4.0].

6.2.6 File Transfer Mechanisms

The CCAP implements several file transfer mechanisms that can be used to "download" a software image or file from an external host to the CCAP or "upload" a copy of a software image or file to an external host.

The CCAP MUST support the Secure Copy Protocol (SCP) - based on Secure Shell version 2 - for both file download and upload operations.

The CCAP MUST support the initiation of Secure Copy download and upload operations from both a remote host and from the CCAP CLI.

The CCAP MUST support the Trivial File Transfer Protocol (TFTP), as specified in [RFC 1350], for both file download and upload operations.

Since TFTP has no inherent authentication mechanism, the CCAP MUST only support the initiation of Trivial File Transfer download and upload operations from the CCAP CLI by an authenticated and authorized user.

The CCAP SHOULD support Secure Hypertext Transfer Protocol (HTTPS) for both file download and upload operations.

The CCAP SHOULD implement support for HTTP1.1 [RFC 7231].

The CCAP SHOULD implement support for HTTP1.1 [RFC 7231] over TLS1.2 [RFC 5246]. This protocol combination is commonly referred to as HTTPS.

The CCAP MAY also support HTTP1.1 over TLS1.3 [RFC 8446].

Further TLS requirements (such as path verification) are specified in Section 6.2.6.1.

If the CCAP supports HTTPS, the CCAP MUST reject any HTTP request that is not secured with TLS. The following optional requirements can also be implemented at the vendor's discretion:

- The CCAP SHOULD provide code 301 Moved Permanently [RFC 2616] and Location header in its request response when the HTTPS server is on the same CCAP and TLS was not used to secure the HTTP request.
- The CCAP MAY provide a status code of 403 Forbidden [RFC 2616] in its request response when the HTTP request is not secured via TLS.

If the CCAP supports HTTPS, the CCAP MUST support HTTP over TLS on TCP Port 443.

The CCAP SHOULD support the initiation of HTTPS download and upload operations from both a remote host and from the CCAP CLI.

If HTTPS download initiation from a remote host is supported by the CCAP, the CCAP MUST implement TLS validation of the X.509 certificate presented by the remote host.

For both SCP and HTTPS file download and upload operations, the CCAP MUST support the ability to authenticate the file transfer connection via TACACS+ and RADIUS as well as usernames configured locally on the CCAP.

If an initiated file transfer fails, the CCAP MUST log an event with severity level "Error" (Event ID: 70000102) and provide an error message to the user interface indicating that the file transfer failed, regardless of the type of terminal session in use by the user.

6.2.6.1 TLS for HTTPS

Authentication of the remote host server by the CCAP is performed by validating the certificate provided by the remote host during TLS setup.

The CCAP MUST negotiate TLS-related integrity protection and encryption features at the TLS layer.

The remote host will always offer TLS cipher suites to be used for the session, as specified in [RFC 5246].

The CCAP MUST decide which TLS cipher suites are used, as specified in [RFC 5246].

The CCAP MUST verify that the data is sent and received according to [RFC 5246]. This verification is also used to detect if the received data has been tampered with.

The CCAP MUST support the list of TLS cipher suites specified in [SECv4.0].

The use of NULL integrity protection and/or NULL encryption by the CCAP is not anticipated.

The remote host will present X.509 digital certificates, per [RFC 5280], for authentication in TLS, as profiled in Table 6.

Table 6 - TLS Certificate Profile

TLS Server Certificates	
Subject Name Form	C=<Country> O=<Company> CN=<FQDN> FQDN is the remote host's fully qualified domain name (e.g., es.example.com). Only a single FQDN is allowed in the CN field. Additional fields may be present in the subject name.
Intended Usage	These certificates are used to authenticate TLS handshake exchanges (and encrypt when using RSA key exchange).
Validity Period	Set by operator policy
Modulus Length	1024, 1536, 2048
Extensions	KeyUsage[critical](digitalSignature, keyEncipherment) extendedKeyUsage (id-kp-serverAuth, id-kp-clientAuth) authorityKeyIdentifier (keyIdentifier=<subjectKeyIdentifier value from CA cert>)

Remote host certificates will be issued by the cable operator.

The CCAP MUST verify that the remote host's TLS certificates are part of a certificate chain that chains up to the cable operator's certificate authority (CA).

If changes other than the certificate serial number, validity period and the value of the signature exist in the root certificate that was sent by the remote host to the CCAP in comparison to the known root certificate, the CCAP MUST conclude that the certificate verification has failed.

The CCAP MUST build the certificate chain and validate the TLS certificate according to the "Certificate Path Validation" procedures described in [RFC 5280].

6.3 CCAP NETCONF-Based Configuration

6.3.1 NETCONF Theory of Operation

The CCAP has the option to support configuration via the NETCONF protocol. In this case configuration instructions are sent using XML-encoded remote procedure calls (RPCs) in NETCONF protocol messages from a configuration management tool to the CCAP. The XML configuration data, representing the CCAP configuration, is conformant to the YANG modules specified in this document.

The use case for configuring a CCAP via NETCONF is depicted in Figure 22.

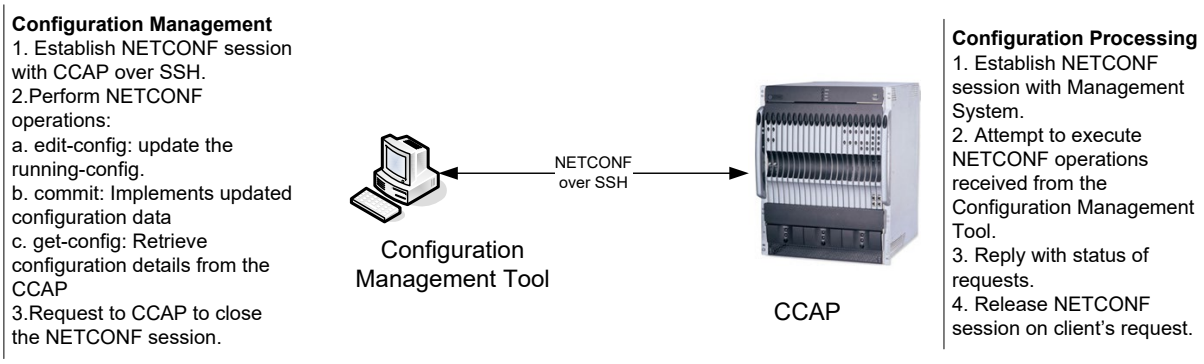


Figure 22 - CCAP NETCONF-Based Configuration Use Case

The YANG modules, based on the CCAP configuration information model, are implemented by the configuration management tool and the CCAP; these modules are used to generate valid configuration NETCONF operations and content from the management system and to validate and execute those operations and content on the CCAP.

When the configuration management tool begins the configuration process, an SSH session is set up between the configuration management tool and the CCAP being configured. The configuration management tool can then deliver full or partial CCAP configuration changes using NETCONF operations. The configuration content can be machine-generated or hand created; they are sent in the NETCONF RPC to the CCAP.

The CCAP receives, parses, and processes the configuration operations received via NETCONF from the configuration management tool. The CCAP can be fully or partially reconfigured; invalid configuration instructions can be ignored while valid instructions will still be processed. The CCAP can also reject configuration instructions if they cannot be met by the capabilities of the hardware present.

The CCAP can also respond to <get-config> operations from the configuration management tool and provide a full or partial XML-based representation of the current device configuration, delivered to the configuration management tool via NETCONF.

The CCAP NETCONF configuration process is discussed in the following sections.

6.3.2 NETCONF Overview

NETCONF [RFC 6241] is a configuration management protocol defined by the IETF. NETCONF provides mechanisms to install, manipulate, and delete the configuration of network devices.

NETCONF uses an XML-based data encoding for the configuration data as well as protocol messages. The protocol operations are realized on top of a simple Remote Procedure Call (RPC) layer. A client encodes an RPC in XML and sends it to a server using a secure, connection-oriented session. The server responds with a reply encoded in XML. The contents of both the request and the response are fully described using YANG ([RFC 6020]) allowing both parties to recognize the syntax constraints imposed on the exchange.

NETCONF is connection-oriented, requiring a persistent connection between peers. This connection is expected to provide reliable, sequenced data delivery. NETCONF connections are long-lived, persisting between protocol operations; the connection is also expected to provide authentication, data integrity, and confidentiality.

There are currently several transport mappings published, including SSHv2 [RFC 4742], SOAP [RFC 4743], BEEP [RFC 4744], and TLS [RFC 5539]. The SSH transport protocol mapping is mandatory to implement and the others are optional.

In addition to the XML file based configuration of the CCAP, it is expected that some vendors will provide a NETCONF option for configuring and managing a CCAP using the YANG module specified in [CCAP-CONFIG-YANG]. These modules are based on the CCAP configuration information model specified in Section 6.4.

6.3.3 NETCONF Requirements

The CCAP SHOULD implement NETCONF Server, as specified in [RFC 6241].

If the CCAP implements NETCONF Server, the base NETCONF capability identified by the urn:ietf:params:netconf:base:1.0 URN MUST be implemented; all remaining capabilities described in the RFC are optional.

Any NETCONF Server implemented in the CCAP MUST comply with the mandatory SSHv2 transport mapping specified in [RFC 4742].

If the CCAP supports NETCONF-based configuration, the CCAP MUST support the "merge", "replace", and "delete" operations defined in section 7.2 of [RFC 6241]. This specification does not intend to make use of the "create" operation.

If the CCAP supports NETCONF-based configuration, the CCAP MUST support the ccap.yang module defined in [CCAP-CONFIG-YANG].

This specification makes use of the unified modeling language (UML) to define the common configuration elements of a CCAP. YANG modules are based on the CCAP configuration UML information model.

If the CCAP supports NETCONF-based configuration, the CCAP SHOULD support the with-defaults Capability for NETCONF according to the 'report-all' basic mode, as defined in [RFC 6243]. A server that uses the 'report-all' basic mode does not consider any data node to be default data, even schema default data. If the CCAP supports NETCONF-based configuration, when a client retrieves data with a <with-defaults> parameter equal to 'report-all', the CCAP MUST report all data nodes, including any data nodes considered to be default data by the server.

If the CCAP supports NETCONF, the CCAP MUST support NETCONF operations which includes configuration elements that are related to hardware that is not installed in the CCAP chassis at the time of processing to allow for pre-provisioning. The CCAP MUST allow the pre-provisioning of configuration objects associated with line cards that are not yet present in the chassis.

6.4 CCAP Data Type Definitions

The following data types have been created to support the CCAP Information Models. See Annex F for the primitive and derived data types used in this model.

Table 7 - Data Types

Data Type Name	Base Type	Type Constraints	Reference	YANG Data Type
AdminStateType	Enum	other(1), up(2), down(3), testing(4)	[RFC 2863]	admin-state-type
AttrAggrRuleMask	HexBinary	SIZE (4)		
AttributeMask	EnumBits	bonded(0), lowLatency(1), highAvailability(2)		attribute-mask-type
BitRate	UnsignedInt	0..4294967295		
ChannelList	HexBinary	SIZE (0..255)		
ChChgInitTechMap	EnumBits	reinitializeMac(0), broadcastInitRanging(1), unicastInitRanging(2), initRanging(3), direct(4)		
ChId	UnsignedByte	0..255		
ChSetId	UnsignedInt	0..4294967295		
CmtsCmRegState	Enum	other(1) initialRanging(2) rangingAutoAdjComplete (4) startEae (10) startDhcpV4 (11) startDhcpV6(12) dhcpV4Complete(5) dhcpV6Complete(13) startConfigFileDownload(14) configFileDownloadComplete(15) startRegistration(16) registrationComplete(6) operational (8) bpiInit (9) forwardingDisabled(17) rfMuteAll(18)		

Data Type Name	Base Type	Type Constraints	Reference	YANG Data Type
CpeInterfaceMaskType	EnumBits	eCm(0) cmci(1) docsCableMacLayer(2) docsCableDownstream(3) docsCableUpstream(4) eMta(16) eStbIp(17) eStbDsg(18)	[MULPIv4.0]	
DataRateUnitType	Enum	bps(0), kbps(1), mbps(2), gbps(3)		
DocsSAid	UnsignedShort	1..16383	[RFC 4131]	
DocsSAIdOrZero	UnsignedShort	0 | 1..16383	[RFC 4131]	
Dsid	UnsignedInt	0..1048575		
DsOfdmCyclicPrefixType	UnsignedShort	(192 | 256 | 512 | 768 | 1024)		
DsOfdmModulationType	Enum	other(1) zeroBitLoaded(2) qpsk(3) qam16(4) qam64(5) qam128(6) qam256(7) qam512(8) qam1024(9) qam2048(10) qam4096(11) qam8192 (12) qam16384 (13)		
DsOfdmSubcarrierSpacingType	UnsignedByte	(25 | 50)		
DsOfdmWindowingType	UnsignedShort	(0 | 64 | 128 | 192 | 256)		
HePidValue	UnsignedShort	(0..8191 | 65535)	[SCTE 154-5]	
HundredthdB	Int			
ifDirection	Enum	downstream(1) upstream(2)		
IPHostPrefix	Union of IPv4HostPrefix and Ipv6HostPrefix			ip-host-prefix
Ipv4HostPrefix				ipv4-host-prefix
Ipv6HostPrefix			[RFC 4291]	ipv6-host-prefix
NodeName	String	SIZE(0..64)	[RFC 3411]	
OptOpCodeType	Enum	other(1) start(2) abort(3) fdxTriggeredStart(4)	[MULPIv4.0]	
PartialChannelType	EnumBits	fecErrorsDsProfile(0) fecErrorsNcpProfile(1) fecErrorsPlc(2)	[MULPIv4.0]	
PartialChanReasonType	Enum	none(0) dsOfdmProfileFailure(16) dpdMismatch(18) ncpProfileFailure(20) plcFailure(21)		

Data Type Name	Base Type	Type Constraints	Reference	YANG Data Type
PartialServiceType	Enum	other(1) none(2) partialSvcDsOnlyImpaired(3) partialSvcUsOnlyImpaired(4) partialSvcDsAndUsImpaired(5)	[MULPIv4.0]	
PartialSvcReasonType	Enum	none(0) secondaryChanMddTimeout(1), lostFecLock(2) iuc13CwErrors(3) other(4)	[MULPIv4.0]	
PrimaryDsIndicatorType	Enum	other(1) primaryDsChannel(2) backupPrimaryDs(3) notSpecified(4)	[MULPIv4.0]	
QuarterdB	UnsignedByte			
RbaSubbandDirSetType	HexBinary	SIZE (1..3)		
RcpId	HexBinary	SIZE (5)	[MULPIv4.0]	
SchedulingType	Enum	undefined(1) bestEffort(2) nonRealTimePollingService(3) realTimePollingService(4) unsolicitedGrantServiceWithAD(5) unsolicitedGrantService(6) proactiveGrantService(7)	[MULPIv4.0]	
SubcarrierSpacingType	UnsignedByte	(25 | 50)	[PHYv4.0]	
TenthdB	Short		[RFC 4546]	
ThousandthdB	Int			
TriggerFlag	EnumBits	registration(0) rangingRetry(1)		trigger-flag-type
UpDownTrapEnable	Boolean		[RFC 2863]	up-down-trap-enable
UsOfdmaCyclicPrefixType	Unsigned Short	(96 | 128 | 160 | 192 | 224 | 256 | 288 | 320 | 384 | 512 | 640)		
UsOfdmaModulationType	Enum	other(1) zeroValued(2) reserved(3) qpsk(4) qam8(5) qam16(6) qam32(7) qam64(8) qam128(9) qam256(10) qam512(11) qam1024(12) qam2048(13) qam4096(14)		
UsOfdmaWindowingSizeType	UnsignedByte	(0 | 32 | 64 | 96 | 128 | 160 | 192 | 224)		

6.4.1 AdminStateType

This data type defines the Admin state. The value of other(1) is used when a vendor extension has been implemented for this attribute.

Reference: [RFC 2863]

6.4.2 AttrAggrRuleMask

This data type represents a sequence of 32-bit positions that defines logical (e.g., AND, OR) operations to match against the channel list Provisioned Mask and Service Flow Required Mask bit positions when the CMTS is determining the service flow for assignment to a bonding group not configured by the management system.

Reference: Service Flow Assignment section.

6.4.3 AttributeMask

This data type consists of a sequence of 32-bit positions used to select the bonding group or the channel to which a service flow is assigned. DOCSIS defines three types of Attribute Masks for which this type applies: the Provisioned Attribute Mask that is configured to a Bonding Group or a single-channel, whereas the Required Attribute and the Forbidden Attribute Mask are part of the Service Flow QoS Parameter Set to be matched with the Provisioned Attribute Mask of CMTS-configured Bonding Groups or single-channels. DOCSIS reserves the assignment of the meaning of the first 16 bit positions (left to right) as follows:

Bit 0: bonded

Bit 1: lowLatency

Bit 2: highAvailability

Bit positions 3-15 are reserved.

Bit positions 16-31 are freely assigned by operators to represent their own constraints on the channel(s) selection for a particular service flow.

Reference: Service Flow Assignment section.

6.4.4 BitRate

This data type represents the rate of traffic. The units are specified by a multiplier attribute, DataRateUnitSetting, as bps, kbps, Mbps, or Gbps.

6.4.5 ChannelList

This data type represents a unique set of channel IDs in either the upstream or the downstream direction. Each octet represents an upstream channel identifier (UCID) or a downstream channel identifier (DCID), depending on the direction of the channels within the list. The CCAP MUST ensure that this combination of channels is unique per direction within the MAC Domain.

A query to retrieve the value of an attribute of this type returns the set of channels in the channel list in ascending order of channel IDs.

6.4.6 ChChgInitTechMap

This data type enumerates the allowed initialization techniques for Dynamic Channel Change (DCC) and Dynamic Bonding Change (DBC) operations. The techniques are represented by the 5 most significant bits (MSB). Bits 0 through 4 map to initialization techniques 0 through 4.

Each bit position represents the internal associated technique as described below:

- 'reinitializeMac'
  Reinitialize the MAC

- 'broadcastInitRanging'
  Perform Broadcast initial ranging on new channel before normal operation
- 'unicastInitRanging'
  Perform unicast ranging on new channel before normal operation
- 'initRanging'
  Perform either broadcast or unicast ranging on new channel before normal operation
- 'direct'
  Use the new channel(s) directly without re-initializing or ranging

Multiple bits may be set to 1 to allow the CMTS to select the most suitable technique in a proprietary manner.

An empty value or a value with all bits in '0' means no channel changes allowed

References: Initialization Technique.

6.4.7 ChId

This data type is an 8-bit number that represents a provisioned DCID or a provisioned UCID. A channel ID is unique per direction within a MAC Domain. The value zero is reserved for use when the channel ID is unknown.

References: [MULPIv4.0] Upstream Channel Descriptor (UCD) section.

6.4.8 ChSetId

This data type is a CMTS-derived unique number within a MAC Domain used to reference a Channel Set within the CMTS. Values in the range of 1 to 255 define a single-channel Channel Set and correspond to either the DCID or an UCID of that channel. Values greater than 255 indicate a Channel Set consisting of two or more channels in the same direction within the MAC Domain.

References: [MULPIv4.0] Channel Bonding section.

6.4.9 CmtsCmRegState

This data type defines the CM connectivity states as reported by the CMTS.

References: [MULPIv4.0] Cable Modem - CMTS Interaction section.

The enumerated values associated with the CmtsCmRegState are:

- other

  'other' indicates any state not described below.
- initialRanging

  'initialRanging' indicates that the CMTS has received an Initial Ranging Request message from the CM, and the ranging process is not yet complete.
- rangingAutoAdjComplete

  'rangingAutoAdjComplete' indicates that the CM has completed initial ranging and the CMTS sends a Ranging Status of success in the RNG-RSP.
- startEae

  'startEae' indicates that the CMTS has received an Auth Info message for EAE from the CM.
- startDhcpV4

  'startDhcpV4' indicates that the CMTS has received a DHCPv4 DISCOVER message from the CM.
- startDhcpV6

  'startDhcpV6' indicates that the CMTS has received a DHCPv6 Solicit message from the CM.

- dhcpV4Complete

  'dhcpV4Complete' indicates that the CMTS has sent a DHCPv4 ACK message to the CM.

- dhcpV6Complete

  'dhcpV6Complete' indicates that the CMTS has sent a DHCPv6 Reply message to the CM.

- startConfigFileDownload

  'startConfigFileDownload' indicates that the CM has started the config file download. If the TFTP Proxy feature is not enabled, the CMTS may not report this state.

- configFileDownloadComplete

  'configFileDownloadComplete' indicates that the CM has completed the config file download process. If the TFTP Proxy feature is not enabled, the CMTS is not required to report this state.

- startRegistration

  'startRegistration' indicates that the CMTS has received a Registration Request (REG-REQ or REG-REQ-MP) from the CM.

- registrationComplete

  'registrationComplete' indicates that the CMTS has received a Registration Acknowledge (REG-ACK) with a confirmation code of okay/success.

- operational

  'operational' indicates that the CM has completed all necessary initialization steps and is operational.

- bpiInit

  'bpiInit' indicates that the CMTS has received an Auth Info or Auth Request message as part of BPI Initialization.

- forwardingDisabled

  'forwardingDisabled' indicates that the CM registration process was completed, but the network access option in the received configuration file prohibits the CM from forwarding.

- rfMuteAll

  'rfMuteAll' indicates that the CM is instructed to mute all channels in the CM-CTRL-REQ message from CMTS.

6.4.10 CpeInterfaceMaskType

This data type indicates a set of CM MAC bridge interfaces, encoded as an EnumBits syntax with a bit set to '1' for each interface included in the set.

Bit position eCm(0) represents a conceptual interface to the internal 'self' host MAC of the eCM itself. All other bit positions K correspond to CM MAC bridge port interface index with ifIndex value K.

In a CM, ifIndex value 1 corresponds to the primary CPE interface. In CableHome devices, this interface is assigned to the embedded Portal Services (ePS) host interface, which provides a portal to the primary physical CPE interface.

In many contexts of a CpeInterfaceMaskType, a '1' in bit position 1 corresponds to 'any' or 'all' CPE interfaces when the CM contains more than one CPE interface.

The ifIndex value 2 corresponds to the docsCableMacLayer RF MAC interface.

The ifIndex values 3 and 4 correspond to the docsCableDownstream and docsCableUpstream interfaces, respectively, which are not separate MAC bridge port interfaces. Bit positions 3 and 4 are unused in this type; they are required to be saved and reported as configured, but otherwise ignored.

The ifIndex values 5 through 15 are reserved for individual CPE interfaces for devices that implement more than one CPE interface. In such devices, CpeInterfaceMaskType bit position 1 corresponds to the set of all CPE interfaces.

A CM with more than one CPE interface MAY assign a CpeInterfaceMaskType bit position within the range of 5..15 to refer to the single primary CPE interface.

The ifIndex value 16 is assigned to any embedded Multimedia Terminal Adapter (eMTA) as defined by PacketCable.

The ifIndex value 17 is assigned to the IP management host interface of an embedded Set Top Box (eSTB).

The ifIndex value 18 is reserved for the DOCSIS Set-top Gateway (DSG) traffic delivered to an eSTB.

The ifIndex values 19 through 31 are reserved for future defined embedded Service Application.

References: [MULPIv4.0] CM Interface Mask (CMIM) Encoding section in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.4.11 DataRateUnitType

This data type specifies the base unit for traffic rate parameters. The value of this data type allows for their interpretation in units of bps, kbps, Mbps, or Gbps. The enumeration starts from 0 to match corresponding DOCSIS protocol TLV values.

6.4.12 DocsSAid

This data type defines the DOCSIS Security Association identifier (SAID).

6.4.13 DocsSAidOrZero

This data type defines the DOCSIS Security Association identifier (SAID). The value zero indicates that the SAID is yet to be determined.

6.4.14 Dsid

This data type defines the 20-bit Downstream Service Identifier used by the CM for downstream resequencing, filtering, and forwarding. The value zero is reserved for use when the DSID is unknown or does not apply.

Reference: [MULPIv4.0] DSID Definition section.

6.4.15 DsOfdmCyclicPrefixType

This data type is defined to specify the five possible values for the number of samples in a downstream cyclic prefix (N_{cp}). The cyclic prefix (in µs) is converted into samples using the sample rate of 204.8 Msamples/s and is an integer multiple of: 1/64 * 20 µs.

Reference: [PHYv4.0] Table 7-34 - Cyclic Prefix (CP) Values

6.4.16 DsOfdmModulationType

This data type is defined to specify the modulation types supported by the CCAP modulator. The value of zeroBitLoaded means that the subcarrier is BPSK modulated.

Reference: [PHYv4.0] Modulation Formats section

6.4.17 DsOfdmSubcarrierSpacingType

This data type defines the subcarrier spacing. In the downstream direction, if the spacing is 50 kHz, then the FFT length is 4K, and if the spacing is 25 kHz, then the FFT length is 8K.

Reference: [PHYv4.0] Table 7-1 - Downstream OFDM parameters

6.4.18 DsOfdmWindowingType

This data type is defined to specify the five possible values for the downstream windowing roll-off period samples. The Roll-Off Period Samples are given in number of samples per roll-off period (N_{RP}).

Reference: [PHYv4.0] Roll-off Period (RP) Values Table

6.4.19 HePidValue

This data type represents a packet identifier (PID) value which ranges from 0 to (2^{13} - 1). The value of 65535 indicates that either the PID is invalid or does not exist.

Reference: [SCTE 154-5]

6.4.20 HundredthdB

The HundredthdB data type represents power levels that are normally expressed in dB. Units are in hundredths of a dB. For example, 5.17 dB will be represented as 517 when the data type is HundredthdB.

6.4.21 ifDirection

Indicates a direction on an RF MAC interface. The value downstream(1) is from CCAP to CM. The value upstream(2) is from CM to CCAP.

Reference: [MULPIv4.0] Terms and Definitions section.

6.4.22 InetPortNum

The value in this data type represents the port number configured.

Reference: [RFC 4001]

6.4.23 IPHostPrefix

This data type represents an IP host address plus prefix and is IP version neutral. The format of the textual representations implies the IP version. This type is similar to inet:ip-prefix.

This data type is the union of the Ipv4HostPrefix data type and the Ipv6HostPrefix data type.

6.4.24 Ipv4HostPrefix

This data type represents an IPv4 host address plus the prefix length, separated by a slash. The prefix length is given by a number less than or equal to 32 following the slash character. A prefix length value of n corresponds to an IP address mask that has n contiguous 1-bits from the most significant bit (MSB) and all other bits set to 0.

This type is derived from the inet:ipv4-prefix type, which has all bits of the IPv4 address set to zero that are not part of the IPv4 prefix. Use of that type requires separate configuration of the interface host address.

The pattern for this looks like: (([0-9]|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])/(([0-9])|([1-2][0-9])|(3[0-2]))

6.4.25 Ipv6HostPrefix

This data type is derived from the inet:ipv6-prefix type, which has all bits of the IPv6 address set to zero that are not part of the IPv6 prefix. Use of that type requires separate configuration of the interface host address. The IPv6 address is represented in the compressed format described in [RFC 4291], section 2.2, item 2 with the following additional rules: the "::" substitution is applied to the longest sequence of all-zero 16-bit chunks in an IPv6 address. If there is a tie, the first sequence of all-zero 16-bit chunks is replaced by "::". Single, all-zero 16-bit chunks are not compressed. The canonical format using lowercase characters and leading zeros are not allowed.

Reference: [RFC 4291]

The pattern for this looks like this:

((:|[0-9a-fA-F]{0,4}):)([0-9a-fA-F]{0,4}:){0,5}' + '((([0-9a-fA-F]{0,4}:)?(:|[0-9a-fA-F]{0,4}))|' + '(((25[0-5]|2[0-4][0-9]|[01]?[0-9]?[0-9])\.){3}' + '(25[0-5]|2[0-4][0-9]|[01]?[0-9]?[0-9])))' + '(/(([0-9])|([0-9]{2})|(1[0-1][0-9])|(12[0-8])))';

pattern '(([^:]+:){6}(([^:]+:[^:]+)|(.*\..*)))|' + '((([^:]+:)*[^:]+)?::(([^:]+:)*[^:]+)?)' + '(/.+)';

6.4.26 NodeName

This data type is a human readable string that represents the name of a fiber node. Internationalization is supported by conforming to the SNMP textual convention SnmpAdminString. The US-ASCII control characters (0x00 - 0x1F), the DEL character (0x7F), and the double-quote mark (0x22) are prohibited within the syntax of this data type.

References: [RFC 3411]

6.4.27 OptOpCodeType

This data type enumerates each of the defined values for the OpCode field of the OFDM Profile Test Request (OPT-REQ) Message [MULPIv4.0]. Defined values are listed below:

other(1) – OPT-REQ OpCode type other than the following defined values

start(2) – request for the cable modem receiving the OPT-REQ message to initiate the OFDM Profile Test

abort(3) – request for the cable modem receiving the OPT-REQ message to abort a running OFDM Profile Test

fdxTriggeredStart(4) – request for the cable modem receiving the OPT-REQ message to initiate the OFDM Profile Test in compliance with [MULPIv4.0] *FDX Triggered RxMER Measurements* section

Reference: [MULPIv4.0] *OFDM Downstream Profile Test Request (OPT-REQ)* section

6.4.28 PartialChannelType

This data type enumerates each of the possible profiles or channel attributes which can contribute to an OFDM channel being considered a Partial Channel by the MAC layer. As more than one of these error conditions can exist at the same time this data type is based on EnumBits. The bits from low to high are:

Bit 0: fecErrorsDsProfile

Bit 1: fecErrorsNcpProfile

Bit 2: fecErrorsPlc

6.4.29 PartialChanReasonType

This data type enumerates the CM-STATUS events which a CM can utilize to report a Partial Channel situation.

none(0),

dsOfdmProfileFailure(16),

dpdMismatch(18),

ncpProfileFailure(20),

plcFailure(21),

6.4.30 PartialServiceType

This data type enumerates the type of channel issue which the MAC Layer indicates is causing the CM to be in DOCSIS 3.0 Partial Service mode. The possible values are as follows:

other(1)

none(2)

partialSvcDsOnlyImpaired(3)

partialSvcUsOnlyImpaired(4)

partialSvcDsAndUsImpaired(5)

6.4.31 PartialSvcReasonType

This data type enumerates the CM-STATUS events which a CM can utilize to report a Partial Service situation.

none(0) - used when the channel is not in partial service

secondaryChanMddTimeout(1) - receipt of a CM-STATUS event type 1 indicating secondary channel MDD timeout

lostFecLock(2) - receipt of a CM-STATUS event type 2 indicating QAM/FEC lock failure on a downstream channel

iuc13CwErrors(3) - codeword errors are over limit on IUC 13 of an OFDMA channel. The criteria for this decision are vendor-specific

other(4) - partial service is the result of a reason not described by the other defined enumerations

6.4.32 PrimaryDsIndicatorType

This data type enumerates the different type of Primary downstream channels. Possible values are:

- primaryDsChannel - when both the CM and CCAP are compliant with DOCSIS 4.0 specifications, this value indicates that the channel is the primary channel for the CM receiving this RCC. A DOCSIS 4.0-compliant CCAP MUST NOT use an RCC configuration having more than one primaryDsChannel. For DOCSIS 3.0-compliant devices, this value indicates that the channel is primary-capable; multiple such channels are allowed in this mode.
- backupPrimaryDs - when both the CM and CCAP are compliant with DOCSIS 4.0 specifications, this value indicates that the channel is a backup primary channel for the CM receiving this RCC. The priority-ordered list of backup primary channels sent to the CM is the same order as the backupPrimaryDs channels are configured in RxChCfg. For DOCSIS 3.0-compliant devices, this value indicates that the channel is primary-capable. DOCSIS 3.0 specifications do not support the backup primary channel feature.
- notSpecified - indicates that this channel has not been specified as a primary-capable channel.
- other - indicates a vendor-specific value.

References: [MULPIv4.0] Common TLV Encodings Annex, Receive Channel Primary Downstream Channel Indicator section, Encodings for Configuration and MAC-Layer Messaging.

6.4.33 QuarterdB

The QuarterdB data type represents power levels that are normally expressed in dB. Units are in quarters of a dB.

The base data type is an unsigned byte where every bit of value is a quarter dB (e.g., a QuarterdB value of 0x5F represents 23.75 dB). The range is 0 to 63.5 dB in 1/4 dB steps. The value 0xFF is used to indicate no measurement is available for a given subcarrier. Any value over 63.5 dB is reported as 63.5 dB. Any value below 0 dB is reported as 0 dB.

Some attributes with a data type of QuarterdB choose to use HundredthdB with a quarter-dB accuracy for easier readability.

6.4.34 RbaSubbandDirSetType

This data type represents the encoding for the RBA Sub-band Direction Set, which is the set of all active FDX sub-bands and the associated direction for those sub-bands. The length of the HexBinary value indicates the number of sub-bands. The direction of each sub-band in the RBA Sub-band Direction Set encoding is the same as in the RBA message: 0 is downstream, 1 is upstream. A value of 2 is undefined and not applicable to FDX CMs. The left-most byte represents sub-band id 0, which is at the lowest frequency.

The following explain the two example encodings.

001: RBA Sub-band Direction Set consisting of three sub-bands with sub-band 0 as downstream, sub-band 1 as downstream, and sub-band 2 as upstream.

10: RBA Sub-band Direction Set consisting of two sub-bands with sub-band 0 as upstream and sub-band 1 as downstream.

References: [MULPIv4.0] Resource Block Assignment (RBA) section

6.4.35 RcpId

This data type defines a 'Receive Channel Profile Identifier' (RCP-ID). An RCP-ID consists of a 5-octet length string where the first 3 bytes (from left to right) correspond to the Organizational Unique ID (OUI), followed by a two-byte vendor-maintained identifier to represent multiple versions or models of RCP-IDs.

References: [MULPIv4.0] RCP-ID section in the Encodings for Configuration and MAC-Layer Messaging Annex

6.4.36 SchedulingType

The scheduling service provided by a CMTS for an upstream Service Flow. This parameter is reported as 'undefined' for downstream QoS Parameter Sets.

Reference: [MULPIv4.0] Service Flow Scheduling Type section

6.4.37 SubcarrierSpacingType

This data type defines the frequency spacing in kilohertz between centers of adjacent subcarriers in an OFDM or OFDMA symbol.

6.4.38 TenthdB

This data type represents power levels that are normally expressed in dB. Units are in tenths of a dB; for example, 5.1 dB will be represented as 51.

Reference: [RFC 4546]

6.4.39 ThousandthdB

The ThousandthdB data type represents power levels that are normally expressed in dB. Units are in thousands of a dB. For example, 5.175 dB will be represented as 5175 when the data type is ThousandthdB.

6.4.40 TriggerFlag

This data type defines the union of Diagnostic Log trigger types. Bit 0 represents the registration trigger. Bit 1 represents the ranging retry trigger.

6.4.41 UpDownTrapEnabled

Indicates whether linkUp/linkDown traps should be generated for this interface. This is a Boolean type, where true means that the trap is enabled.

Reference: [RFC 2863], ifLinkUpDownTrapEnable

6.4.42 UsOfdmaCyclicPrefixType

This data type is defined to specify the eleven possible values for the number of samples in the upstream cyclic prefix (N_{cp}). The cyclic prefix (in µs) is converted into samples using the sample rate of 102.4 Msamples/s and is an integer multiple of: 1/64 * 20 µs.

Reference: [PHYv4.0] Table 9 - Cyclic Prefix (CP) Values

6.4.43 UsOfdmaModulationType

This data type is defined to specify the modulation order of a given OFDMA subcarrier.

Reference: [PHYv4.0] Modulation Formats section

6.4.44 UsOfdmaWindowingSizeType

This data type is defined to specify the eight possible values for the upstream windowing roll-off period samples. The Roll-Off Period Samples (N_{RP}) are given in number of samples using the sample rate of 102.4 Msamples/s.
Reference: [PHYv4.0] Table 10 - Roll-Off Period (RP) Values

6.5 Configuration Information Model

6.5.1 CCAP Configuration Information Model Overview

The CCAP UML configuration information model, as well as the data models based on that information model, have been divided into eight distinct groupings:

- CCAP: The Ccap object is the container of all CCAP configuration objects.
- Chassis: Consists of objects for configuring the hardware components of the CCAP.
- Video: Consists of those objects that are related to the EQAM functions of the CCAP, including ERM, encryption and decryption objects.
- DOCSIS: Consists of the DOCSIS configuration objects that are needed for configuring DOCSIS Mac Domains and services such as DSG.
- Network: Consists of objects related to configuring the core services for things like integrated servers, access lists, Syslog, HTTP, FTP, SSH, and other related network services.
- Interfaces: Consists of the objects needed to configure interfaces within the CCAP.
- Management: Consists of objects used to configure SNMP and Fault Management for the CCAP.
- EPON: Consists of the objects that are related to the DPoE configuration of the CCAP.
- Streaming Telemetry: Consists of objects used to configure IPDR and gNMI Streaming Telemetry functionality in the CCAP.

The CCAP configuration information model strives to make maximum re-use of existing SCTE HMS and DOCSIS MIBs and information models. In some cases, these models were modified to address specific issues that were CCAP-related.

The CCAP supports the configuration objects defined in the following sections via implementation of the CCAP YANG [CCAP-CONFIG-YANG] model via NETCONF configuration [RFC 4742] or other vendor-specific mechanisms.

6.5.1.1 Default Values and Mandatory Configuration of Attributes in the Configuration Information Model

In the UML configuration information model attribute tables in the following sections, a default value is defined in the Default table column for some object attributes. When the UML is translated into data models, default values are carried onto these data models as appropriate. In cases where a default value is defined for an element, the CCAP will use the specified default value if the configuration operation payload does not include the attribute.

Protocols such as NETCONF define operations that specify how to apply the configuration payload. The specification of those operations provide the details on how to deal with the mandatory and default values specified in the YANG model definitions. The "Required Attribute" is typically translated to "mandatory statement" in the YANG model for the corresponding attribute. Default values specified in the Information Models are translated to defaults in the YANG model.

In cases where the Default column reads "vendor-specific", the CCAP MUST provide a default value of the vendor's choosing for the attribute in the implementation. In cases where the vendor is defining the default value, the operator need not include these attributes in the configuration operation payload.

Attributes explicitly required in the configuration operation payload are marked "Yes" in the Required Attribute column; these attributes do not have a default value. In these cases, the operator needs to provide a value for these attributes in the payload when an object containing those attributes is being configured. In cases where the Required Attribute column reads "No", either a default value is provided in the table or the CCAP will use a vendor-specific value.

6.5.1.2 Enumeration Values in the Configuration Information Model

In the configuration information model attribute tables in the following sections, enumerated lists are all intended to begin at a value of "1"; in most cases, the first value will be other ("other(1)"). Since this specification borrows objects from existing MIBs, there will be cases where the enumeration values specified here do not match those of the MIB on which the object attribute was based. CCAP vendors are expected to properly translate values provided in the configuration operation payload into the correct values needed for SNMP reporting via the standard MIB objects.

Note that integers are specified for each enumeration in the UML configuration information model. When the UML is translated into data models (JSON, YANG, SNMP MIB, etc.), the enumeration labels and/or integers are included in these data models as appropriate. For YANG, enumeration labels will be included.

6.5.1.3 Use of Interface Names in Configuration

Several configuration objects defined in this specification are identified with keys in the form of a text string name. In general, these configuration objects are modeled after interfaces that have equivalent representation in SNMP (ifTable). While this specification does not impose formal requirements on the format of interface names, CCAP vendors are expected to implement consistent conventions for assigning textual names to interfaces and disclose the rules on which such conventions are based.

6.5.1.4 Unconstrained Strings in the Configuration Information Model

For object attributes with a data type of String, there are cases where this specification does not provide a length constraint. For these attributes, the CCAP MAY impose a vendor-specific length constraint. If a value in the configuration operation payload exceeds this vendor-specific length constraint, the CCAP SHOULD truncate the text string to that limit.

6.5.2 Vendor-Specific Extensions

A CCAP is expected to implement vendor-proprietary configuration objects beyond those defined in this specification. Standard objects are those that have been defined in the configuration UML information model, defined in the following sections. Vendor-proprietary configuration objects consist of both new configuration objects not represented in the CCAP configuration UML information model and new or modified attributes of configuration objects that exist in the CCAP configuration UML information model.

The CCAP's configuration information model can be extended via the creation of vendor-proprietary YANG modules. Vendor extensions can be performed in YANG.

Modifications to standard configuration objects are allowed within the specific rules defined in Annex E.

See Annex E for requirements related to implementing vendor-specific extensions to the CCAP configuration. Annex E also specifies rules for modifications to standard configuration objects.

6.5.3 CCAP Configuration Information Model

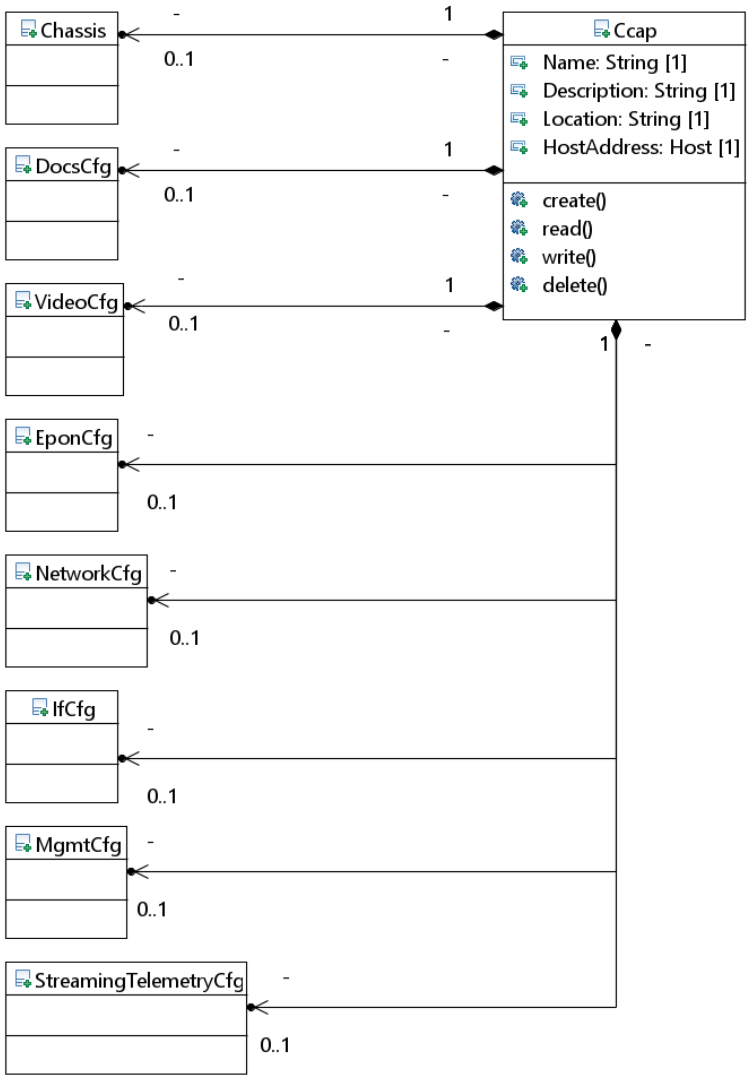


Figure 23 - CCAP Configuration Information Model

6.5.3.1 Ccap

The Ccap object serves as the root of the CCAP configuration data. It consists of three attributes that together describe the CCAP platform.

Table 8 - Ccap Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes	1..32		
Description	String	Yes			
Location	String	Yes	1..128		
Host	Host	Yes			

Table 9 - Ccap Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Chassis	Directed composition to Chassis		0..1	
DocsCfg	Directed composition to DocsCfg		0..1	
VideoCfg	Directed composition to VideoCfg		0..1	
EponCfg	Directed composition to EponCfg		0..1	
NetworkCfg	Directed composition to NetworkCfg		0..1	
IfCfg	Directed composition to IfCfg		0..1	
MgmtCfg	Directed composition to MgmtCfg		0..1	
StreamingTelemetryCfg	Directed composition to StreamingTelemetryCfg		0..1	

6.5.3.1.1 Name

This attribute defines the name of the CCAP platform being configured.

6.5.3.1.2 Description

This attribute contains the description of the CCAP platform.

6.5.3.1.3 Location

This attribute contains any location information for the CCAP.

6.5.3.1.4 Host

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the CCAP.

The CCAP MUST support configuring an IP address for the Ccap Host attribute.

The CCAP SHOULD support configuring an FQDN for the Ccap Host attribute.

6.5.3.2 Chassis

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.4.2.

6.5.3.3 DocsCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.6.1.2.

6.5.3.4 VideoCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.5.2.

6.5.3.5 EponCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.10.2.

6.5.3.6 NetworkCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.7.2.

6.5.3.7 IfCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.8.2.

6.5.3.8 MgmtCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 6.5.9.2.

6.5.3.9 StreamingTelemetryCfg

This configuration object is included in Figure 23 for reference. It is defined in Section 0.

6.5.4 CCAP Chassis Information Model

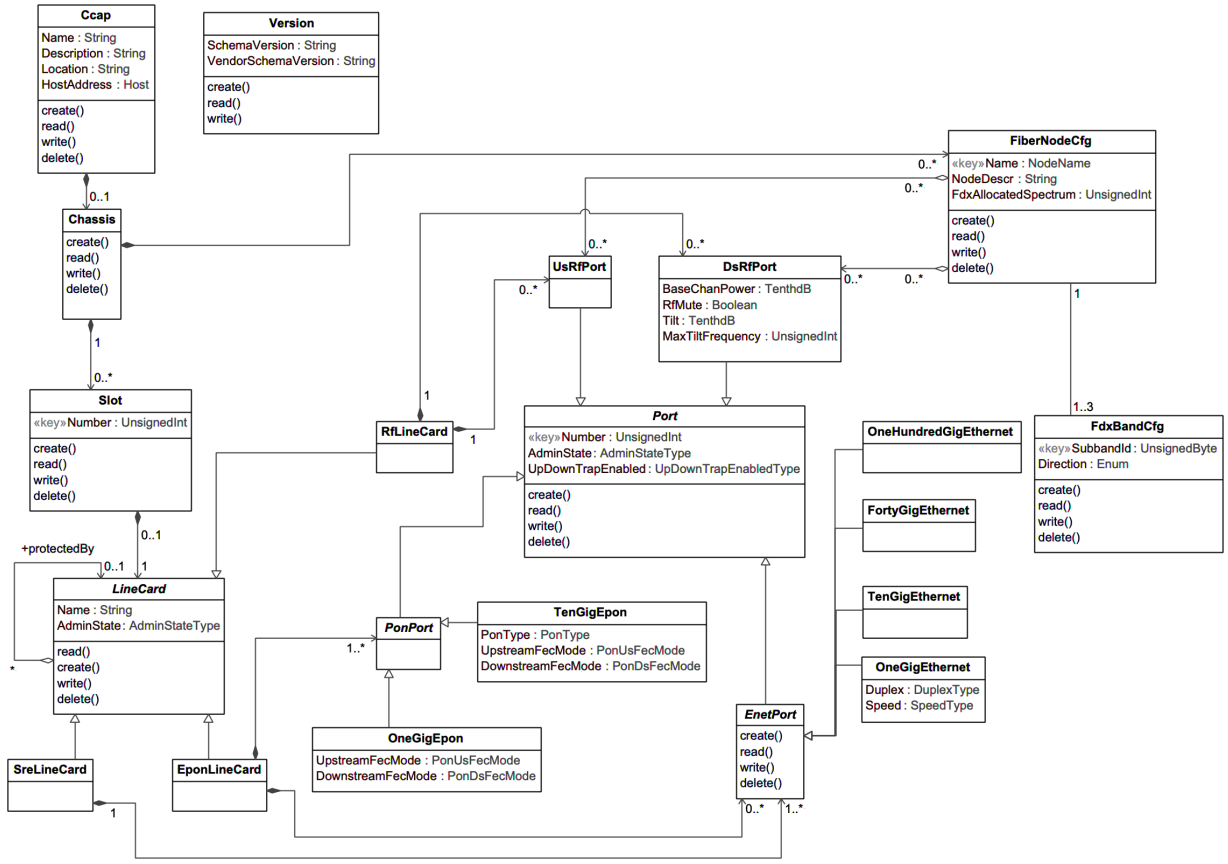


Figure 24 - CCAP Chassis Information Model

6.5.4.1 Ccap

This configuration object is included in Figure 24 for reference. It is defined in Section 6.5.3.1.

6.5.4.2 Chassis

The Chassis object allows the user to configure the CCAP hardware elements. The Chassis object has the following associations.

Table 10 - Chassis Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Slot	Directed composition to Slot	1	0..*	
Decryptor	Directed composition to Decryptor	1	0..*	
FiberNodeCfg	Directed composition to FiberNodeCfg		0..*	
DocsisPhyProfile	Directed composition to DocsisPhyProfile		0..*	
VideoPhyProfile	Directed composition to VideoPhyProfile		0..*	

6.5.4.3 Decryptor

This configuration object is included in Figure 24 for reference. It is defined in Section 6.5.5.27.

6.5.4.4 Slot

This object configures a slot within the CCAP chassis. Line cards reside in slots.

Table 11 - Slot Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Number	UnsignedInt	Yes (Key)	0..*		

Table 12 - Slot Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LineCard	Directed composition to LineCard	1	0..1	

6.5.4.4.1 Number

This attribute configures the slot number for which a LineCard object will be configured. The Number attribute is a zero- or one-based index that sequentially numbers the physical slots in the chassis. For example, the Slot numbers start at zero and increase to n-1, where n is the number of slots the chassis supports.

6.5.4.5 LineCard

The abstract object LineCard allows the user to define the common configuration elements for a CCAP line card. There are several types of line cards defined for the CCAP: Downstream (DLC), Upstream (ULC), System Route Engine (SRE), a combined Upstream and Downstream line card, and an EPON line card.

Table 13 - LineCard Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes			
AdminState	AdminStateType	No			down

Line card redundancy or sparing is achieved with a protect relationship between two line cards.

Table 14 - LineCard Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LineCard	Directed aggregation to LineCard	*	0..1	ProtectedBy

6.5.4.5.1 Name

This attribute stores the name of the line card being configured.

6.5.4.5.2 AdminState

This attribute sets the administrative state of the card.

6.5.4.6 RfLineCard

This object holds the configuration data for a specific RF line card, either a downstream line card (DLC), an upstream line card (ULC), or a combined downstream/upstream line card. This object inherits all of the attributes of the LineCard abstract class. A Slot object contains one LineCard object associated with zero or one RfLineCard. A

downstream RfLineCard contains one or more DsRfPort; an upstream contains one or more UsRfPort objects; an upstream/downstream RfLineCard contains both DsRfPorts and UsRfPorts. There are several associations for the RfLineCard.

Table 15 - RfLineCard Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LineCard	Specialization of LineCard			
Encryptor	Directed composition to Encryptor	1	0..*	
DsRfPort	Directed composition to DsRfPort	1	0..*	
UsRfPort	Directed composition to UsRfPort	1	0..*	
StaticUdpMapEncryption	Directed aggregation to StaticUdpMapEncryption	1	0..*	EnableEncryptionIndex

There are no specific attributes other than what is inherited from the above associations. A minimum lower frequency may be added in a future revision of this specification.

6.5.4.7 EponLineCard

This object configures an EPON line card.

Table 16 - EponLineCard Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LineCard	Specialization of LineCard			
PonPort	Directed composition to PonPort		1..*	
EnetPort	Directed composition to EnetPort		0..*	

6.5.4.8 SreLineCard

The SRE line card is the name given to the line card in the CCAP chassis that contains all the NSI and Management functions for the CCAP. This line card is associated with at least one EnetPort, which serves as the NSI. This object inherits all of the attributes of the LineCard abstract object. There are two associations for the SRE.

Table 17 - SreLineCard Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LineCard	Specialization of LineCard			
EnetPort	Directed composition to EnetPort	1	1..*	

6.5.4.9 Encryptor

This configuration object is included in Figure 24 for reference. It is defined in Section 6.5.5.34.

6.5.4.10 Port

The Port object is an abstract class from which all physical port objects on CCAP line cards are derived. There are no Port objects instantiated per-se in a configuration based on the YANG model; only the derived physical port objects are instantiated. All physical port objects that derive from Port contain the attributes of a Port.

Table 18 - Port Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Number	UnsignedInt	Yes (Key)	0..*		
AdminState	AdminStateType	No			down
UpDownTrapEnabled	UpDownTrapEnabled	No			false

6.5.4.10.1 Number

The Number attribute of Port is a zero- or one-based index that sequentially numbers the physical ports of each derived type. For example, the port numbers of the DsRfPort objects start at zero and increase to n-1, where n is the total number of DsRfPorts.

6.5.4.10.2 AdminState

This attribute configures the administrative state of the physical port.

6.5.4.10.3 UpDownTrapEnabled

This attribute configures whether linkUp/linkDown traps are enabled for this port.

6.5.4.11 DsRfPort

This object allows for the configuration of a physical Downstream RF port on an RfLineCard. The DsRfPort is a type of the abstract class Port and inherits those common parameters. In the CCAP, a single port now encompasses the entire downstream spectrum instead of a few carriers as are seen in previous generation EQAM and CMTS products. A DsRfPort object contains the attributes in the following table.

Table 19 - DsRfPort Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
BaseChanPower	TenthdBmV	No		TenthdBmV per 6 MHz	vendor-specific
RfMute	Boolean	No			false
Tilt	TenthdB	No	0..120	TenthdB	
TiltMaxFrequency	UnsignedInt	No		Hz	

Table 20 - DsRfPort Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Port	Specialization of Port			

6.5.4.11.1 BaseChanPower

This attribute configures the base output power for each single channel (SC-QAM or OFDM) on the DsRfPort. The value is expressed in dBmV in units of TenthdBmV per 6 MHz. The default value is vendor-specific. Acceptable power ranges for this attribute are defined in [PHYv4.0] in the Power per Channel CMTS or EQAM section of [DRFI].

Reference: [DRFI], Power per Channel CMTS or EQAM section

6.5.4.11.2 RfMute

The attribute RfMute refers to a diagnostic state defined in the [PHYv4.0] Specification. Muting an RF port affects only the output power and does not impact the operational status of any channel on the port.

6.5.4.11.3 Tilt

This attribute configures the Tilt value to be applied over the supported downstream spectrum (from the minimum downstream frequency to the Tilt Maximum Frequency) on this DsRfPort. For the purpose of tilt range definition, the minimum frequency is understood as the lower edge of the lowest occupied downstream channel. When a non-zero tilt value is configured, the BaseChanPower specifies the output power at the frequency specified by the TiltMaxFrequency attribute. The CCAP implements tilt by reducing output power at lower frequencies.

NOTE: The amount of Tilt supported by a given CCAP is vendor-specific. The range provided here is not intended as a requirement on CCAP implementations as many implementations support a lower maximum Tilt value than is specified here.

6.5.4.11.4 Tilt Maximum Frequency

This attribute configures the maximum frequency (aka tilt pivot point) where the Tilt value applies.

6.5.4.12 FiberNodeCfg

The FiberNodeCfg object defines the cable hybrid fiber/coax system (HFC) plant Fiber Nodes reached by RF ports on a CCAP.

This object supports the creation and deletion of multiple instances.

The CMTS and CCAP MUST persist all instances of FiberNodeCfg across reinitializations.

Table 21 - FiberNodeCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	NodeName	Yes (Key)			""
NodeDescr	String	No			""
FdxAllocatedSpectrum	UnsignedInt	No	0, 96, 192, 288, 384, 576	MHz	0

The FiberNodeCfg object has the following associations.

Table 22 - FiberNodeCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsRfPort	Directed aggregation to DsRfPort	0..*	0..*	DsRfPort
UsRfPort	Directed aggregation to UsRfPort	0..*	0..*	UsRfPort
FdxBandCfg	Directed composition to FdxBandCfg	1	0..3	FdxBandCfg

6.5.4.12.1 Name

This key attribute represents a human-readable name for a fiber node.

References: [MULPIv4.0] RF Topology Configuration section.

6.5.4.12.2 NodeDescription

This attribute represents a human-readable description of the node.

6.5.4.12.3 FdxAllocatedSpectrum

This attribute is used to configure the width of FDX spectrum for the node. The lower end of FDX band starts at frequency of 108 MHz and ranges up to frequency of 108 MHz + FdxAllocatedSpectrum. All OFDM and all OFDMA channels configured within the FDX Band need to comply with the requirements outlined in section Upstream and Downstream Frequency Plan of Annex F of [PHYv4.0].

If this attribute is set to 0 MHz, this node does not operate FDX.

6.5.4.13 FdxBandCfg

The FdxBandCfg object enables the ability to configure the CCAP to establish simplex (i.e., either upstream or downstream) or full duplex operation for each sub-band. This configuration applies to all TGs that are derived on a specific FDX node. It is not a per-TG configuration.

Table 23 - FdxBandCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SubbandId	UnsignedByte	Yes (Key)			
Direction	Enum	No	other(1), upstream(2), downstream(3), dynamic(4)		dynamic

6.5.4.13.1 SubbandId

This key defines the sub-bands to be configured. The number of sub-bands is determined by the FdxAllocatedSpectrum attribute. The sub-bands are numbered sequentially in ascending order beginning with 1.

6.5.4.13.2 Direction

This attribute defines the direction(s) (i.e., upstream and/or downstream) to be assigned in a Resource Block. The value 'dynamic' configures the CCAP to establish bidirectional RBAs on the sub-band. The default is 'dynamic'.

6.5.4.14 UsRfPort

A UsRfPort object represents a physical upstream RF connector on an RfLineCard. It is derived from the Port abstract class, and so inherits all attributes of that class, including its associations. A UsRfPort is contained by an RfLineCard. It may contain one or more of the following objects:

- UpstreamPhysicalChannel
- UsOfdmaChannel
- UsOfdmaExclusion

This object has no attributes other than what has been inherited from the abstract class *Port* but does have several associations.

Table 24 - UsRfPort Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Port	Specialization of Port			
UpstreamPhysicalChannel	Directed composition to UpstreamPhysicalChannel	1	0..*	
UsOfdmaChannel	Directed composition to UsOfdmaChannel	1	0..*	
UsOfdmaExclusion	Directed composition to UsOfdmaExclusion	1	0..*	

6.5.4.15 UpstreamPhysicalChannel

This configuration object is included in Figure 24 for reference. It is defined in Section 6.5.6.8.6, UpstreamPhysicalChannel.

6.5.4.16 EnetPort

The EnetPort object is an abstract class that allows an Ethernet port to be configured on a line card that contains Ethernet ports. EnetPort is also a type of the abstract class Port. Ethernet ports are associated with the SreLineCard and the EponLineCard.

Table 25 - EnetPort Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Port	Specialization of Port			
IpInterface	Directed composition to IpInterface		0..1	
IpAcl	Directed association to IpAcl		0..1	Ingress
IpAcl	Directed association to IpAcl		0..1	Egress

6.5.4.17 OneGigEthernet

This object configures a one-gigabit interface for an Ethernet port. The speed and duplex settings for this type of port can be configured via this object.

Table 26 - OneGigEthernet Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Duplex	Enum	No	other(1), fullDuplex(2), halfDuplex(3), autoNegotiated(4)		fullDuplex
Speed	Enum	Yes	other(1), tenMbitEthernet(2), hundredMbitEthernet(3), oneGigabit(4), auto(5)		

Table 27 - OneGigEthernet Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EnetPort	Specialization of EnetPort			

6.5.4.17.1 Duplex.

This attribute configures the Ethernet DuplexState of the interface. The value of other(1) is used when a vendor-extension has been implemented for this attribute

6.5.4.17.2 Speed

This attribute configures the speed of the interface for interfaces that can support multiple speeds. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.4.18 TenGigEthernet

This object configures a ten-gigabit interface for an Ethernet port.

Table 28 - TenGigEthernet Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EnetPort	Specialization of EnetPort			

6.5.4.19 FortyGigEthernet

This object configures a 40-gigabit interface for an Ethernet port.

Table 29 - FortyGigEthernet Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EnetPort	Specialization of EnetPort			

6.5.4.20 OneHundredGigEthernet

This object configures a 100-gigabit interface for an Ethernet port.

Table 30 - OneHundredGigEthernet Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EnetPort	Specialization of EnetPort			

6.5.4.21 PonPort

This abstract configuration object allows for an EPON port to be configured on an EPON line card. PonPort is a type of the abstract class Port.

Table 31 - PonPort Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Port	Specialization of Port			

6.5.4.22 OneGigEpon

This configuration object allows for a one Gigabit EPON port to be configured on an EPON line card. It is a type of the abstract class PonPort.

Table 32 - OneGigEpon Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
UpstreamFecMode	Enum	No	other(1), enabled(2), disabled(3), perOnu(4)		disabled
DownstreamFecMode	Enum	No	other(1), enabled(2), disabled(3), perOnu(4)		disabled

Table 33 - OneGigEpon Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PonPort	Specialization of PonPort			

6.5.4.22.1 UpstreamFecMode

This attribute configures the FEC mode applied to the EPON upstream. The perOnu option allows the ONU provisioning process to determine whether FEC should be enabled or disabled. This option is only valid for 1G EPON interfaces.

The default value for the 1G EPON interface is disabled(3).

The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.4.22.2 DownstreamFecMode

This attribute configures the FEC mode of the EPON downstream. The perOnu option allows the ONU provisioning process to determine whether FEC should be enabled or disabled. This option is only valid for 1G EPON interfaces.

The default value for the 1G EPON interface is disabled(3).

The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.4.23 TenGigEpon

This configuration object allows for a symmetric or asymmetric ten Gigabit EPON port to be configured on an EPON line card. It is a type of the abstract class PonPort.

Table 34 - TenGigEpon Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
PonType	Enum	Yes	other(1), symmetric10x10(2), asymmetric10x1(3)		
UpstreamFecMode	Enum	No	other(1), enabled(2), disabled(3), perOnu(4)		See description
DownstreamFecMode	Enum	No	other(1), enabled(2), disabled(3), perOnu(4)		See description

Table 35 - TenGigEpon Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PonPort	Specialization of PonPort			

6.5.4.23.1 PonType

This attribute configures the speed of the 10G EPON interfaces on the line card and allows for asymmetrical upstream and downstream speeds. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.4.23.2 UpstreamFecMode

This attribute configures the FEC mode applied to the EPON upstream. The perOnu option allows the ONU provisioning process to determine whether FEC should be enabled or disabled. This option is only valid for 1G EPON interfaces.

The default value for the 1G EPON interface is disabled(3).

The default value for the 10G EPON interface is enabled(2).

The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.4.23.3 DownstreamFecMode

This attribute configures the FEC mode of the EPON downstream. The perOnu option allows the ONU provisioning process to determine whether FEC should be enabled or disabled. This option is only valid for 1G EPON interfaces.

The default value for the 1G EPON interface is disabled(3).

The default value for the 10G EPON interface is enabled(2).

The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5 CCAP Video Session Configuration Information Model

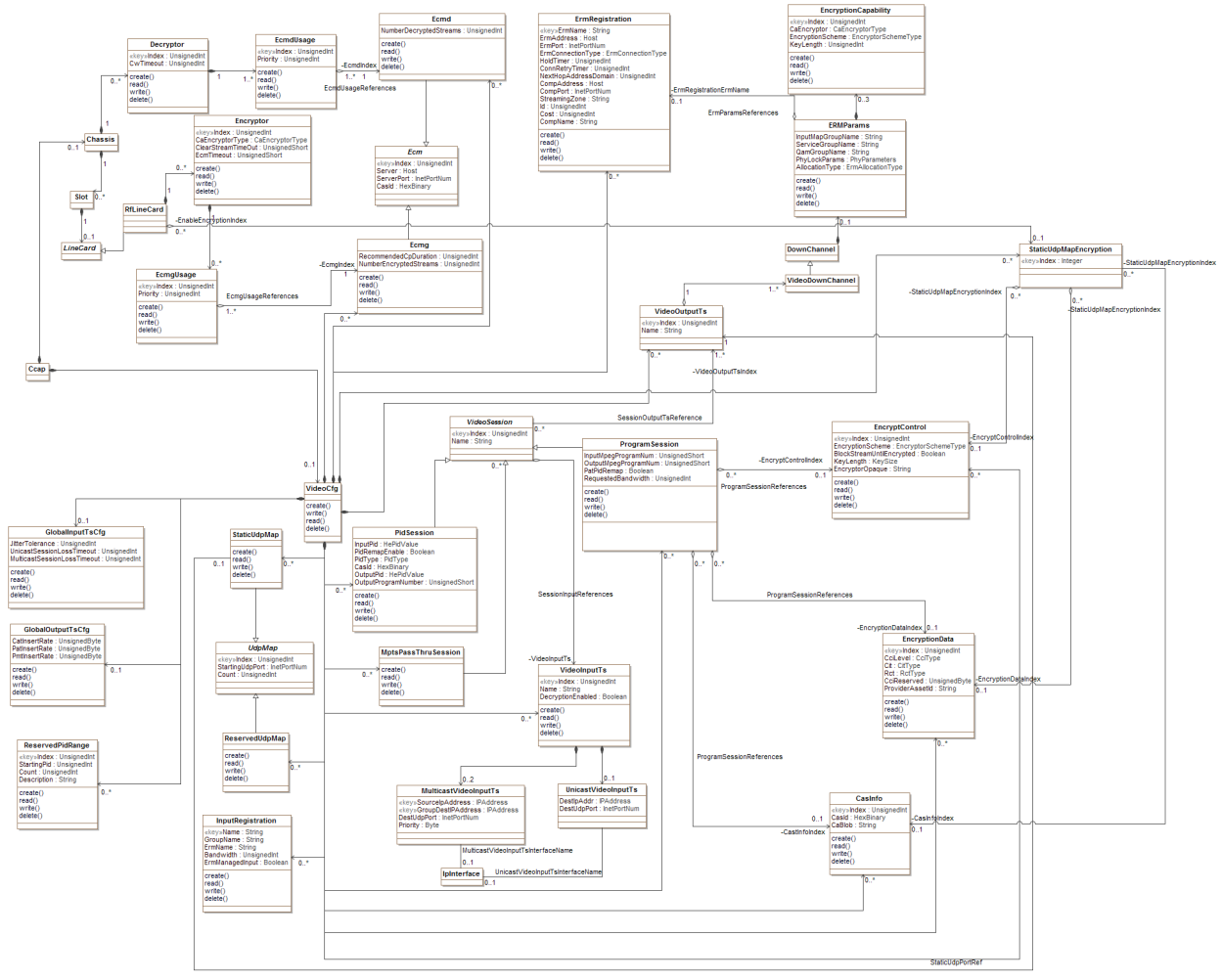


Figure 25 - CCAP Video Session Configuration Information Model

6.5.5.1 Ccap

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.3.1, Ccap Object.

6.5.5.2 VideoCfg

The VideoCfg object is the primary container of video configuration objects. It has the following associations:

Table 36 - VideoCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
GlobalInputTsCfg	Directed composition to GlobalInputTsCfg		0..1	
GlobalOutputTsCfg	Directed composition to GlobalOutputTsCfg		0..1	
StaticUdpMap	Directed composition to StaticUdpMap		0..*	
ReservedUdpMap	Directed composition to ReservedUdpMap		0..*	
ReservedPidRange	Directed composition to ReservedPidRange		0..*	
InputRegistration	Directed composition to InputRegistration		0..*	
ProgramSession	Directed composition to ProgramSession		0..*	
MptsPassThruSession	Directed composition to MptsPassThruSession		0..*	
PidSession	Directed composition to PidSession		0..*	
VideoInputTs	Directed composition to VideoInputTs		0..*	
CasInfo	Directed composition to CasInfo		0..*	
EncryptionData	Directed composition to EncryptionData		0..*	
EncryptControl	Directed composition to EncryptControl		0..*	
ErmRegistration	Directed composition to ErmRegistration		0..*	
VideoOutputTs	Directed composition to VideoOutputTs		0..*	
Ecmg	Directed composition to Ecmg		0..*	
Ecmd	Directed composition to Ecmd		0..*	
StaticUdpMapEncryption	Directed composition to StaticUdpMapEncryption		0..*	

6.5.5.3 GlobalInputTsCfg

This object represents global configuration of input transport streams.

Table 37 - GlobalInputTsCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
JitterTolerance	UnsignedInt	No		milliseconds	100
UnicastSessionLossTimeout	UnsignedInt	No		milliseconds	5000
MulticastSessionLossTimeout	UnsignedInt	No		milliseconds	5000

6.5.5.3.1 JitterTolerance

This attribute represents the acceptable delay variation in milliseconds for incoming streams. The jitter option sets the size of a dejittering buffer that absorbs the input jitter of a session.

6.5.5.3.2 UnicastSessionLossTimeout

This attribute represents the loss of signal timeout in milliseconds for unicast input streams. See [SCTE 154-4], mpegLossOfSignalTimeout.

6.5.5.3.3 MulticastSessionLossTimeout

This attribute represents the loss of signal timeout in milliseconds for the multicast input streams.

6.5.5.4 GlobalOutputTsCfg

This object represents global configuration of output transport streams.

Table 38 - GlobalOutputTsCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
CatInsertRate	UnsignedByte	No	0..32	tables/second	10
PatInsertRate	UnsignedByte	No	0..32	tables/second	10
PmtInsertRate	UnsignedByte	No	0..32	tables/second	10

6.5.5.4.1 CatInsertRate

This attribute represents the CAT insertion rate expressed in tables/second (see [SCTE 154-4], mpegOutputTSCatInsertRate).

6.5.5.4.2 PatInsertRate

This attribute represents the PAT table interval expressed in tables/second (see [SCTE 154-4], mpegOutputTSPatInsertRate).

6.5.5.4.3 PmtInsertRate

This attribute represents the PMT table interval expressed in tables/second (see [SCTE 154-4], mpegOutputTSPatInsertRate).

6.5.5.5 UdpMap

This abstract object holds the UDP attributes that are used in the StaticUdpMap and ReservedUdpMap objects.

Table 39 - UdpMap Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
StartingUdpPort	InetPortNum	No			0
Count	UnsignedInt	No			0

6.5.5.5.1 Index

This key represents a globally unique identifier of the object instance.

6.5.5.5.2 StartingUdpPort

This attribute represents the UDP port range start value.

6.5.5.5.3 Count

This attribute represents the number of UDP ports starting from the StartingPort attribute value.

6.5.5.6 StaticUdpMap

This object represents the UDP port ranges used for static video sessions. It is a specialization of UdpMap.

Table 40 - StaticUdpMap Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UdpMap	Specialization of UdpMap			
VideoOutputTs	Directed association to VideoOutputTs	0..1	1	StaticUpdPortRef

6.5.5.7 ReservedUdpMap

This object represents reserved ports to be used for non-video applications. It is a specialization of UdpMap.

Table 41 - ReservedUdpMap Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UdpMap	Specialization of UdpMap			

6.5.5.8 ReservedPidRange

This object represents reserved PID range to not be used on ERM assignments.

Table 42 - ReservedPidRange Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
StartingPid	UnsignedInt	No			0
Count	UnsignedInt	No			0
Description	String	No			""

6.5.5.8.1 Index

This key represents the unique identifier of an instance of this object.

6.5.5.8.2 StartingPid

This attribute represents the PID range starts for other applications' reserved PIDs.

6.5.5.8.3 Count

This attribute represents the number of reserved PIDs starting from the StartingPid attribute value.

6.5.5.8.4 Description

This attribute represents the description associated with a PID range configured instance.

6.5.5.9 InputRegistration

This object configures which input interfaces are advertised to the ERM and whether a given advertised interface has its capacity managed by the ERM or the CCAP.

Table 43 - InputRegistration Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			
GroupName	String	No			""
ErmName	String	Yes			

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Bandwidth	UnsignedInt	No			0
ErmManagedInput	Boolean	Yes			

6.5.5.9.1 Name

This key represents the Input interface name. This name corresponds to the [RFC 6933], ENTITY-MIB entPhysicalName.

6.5.5.9.2 GroupName

This attribute represents the name of the Edge Input Group associated with this input. This parameter is reported to the ERM via the RMI-SDR interface in the Edge Device Configuration message and in the ERRP Edge Input attribute.

6.5.5.9.3 ErmName

This attribute represents the ERM where the input interface is advertised.

6.5.5.9.4 Bandwidth

This attribute represents the bandwidth of the edge input to be advertised. If zero or not present, the CCAP advertises the full bandwidth of the edge input. If the attribute ErmManagedInput is set to false, operators should set this attribute to a value that greatly exceeds the speed of the input interface; this will cause the ERM to not actively manage the input bandwidth.

6.5.5.9.5 ErmManagedInput

This attribute allows the Operator to configure whether or not the ERM should manage the input bandwidth on this EdgeInput Interface. A value of true indicates that the ERM will manage the input bandwidth; a value of false indicates that the CCAP will manage the input bandwidth. If set to false, operators should set the Bandwidth attribute to a value that greatly exceeds the speed of the input interface so that the ERM will not actively manage the input bandwidth.

6.5.5.10 CasInfo

The CasInfo object serves two purposes:

1. It identifies the ECMG(s) that need(s) to be involved in the encryption of the program session. In the case of a Simulcrypt operation, more than one CasInfo object can be attached to the same ProgramSession.
2. It defines a CA-specific opaque object that needs to be forwarded to the appropriate ECMG when the session is initialized.

A CasInfo object contains the attributes in the following table.

Table 44 - CasInfo Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
CasId	HexBinary	Yes	size(8)		
CaBlob	String	Yes			

6.5.5.10.1 Index

This attribute configures the index for an instance of CasInfo for a given ProgramSession.

6.5.5.10.2 CasId

CasId is the hexadecimal representation of the CAS system identifier.

6.5.5.10.3 CaBlob

CaBlob is opaque data that the Encryptor is required to forward to the ECMG associated with the specified CasId.

6.5.5.11 EncryptionData

The EncryptionData object allows a per video session encryption configuration.

Table 45 - EncryptionData Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
CciLevel	Enum	Yes	other(1), copyFreely(2), copyOneGeneration(3), copyNoMore(4), copyNever(5)		
Cit	Enum	Yes	other(1), clear(2), set(3)		
Rct	Enum	Yes	other(1), notAsserted(2), required(3)		
CciReserved	UnsignedByte	Yes	0..3		
ProviderAssetId	String	Yes	1..255		

6.5.5.11.1 Index

The index is the key for the EncryptionData object.

6.5.5.11.2 CciLevel

This attribute represents the Copy Control Indicator/Digital Rights protection applicable to the program. It is forwarded to all active ECMGs to be encapsulated into ECMs. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.11.3 Cit

This attribute represents the Constrained Image Trigger flag applicable to the program. It is forwarded to all active ECMGs to be encapsulated into ECMs. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.11.4 Rct

This attribute represents the Redistribution Control Trigger flag applicable to the program. It is forwarded to all active ECMGs to be encapsulated into ECMs. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.11.5 CciReserved

This attribute reserves 2 bits of copy control information (CCI) for future use. It is forwarded to all active ECMGs to be encapsulated into ECMs.

6.5.5.11.6 ProviderAssetId

This attribute configures the Provide Asset Id parameter that is passed in the initial RTSP session SETUP (e.g., for VOD) to the Encryptor and enables the Encryptor to uniquely identify/reference the VOD asset or broadcast channel.

6.5.5.12 EncryptControl

This configuration object selects the encryption option of a static encryption session.

Table 46 - EncryptControl Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
EncryptionScheme	Enum	Yes	other(1), des(2), aes(3), 3des(4), dvbcsa(5), dvbcsa3(6)		
BlockStreamUntilEncrypted	Boolean	No			true
KeyLength	Enum	Yes	other(1), 56bits(2), 128bits(3), 192bits(4), 256bits(5)		
EncryptorOpaque	String	Yes			

6.5.5.12.1 Index

This attribute configures the index for an instance of EncryptControl for a given ProgramSession.

6.5.5.12.2 EncryptionScheme

This attribute defines the encryption algorithm to be used for a given video session. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.12.3 BlockStreamUntilEncrypted

BlockStreamUntilEncrypted indicates if the encryption engine should block the program until it can encrypt it (i.e., it has received a first Entitlement Control Message (ECM) and Control Word (CW) from the ECMG) or release it in the clear to the destination or output. Values are 0 meaning false or 1 meaning true. Note that this parameter can be used to enforce synchronous behavior, wherein the RTSP server (i.e., Encryption Engine) will not acknowledge the session request back to the ERM until it has actually started to encrypt the stream. Obviously, this assurance comes at the expense of setup latency.

6.5.5.12.4 KeyLength

This attribute configures the number of bits in the encryption keys used by encryption algorithm defined by the EncryptionScheme attribute. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.12.5 EncryptorOpaque

EncryptorOpaque holds private data used by the Encryptor that may be under CA license from the CA vendor.

6.5.5.13 VideoInputTs

The VideoInputTs object configures a given MPEG-2 Transport stream that may be unicast or multicast. Each VideoInputTs object MUST have either:

- one or two MulticastVideoInputTs objects associated with it,
- one UnicastVideoInputTs object associated with it.

Having two MulticastVideoInputTs objects associated with it occurs when input TS redundancy is configured (Hot-Hot sparing).

Table 47 - VideoInputTs Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
Name	String	No			""
DecryptionEnabled	Boolean	No			false

When redundancy of the input multicast TS is configured, a VideoInputTs object is associated with two MulticastVideoInputTs objects. A VideoInputTs object can also be referenced from multiple ProgramSession, MptsPassThruSession, or PidSession objects.

Table 48 - VideoInputTs Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
MulticastVideoInputTs	Directed composition to MulticastVideoInputTs		0..2	
UnicastVideoInputTs	Directed composition to UnicastVideoInputTs		0..1	

6.5.5.13.1 Index

This is the index for an instance of the VideoInputTs object.

6.5.5.13.2 Name

This is a unique name for this instance of the VideoInputTs object.

6.5.5.13.3 DecryptionEnabled

This attribute configures whether this input stream is encrypted for transport across the WAN. This WAN encryption is intended to be removed at the CCAP and not related to any CA encryption that may be configured for the output stream. A value of true means that the CCAP needs to decrypt this input stream as applicable. A value of false means that the CCAP does not need to decrypt this input stream. Default value is false.

6.5.5.14 UnicastVideoInputTs

This object specifies the unicast flow of an input transport stream.

Table 49 - UnicastVideoInputTs Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DestIpAddr	IpAddress	See attribute description			
DestUdpPort	InetPortNum	Yes			

A UnicastVideoInputTs object may be associated with a specific IpInterface. In this case, the DestIpAddr is not required. If an association is made to a UnicastVideoInputTsInterfaceName, care needs to be taken to make sure that the DestUdpPort specified does not overlap with the UDP port used for other traffic that may be present on the associated IpInterface instance.

Table 50 - UnicastVideoInputTs Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association to IpInterface		0..1	UnicastVideoInputTsInterfaceName

6.5.5.14.1 DestIpAddr

This attribute corresponds to the IP destination address of the UDP IP flow of the input TS. This attribute is required unless the UnicastVideoInputTs object is associated with an IpInterface instance. If the IP address specified in the DestIpAddr attribute does not exist on the CCAP, the CCAP MUST reject this configuration.

When the value of the DestIpAddr attribute is set to all zeros (e.g., 0.0.0.0), the CCAP MUST listen for the traffic on the specified UDP port number on all IP interfaces.

6.5.5.14.2 DestUdpPort

This attribute corresponds to the UDP destination port of the UDP IP flow of the input TS.

6.5.5.15 MulticastVideoInputTs

This object specifies the multicast flows of an input transport stream. Having two MulticastVideoInputTs objects for one VideoInputTs occurs when input TS redundancy is configured (Hot-Hot sparing). If two MulticastVideoInputTs objects have the same Priority, this implies HOT-HOT redundancy. Which stream is actually forwarded is vendor-specific.

Table 51 - MulticastVideoInputTs Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SourceIpAddress	IpAddress	Yes (Key)			
GroupDestIpAddress	IpAddress	Yes (Key)			
DestUdpPort	InetPortNum	No			0
Priority	Byte	Yes			

A MulticastVideoInputTs object may be associated with a specific IpInterface. This associations provides a static mapping of the source of an input transport stream to an IP interface.

Table 52 - MulticastVideoInputTs Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association to IpInterface		0..1	MulticastVideoInputTsInterfaceName

6.5.5.15.1 SourceIpAddress

This attribute corresponds to the Source Specific Multicast IP Address of the UDP IP flow.

6.5.5.15.2 GroupDestIpAddress

This attribute corresponds to the group address of an SSM (Source Specific Multicast) origination input TS.

6.5.5.15.3 DestUdpPort

This attribute corresponds to the UDP destination port of the UDP IP flow of the input TS.

6.5.5.15.4 Priority

This attribute is a number that identifies the preference order of this transport stream; higher number indicates a higher priority. It is used to order the multicast transport stream for the purpose of redundancy in the case of multiple multicast video sources. If two entries have the same "Priority", it implies Hot-Hot redundancy.

6.5.5.16 VideoOutputTs

The VideoOutputTs object represents a configuration multiplex of one or more ProgramSession, PidSession, or MptsPassThruSession instances. In cases where a VideoDownChannel is dynamically managed by an ERM, the VideoOutputTs may not be associated with any video program sessions.

Table 53 - VideoOutputTs Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
Index	UnsignedInt	Yes (Key)			
Name	String	No			""

Table 54 - VideoOutputTs Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VideoDownChannel	Directed aggregation to VideoDownChannel	1	1..*	

6.5.5.16.1 VideoOutputTs Object Attributes

6.5.5.16.2 Index

This is an index for an instance of this Object. It uniquely identifies a CCAP-generated MPTS composed of one or more program streams, PID streams and/or pass thru MPTS. This is NOT the Output TSID used for replication.

6.5.5.16.3 Name

This attribute configures the name of this instance of VideoOutputTs.

6.5.5.17 VideoDownChannel

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.6.9.4, VideoDownChannel.

6.5.5.18 DownChannel

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.6.9.5, DownChannel.

6.5.5.19 ErmParams

This configuration object allows for the configuration of the needed parameters that are communicated to an ERM for a given DownChannel object instance. If a DownChannel instance is managed by an ERM, it will contain ERM parameters.

Table 55 - ErmParams Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
InputMapGroupName	String	No			""
ServiceGroupName	String	No			""
QamGroupName	String	No			""
PhyLockParams	EnumBits	No	frequency(0), bandwidth(1), power(2), modulation(3), interleaver(4), j83Annex(5), symbolRate(6), mute(7)		"H
AllocationType	EnumBits	Yes	linear(0), vod(1) sdv(2) docsis(3)		

Table 56 - ErmParams Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EncryptionCapability	Directed composition to EncryptionCapability		0..3	
ErmRegistration	Directed aggregation to ErmRegistration		0..1	ErmRegistrationErmName

6.5.5.19.1 InputMapGroupName

This attribute indicates which input interfaces reach this channel output. Instances of the InputRegistration object assign an input group name to input interfaces. If NSI ports and RF ports have any-to-any connectivity, this attribute can be excluded.

For ERMI implementations, this represents the address field in the WithdrawnRoute and ReachableRoutes ERRP attributes. This attribute is optional for DocsisDownChannel.

6.5.5.19.2 ServiceGroupName

This attribute specifies the assigned service group for this down channel.

6.5.5.19.3 QamGroupName

This attribute specifies a name associated with the down channels that are collectively output on the same RF output interface on the CCAP.

6.5.5.19.4 PhyLockParams

This attribute represents the PHY parameters Lock state of the QAM channels for DEPI-initiated PHY parameters updates.

6.5.5.19.5 AllocationType

This attribute defines for the ERM which services this specific DownChannel instance can support.

6.5.5.20 EncryptionCapability

The EncryptionCapability object defines one encryption option of the Encryptor that needs to be reported to the ERM. There can be up to three EncryptionCapability objects per QAM. In return, the ERM is expected to create dynamic sessions using one of the reported encryption options.

Table 57 - EncryptionCapability Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
CaEncryptor	Enum	Yes	other(1), motorola(2), cisco(3), simulcrypt(4)		
EncryptionScheme	Enum	Yes	other(1), des(2), aes(3), 3des(4), dvbcsa(5), dvbcsa3(6)		
KeyLength	UnsignedInt	Yes			

6.5.5.20.1 Index

This attribute assigns a unique identifier to this instance of the EncryptionCapability object.

6.5.5.20.2 CaEncryptor

This enumeration defines the type of CA encryption the Encryptor uses. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.20.3 EncryptionScheme

This attribute defines the encryption algorithms applicable to the CA encryption defined by the CaEncryptor attribute. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.20.4 KeyLength

This attribute defines the key length applicable to the algorithm defined by the EncryptionScheme attribute.

6.5.5.21 ErmRegistration

This object allows for the configuration of the interface to an Edge Resource Manager. Generally, one configured ERM interface exists for the entire CCAP. An ErmRegistration object contains the attributes in the following table. The CCAP MAY support only one instance of the ErmRegistration object. Configuring more than one ERM is generally used for scaling purposes, with each individual ERM being focused on specific, unique service groups. More than one ERM cannot be practically used to support the same service group, and there could be conflicts between the control messages of the independent ERMs.

The optional attributes in this object are provided for backwards compatibility with ERMI.

Table 58 - ErmRegistration Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ErmName	String	Yes (Key)			
ErmAddress	Host	Yes			
ErmPort	InetPortNum	No			0
ErmConnectionType	Enum	No	other(1), client(2), server(3), clientAndServer(4)		client
HoldTimer	UnsignedInt	No	0 | 3.. 3600	seconds	240
ConnRetryTimer	UnsignedInt	No		seconds	20

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
NextHopAddressDomain	UnsignedInt	No			""
CompAddress	Host	No			"
CompPort	InetPortNum	No			6069
StreamingZone	String	Yes	1..255		
Id	UnsignedInt	No			0
Cost	UnsignedInt	No			0
CompName	String	No	1..255		""

6.5.5.21.1 ErmName

This key represents the name of the ERM related to this registration instance. This is an internal reference for associating, e.g., QAM channels and input interfaces to an ERM.

6.5.5.21.2 ErmAddress

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the ERM.

The CCAP MUST support configuring an IP address for the ErmRegistration ErmAddress attribute.

The CCAP SHOULD support configuring an FQDN for the ErmRegistration ErmAddress attribute.

6.5.5.21.3 ErmPort

This attribute represents the TCP port number used to reach the ERM.

6.5.5.21.4 ErmConnectionType

This attribute represents the type of TCP connection that is established by the CCAP. The value can be one of the following:

- other(1) indicates that a vendor-extension has been implemented for this attribute.
- client(2) indicates that the CCAP has to initiate the TCP connection with the ERM.
- server(3) indicates that the CCAP has to wait for the TCP connection from the ERM.
- clientAndServer(4) indicates that either the CCAP or the ERM can initiate the TCP connection.

6.5.5.21.5 HoldTimer

This attribute represents the number of seconds that the sender proposes for the value of the hold timer.

Upon receipt of an OPEN message, the CCAP MUST calculate the value of the Hold Timer by using the smaller of its configured Hold Time and the Hold Time received in the OPEN message.

The Hold Time has to be either zero or at least three seconds.

The CCAP MAY reject connections on the basis of the Hold Time. The calculated value indicates the maximum number of seconds that may elapse between the receipt of successive KEEPALIVE and/or UPDATE messages by the sender.

6.5.5.21.6 ConnRetryTimer

This attribute represents the time in seconds for the connect retry timer. The exact value of the connect retry timer is a local matter but should be sufficiently large to allow TCP initialization.

6.5.5.21.7 NextHopAddressDomain

This attribute represents the address domain number of the next-hop server. The NextHopServer specifies the address to which a manager should use to connect to the component in order to control the resource specified in the reachable route. This parameter is used in the ERRP NextHopServer attribute.

6.5.5.21.8 CompAddress

This attribute represents the host portion of the ERRP NextHopServer attribute. This field contains an FQDN, or an IPv4 address using the textual representation defined in section 2.1 of [RFC 1123], or an IPv6 address using the textual representation defined in section 2.2 of [RFC 4291]. This value is sent in the ERRP NextHopServer attribute with the CompPort value in the ERRP messages. The attribute is optional when signaling DOCSIS only resources, however it is defined as a mandatory attribute since the typical use of ErmRegistration is for video.

6.5.5.21.9 CompPort

This attribute represents the port portion of the ERRP NextHopServer attribute. This field contains numerical value (1-65535) representing the port number. If the port is empty or not given, the default port 6069 is assumed. This value is sent in the ERRP NextHopServer attribute with the CompAddress value in the ERRP messages. The attribute is optional when signaling DOCSIS only resources, however it is defined as a mandatory attribute since the typical use of ErmRegistration is for video.

6.5.5.21.10 StreamingZone

This attribute represents the name of the Streaming Zone within which the component operates. This parameter is used in the ERRP OPEN message. StreamingZone Name is a mandatory parameter when supporting video applications. The capability is optional when signaling DOCSIS only resources.

The value is to be set to the string that represents the StreamingZone Name, i.e., <region>. The characters comprising the string are in the set within TEXT defined in section 15.1 of [RFC 2326]. The CCAP MUST support minimum string lengths of 64 for the StreamingZone attribute of the ErmRegistration object; however, the composition of the string used is defined by implementation agreements specified by the service provider.

A CCAP will exist in a single streaming zone.

6.5.5.21.11 Id

This attribute represents the unique identifier for the CCAP device within its Streaming Zone. This value can be set to the 4-octet value of an IPv4 address assigned to that device. This ID value is determined on startup and is the same for all peer connections. This parameter is used in the ERRP OPEN message header.

6.5.5.21.12 Cost

This attribute represents the static cost for use of this resource.

6.5.5.21.13 CompName

The name of the component for which the data in the update message applies. This parameter is used in the ERRP OPEN message. Component Name is a mandatory parameter when supporting video applications. The capability is optional when signaling DOCSIS only resources.

The value is to be set to the string that represents the Component Name, i.e., <region>.<localname>. The characters comprising the string are in the set within TEXT defined in section 15.1 of [RFC 2326]. The CCAP MUST support minimum string lengths of 64 for the CompName attribute of the ErmRegistration object; however, the composition of the string used is defined by implementation agreements specified by the service provider.

6.5.5.22 VideoSession

The VideoSession abstract object holds the common attributes for the session configuration objects (program, PID, and MPTS passthrough).

Table 59 - VideoSession Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
Name	String	No	0..32		""

Table 60 - VideoSession Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VideoInputTs	Directed aggregation to VideoInputTs	0..*		VideoInputTs
VideoOutputTs	Association to VideoOutputTS	0..*	1..*	VideoOutputTsIndex

6.5.5.22.1 Index

This is the index for the configured session.

6.5.5.22.2 Name

This attribute is the name of the session. Unique names are given to each instance of a session type.

6.5.5.23 ProgramSession

The ProgramSession object allows the identification, encryption, processing and insertion of a single program stream into a VideoOutputTs. The CCAP MUST reject configurations with a ProgramSession object which does not have a VideoInputTs object associated with it.

Table 61 - ProgramSession Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
InputMpegProgramNum	UnsignedShort	Yes			
OutputMpegProgramNum	UnsignedShort	Yes			
PatPidRemap	Boolean	No			true
RequestedBandwidth	UnsignedInt	No		bps	0

To define a ProgramSession object you need to specify either a "unicast" or a "multicast" TSVideoInput object.

Table 62 - ProgramSession Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VideoSession	Specialization of VideoSession			
CasInfo	Directed aggregation to CasInfo	0..*	0..1	CasInfoIndex
EncryptionData	Directed aggregation to EncryptionData	0..*	0..1	EncryptionDataIndex
EncryptControl	Directed aggregation to EncryptControl	0..*	0..1	EncryptControlIndex

6.5.5.23.1 InputMpegProgramNum

This attribute selects a specific program from the transport stream of the incoming video stream. This program number should be part of the incoming PAT. A value of 0 (zero) means that any incoming program number can be accepted.

6.5.5.23.2 OutputMpegProgramNum

This attribute specifies the program number to be present in the transport stream of the outgoing video stream. This program number will be part of the outgoing PAT.

6.5.5.23.3 PatPidRemap

A value of true indicates that the elementary stream PID of this input program can be remapped to the VideoOutputTs, as long as the PAT and PMT are updated. A value of false indicates that the same input elementary stream PID has to be used on the VideoOutputTs.

6.5.5.23.4 RequestedBandwidth

This attribute configures the expected bandwidth parameters for a static input video session described by this object. This parameter is used for encryption and video down channel output resources. A value of 0 (zero) means that no bandwidth validation is required.

6.5.5.24 MptsPassThruSession

The MptsPassThruSession object allows the identification and insertion of an unmodified MPTS into a VideoOutputTs. The CCAP MUST reject configurations that contain a MptsPassThruSession object and do not have a VideoInputTs object associated with it; this association is inherited through the abstract object VideoSession.

To define an MptsPassThruSession object, specify either a "unicast" or a "multicast" VideoInputTs object.

Table 63 - MptsPassThruSession Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VideoSession	Specialization of VideoSession			

6.5.5.25 PidSession

The PidSession object allows the identification, processing and insertion of a PID stream into a VideoOutputTs. The CCAP MUST reject configurations that contain a PidSession object and do not have a VideoInputTs object associated with it.

Table 64 - PidSession Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
InputPid	HePidValue	Yes	0..8191 | 65535		
PidRemapEnable	Boolean	No			false
PidType	Enum	Yes	other(1), emm(2), nit(3), cat(4), pat(5), fixed(6), eas(7), dsm-cc(8), eiss(9), etvbif(10), video(11), audio(12)		
CasId	HexBinary	No	size(8)		00000000
OutputPid	HePidValue	Yes			
OutputProgramNumber	UnsignedShort	No			

Table 65 - PidSession Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VideoSession	Specialization of VideoSession			

6.5.5.25.1 InputPid

This attribute identifies a specific PID stream in the input transport stream.

6.5.5.25.2 PidRemapEnable

This object configures whether or not the identified PID stream can be remapped when inserted in the VideoOutputTs.

6.5.5.25.3 PidType

This enumeration defines the type of the identified PID stream. This value is used to understand what anchor table (i.e., PAT, CAT) would need to be updated in case PidRemapEnable is set to True and a remap is required. In case of type "eas", the table sections of the PID stream may need to be interleaved with other table sections that would be present on the same OutputPid. "dsm-cc" is used for digital storage media command and control. "eiss" is used for ETV Integrated Signaling Streams (Stream type 0xC0 or 0x05 w-descriptor tag 0xA2). "etvbif" is used for ETV Binary Interchange Format (Stream type 0xC0 or 0x05 w-descriptor tag 0xA1 OR Stream Type 0X0B). "video" is used for MPEG2 video streams. "audio" is used for MPEG2 audio streams. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.25.4 CasId

This attribute allows a proper identification of the CAT table parameter(s) that need(s) to be updated when the PidType is set to "EMM", PidRemapEnable is set to True and a remap is required. This parameter is required in Simulcrypt operation when the CAT advertises more than one EMM PID streams. A value of 0 means that no CAS ID is associated with this PID Session.

6.5.5.25.5 OutputPid

This attribute defines the expected PID value of the identified PID stream when inserted in the VideoOutputTS. However, the OutputPid value cannot be guaranteed if the PidRemapEnable flag is set to True.

6.5.5.25.6 OutputProgramNumber

This attribute defines the output program number for the PID session.

6.5.5.26 Chassis

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.4.2, Chassis.

6.5.5.27 Decryptor

The Decryptor object provides for the configuration of a Decryptor module or modules in the CCAP that are used to decrypt encrypted content delivered to the CCAP.

Table 66 - Decryptor Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
CwTimeout	UnsignedInt	No		seconds	10

The Decryptor object has the following association.

Table 67 - Decryptor Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EcmdUsage	Directed composition to EcmdUsage	1	1..*	

6.5.5.27.1 Index

The Index is an unsigned, 32-bit identifier used as a key for this object.

6.5.5.27.2 CwTimeout

This attribute configures the length of time in seconds that the Decryptor should wait for an ECM Decoder (ECMD) before switching to a redundant unit.

6.5.5.28 EcmdUsage

The EcmdUsage object provides for the configuration of multiple decryption sessions. It is an intermediate object that provides linkages between Decryptor objects and the ECMD(s) associated with those encrypted streams. The ECMD object is defined in Section 6.5.5.29.

Table 68 - EcmdUsage Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
Priority	UnsignedInt	Yes			

The EcmdUsage object has the following association.

Table 69 - EcmdUsage Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Ecmd	Directed aggregation to Ecmd	1..*	1	EcmdIndex

6.5.5.28.1 Index

This is an index for an instance of this Object. The EcmdUsage object is a pointer to the Ecmd object that can be used for any program session that requires decryption as long as the CAS identifier of the input program matches.

6.5.5.28.2 Priority

This is the configured selection priority for any program session that requires decryption when multiple ECMDs with the same CAS identifier are active. The ECMD with the lowest number should be selected first.

6.5.5.29 Ecmd

This object allows for the configuration of the interface to an Entitlement Control Message Decoder (ECMD).

Table 70 - Ecmd Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
NumberDecryptedStreams	UnsignedInt	Yes			

Table 71 - Ecmd Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Ecm	Specialization of Ecm			

6.5.5.29.1 NumberDecryptedStreams

The maximum number of decrypted streams the ECMD should handle.

6.5.5.30 Ecm

This abstract object holds the common attributes of ECMD and ECMG instances.

Table 72 - Ecm Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
Server	Host	Yes			
ServerPort	InetPortNum	Yes			
CasId	HexBinary	Yes	size(8)		

6.5.5.30.1 Index

The Index is an unsigned, 32-bit identifier used as a key for this object.

6.5.5.30.2 Server

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the ECMD/ECMG Server.

The CCAP MUST support configuring an IP address for the ECMD/ECMG Server attribute.

The CCAP SHOULD support configuring an FQDN for the ECMD/ECMG Server attribute.

Encryption code words are sent to this address and ECMs are received from this address.

6.5.5.30.3 ServerPort

This is the far-end TCP port for communication.

6.5.5.30.4 CasId

This attribute defines the CA System ID that the ECMD/ECMG will use.

6.5.5.31 Slot

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.4.4.

6.5.5.32 LineCard

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.4.5.

6.5.5.33 RfLineCard

This configuration object is included in Figure 25 for reference. It is defined in Section 6.5.4.6.

6.5.5.34 Encryptor

This object allows for the configuration of an Encryptor. Each Encryptor object is part of a DLC. Each can be associated with one active and zero or more backup ECMGs. For Simulcrypt, the Encryptor would be associated with multiple active ECMGs, each for a different CAS. An Encryptor object contains the attributes in the following table.

Table 73 - Encryptor Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
CaEncryptorType	Enum	Yes	other(1), motorola(2), cisco(3), simulcrypt(4),		
ClearStreamTimeout	UnsignedShort	No		seconds	10
EcmTimeout	UnsignedShort	No		seconds	10

Encryptor has the following association.

Table 74 - Encryptor Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EcmgUsage	Directed composition to EcmgUsage	1	0..*	

6.5.5.34.1 Index

This is an index for an instance of this object.

6.5.5.34.2 CaEncryptorType

This enumeration defines the type of CA encryption the Encryptor uses. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.5.34.3 ClearStreamTimeout

This configured attribute defines the number of seconds a given stream may be sent in the clear when the stream is configured to be encrypted. If this timer expires and the session has not received any encryption information from the ECMG, the CCAP MUST discontinue forwarding this stream.

6.5.5.34.4 EcmTimeout

This attribute configures the number of seconds that a CCAP will wait to get a response from an ECMG before switching to the redundant unit.

6.5.5.35 EcmgUsage

The EcmgUsage object provides for the configuration of multiple encryption sessions. It is an intermediate object that provides linkages between Encryptor objects and the ECMG(s) associated with those encrypted streams. The ECMG object is defined in Section 6.5.5.36.

Table 75 - EcmgUsage Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
Priority	UnsignedInt	Yes			

The EcmgUsage object has the following association.

Table 76 - EcmgUsage Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Ecmg	Directed aggregation to Ecmg	1..*	1	EcmgIndex

6.5.5.35.1 Index

This is an index for an instance of this object. It is a pointer to an active Ecmg object that can be used for any program session that requires encryption as long as the CAS identifier matches.

6.5.5.35.2 Priority

This is the configured selection priority for any program session that requires encryption when multiple ECMGs with the same CAS identifier are active. The ECMG with the lowest number should be selected first.

6.5.5.36 Ecmg

This object allows for the configuration of the interface to an Entitlement Control Message Generator (ECMG). Redundant ECMGs for the same CAS may exist, each with the same CA_System_ID, with the priority determining which is currently in use by an Encryptor for a particular CAS. An Ecmg object contains the attributes in the following table.

Table 77 - Ecmg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
RecommendedCpDuration	UnsignedInt	Yes	1..*	seconds	
NumberEncryptedStreams	UnsignedInt	Yes		streams	

Table 78 - Ecmg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Ecm	Specialization of Ecm			

6.5.5.36.1 RecommendedCpDuration

The recommended cryptoperiod, in seconds, the ECMG should expect.

6.5.5.36.2 NumberEncryptedStreams

The maximum number of encrypted streams the ECMG should handle.

6.5.5.37 StaticUdpMapEncryption

This object allows for the configuration of encryption for all static UDP port-mapped sessions on a given downstream RF line card. When this object is associated with an RfLineCard instance, all static UDP port-mapped

sessions on that RF Line Card are configured for encryption per the associated encryption objects (the mandatory objects of EncryptControl and CasInfo, and the optional object EncryptionData).

If the StaticUdpMapEncryption object is configured without an association to an instance of EncryptControl or CasInfo, the CCAP MUST reject the configuration instance.

Since this functionality is not used by all operators, implementation of this configuration object in the CCAP is not mandatory; the CCAP MAY exclude this configuration object.

Table 79 - StaticUdpMapEncryption Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	Int	Yes			

Table 80 - StaticUdpMapEncryption Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EncryptControl	Directed aggregation to EncryptControl	0..*	0..1	EncryptControlIndex
CasInfo	Directed aggregation to CasInfo	0..*	0..1	CasInfoIndex
EncryptionData	Directed aggregation to EncryptionData	0..*	0..1	EncryptionDataIndex

6.5.5.37.1 Index

This attribute configures a unique index for an instance of this object.

6.5.6 DOCSIS Configuration Information Models

The objects in the following sections configure DOCSIS on the CCAP. They have been grouped logically for usability.

6.5.6.1 DOCSIS System Configuration Information Model

These objects define global DOCSIS configuration for the CCAP.

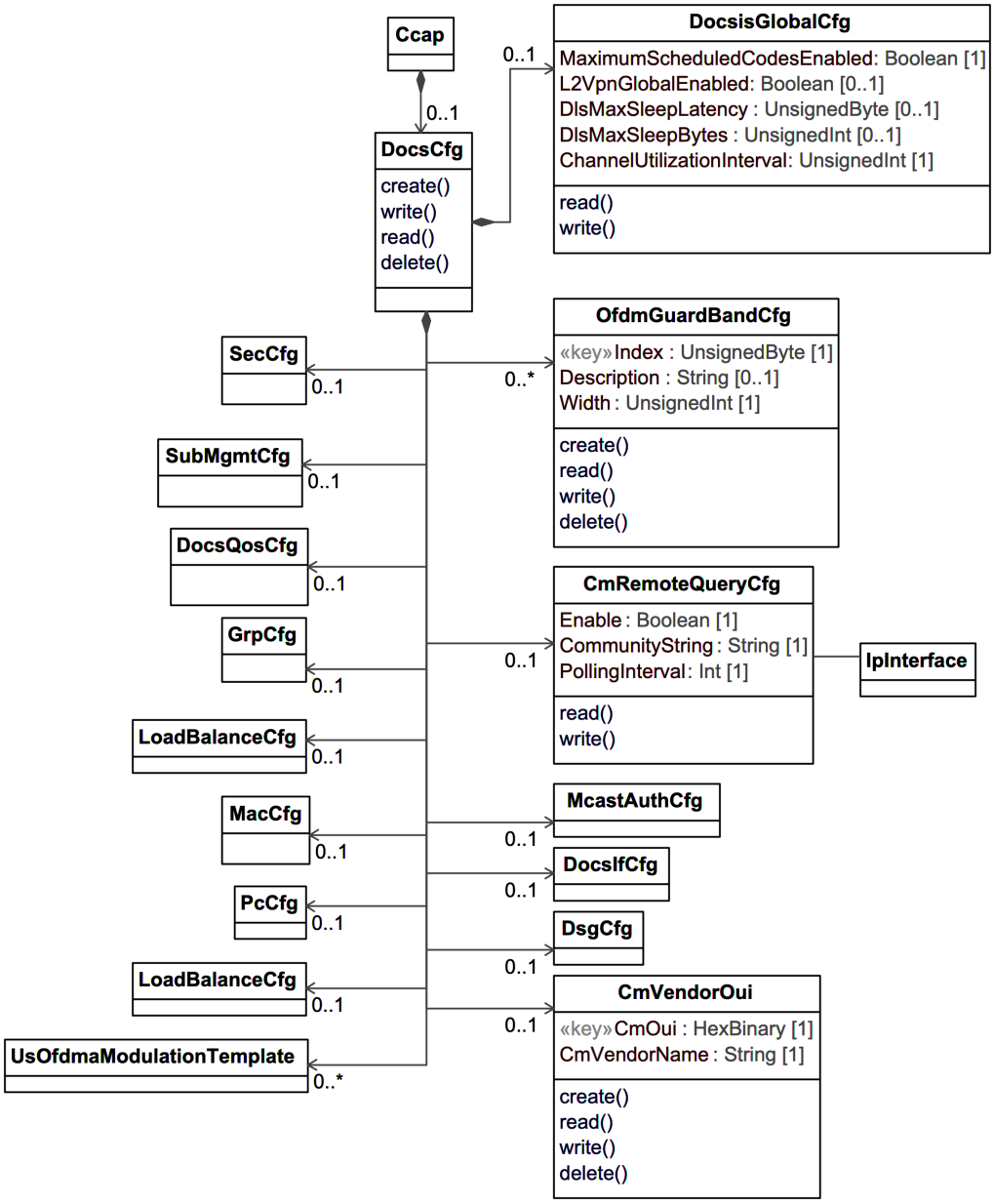


Figure 26 - DOCSIS System Configuration Information Model

6.5.6.1.1 Ccap

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.3.1.

6.5.6.1.2 DocsCfg

The DocsCfg object is the primary container of DOCSIS configuration objects. It has the following associations:

Table 81 - DocsCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SecCfg	Directed composition to SecCfg		0..1	
SubMgmtCfg	Directed composition to SubMgmtCfg		0..1	
DocsQosCfg	Directed composition to DocsQosCfg		0..1	
GrpCfg	Directed composition to GrpCfg		0..1	
MacCfg	Directed composition to MacCfg		0..1	
PcCfg	Directed composition to PcCfg		0..1	
LoadBalanceCfg	Directed composition to LoadBalanceCfg		0..1	
DocsisGlobalCfg	Directed composition to DocsisGlobalCfg		0..1	
OfdmGuardBandCfg	Directed composition to OfdmGuardBandCfg		0..*	
CmRemoteQueryCfg	Directed composition to CmRemoteQueryCfg		0..1	
McastAuthCfg	Directed composition to McastAuthCfg		0..1	
DocsIfCfg	Directed composition to DocsIfCfg		0..1	
DsgCfg	Directed composition to DsgCfg		0..1	
CmVendorOui	Directed composition to CmVendorOui		0..1	
UsOfdmaModulationTemplate	Directed composition to UsOfdmaModulationTemplate		0..*	

6.5.6.1.3 SecCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.2.3.

6.5.6.1.4 SubMgmtCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.3.3.

6.5.6.1.5 DocsQosCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.4.2.

6.5.6.1.6 GrpCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.5.3.

6.5.6.1.7 MacCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.6.3.

6.5.6.1.8 PcCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.11.2.

6.5.6.1.9 LoadBalanceCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.12.

6.5.6.1.10 DocsisGlobalCfg

The DocsisGlobalCfg object defines DOCSIS configuration attributes for the entire system, such as enabling Maximum Scheduled Codes and L2VPN.

Table 82 - DocsisGlobalCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
MaximumScheduledCodesEnabled	Boolean	Yes		1		
L2VpnGlobalEnabled	Boolean	No		0..1		False
DlsMaxSleepLatency	UnsignedByte	No	1..255	0..1	ms	100
DlsMaxSleepBytes	UnsignedInt	No	1..65535	0..1	bytes	1024
ChannelUtilizationInterval	UnsignedInt	Yes	0..86400	1	seconds	

6.5.6.1.10.1 MaximumScheduledCodesEnabled

Indicates the global state of the Maximum Scheduled Codes feature on the CCAP. The value true indicates that this feature can be enabled on individual logical channels on the CCAP. The value false indicates that the feature is not in operation on the CCAP. Note that the CCAP object attribute ScdmaChannelMscState enables or disables Maximum Scheduled Codes on a per logical channel basis.

6.5.6.1.10.2 L2VpnGlobalEnabled

This attribute will enable or disable on a global basis the configuration of L2VPN forwarding for all DOCSIS MAC domains. The default value is false. This attribute only enables L2VPN forwarding; configuration of the feature is handled in a vendor-specific way.

6.5.6.1.10.3 DlsMaxSleepLatency

This attribute specifies the CCAP configuration for the amount of time a CM would allow an upstream channel to queue the packets without transitioning to DLS wake state.

6.5.6.1.10.4 DlsMaxSleepBytes

This attribute specifies the CCAP configuration for the maximum number of bytes a CM would allow an upstream service flow to enqueue without transitioning to DLS wake state.

6.5.6.1.10.5 ChannelUtilizationInterval

This attribute configures the time interval in seconds over which the channel utilization index is calculated. All upstream and downstream channels use the same ChannelUtilizationInterval. Setting ChannelUtilizationInterval to a value of zero disables utilization reporting.

A channel utilization index is calculated over a fixed window applying to the most recent ChannelUtilizationInterval, as described in Annex C.13 CMTS Upstream Utilization Information.

It is left to vendor implementation whether to reset the timer when ChannelUtilizationInterval is changed during a utilization sampling period.

6.5.6.1.11 McastAuthCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.7.3.

6.5.6.1.12 DocsIfCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.8.2.

6.5.6.1.13 DsgCfg

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.10.2.

6.5.6.1.14 CmRemoteQueryCfg

This configuration object enables SNMP queries of CMs.

Table 83 - CmRemoteQueryCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Enable	Boolean	Yes			
CommunityString	String	Yes			
PollingInterval	Int	Yes		Seconds	

This object is associated with the source interface address on the CCAP.

Table 84 - CmRemoteQuery Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association to IpInterface			

6.5.6.1.14.1 Enable

This attribute configures whether or not CM remote query is enabled on the CCAP.

6.5.6.1.14.2 CommunityString

This attribute configures the SNMP Community String for remote queries.

6.5.6.1.14.3 PollingInterval

This attribute configures the minimum amount of time in seconds between consecutive polls of the same MIB object on the same cable modem.

6.5.6.1.15 CmVendorOui

This configuration object allows the operator to create a database of OUIs and Vendors.

Table 85 - CmVendorOui Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
CmOui	HexBinary	Yes (Key)	size(3)		
CmVendorName	String	Yes			

6.5.6.1.15.1 CmOui

This attribute configures the OUI portion of a given MAC address.

6.5.6.1.15.2 CmVendorName

This attribute configures the company name of the vendor with the associated OUI.

6.5.6.1.16 OfdmGuardBandCfg

This configuration object instantiates a list of guard band widths that can be associated with the upper and lower guard bands defined for an OFDM channel.

Table 86 - OfdmGuardBandCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedByte	Yes (Key)			
Description	String	No			""
Width	UnsignedInt	Yes	0 | 1000000..1770000000	Hz	

6.5.6.1.16.1 Index

This attribute configures a unique index for this guard band width.

6.5.6.1.16.2 Description

This attribute allows an optional description of the guard band to be added to help identify its uses.

6.5.6.1.16.3 Width

This attribute allows the width in Hertz of the guard band of the OFDM channel to be configured.

6.5.6.1.17 UsOfdmaModulationTemplate

This configuration object is included in Figure 26 for reference. It is defined in Section 6.5.6.8.17.

6.5.6.2 DOCSIS Security Configuration Information Model

This section details the DOCSIS configuration objects for Security features defined in DOCSIS 4.0. The information model for these features is below. Refer to [SECv4.0] for detailed security requirements.

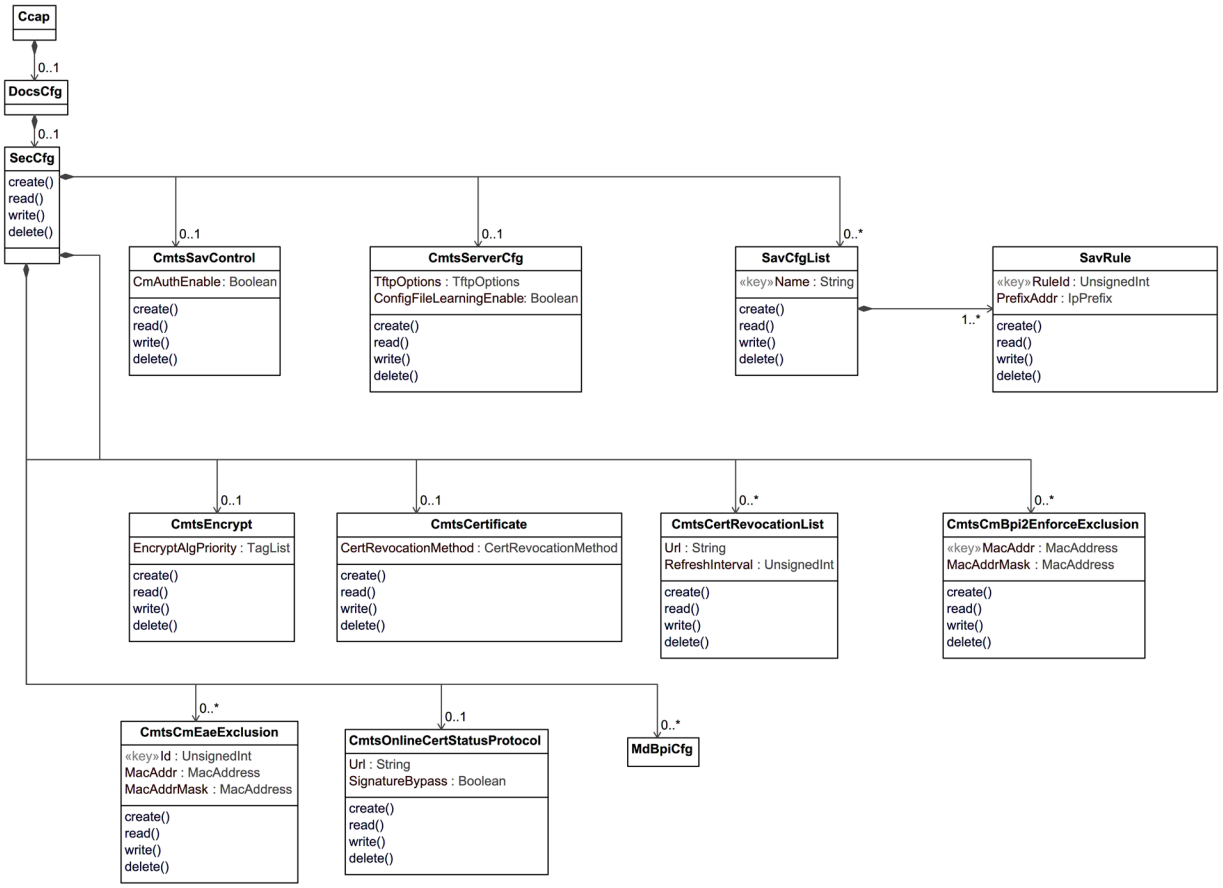


Figure 27 - DOCSIS Security Configuration Information Model

6.5.6.2.1 Ccap

This configuration object is included in Figure 27 for reference. It is defined in Section 6.5.3.1.

6.5.6.2.2 DocsCfg

This configuration object is included in Figure 27 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.2.3 SecCfg

The SecCfg object is the primary container of DOCSIS security configuration objects. It has the following associations:

Table 87 - SecCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SavCfgList	Directed composition to SavCfgList		0..*	
CmtsSavControl	Directed composition to CmtsSavControl		0..1	
CmtsServerCfg	Directed composition to CmtsServerCfg		0..1	
CmtsEncrypt	Directed composition to CmtsEncrypt		0..1	
CmtsCertificate	Directed composition to CmtsCertificate		0..1	
CmtsCertRevocationList	Directed composition to CmtsCertRevocationList		0..*	

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmEaeExclusion	Directed composition to CmtsCmEaeExclusion		0..*	
CmtsOnlineCertStatusProtocol	Directed composition to CmtsOnlineCertStatusProtocol		0..1	
MdBpiCfg	Directed composition to MdBpiCfg		0..*	
CmtsCmBpi2EnforceExclusion	Directed composition to CmtsCmBpi2EnforceExclusion		0..*	

6.5.6.2.4 SavCfgList

This configuration object allows for the configuration of a Source Address Verification (SAV) list which can contain one or more rules for the Prefixes that are managed by this group.

This object supports the creation and deletion of multiple instances. Each object instance defines one CMTS SAV list that will contain 1 or more SAV rules. The SavRule Object will provide the configuration of each of the configured subnet prefix extension for which the CCAP performs source address verification.

Creation of a new instance of this object requires the Name attribute to be set.

Reference: [OSSIv3.0], DOCS-SEC-MIB section

Table 88 - SavCfgList Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			

Table 89 - SavCfgList Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SavRule	Directed composition to SavRule		1..*	

6.5.6.2.4.1 Name

This attribute is the key that identifies the instance of the SavCmAuth object to which this object extension belongs.

6.5.6.2.5 SavRule

This object supports the creation and deletion of multiple instances. Each object instance defines one CMTS configured subnet prefix extension for which the CCAP performs source address verification.

Creation of a new instance of this object requires the RuleId and PrefixAddr attributes to be set.

The CMTS and CCAP MUST persist all instances of SavCfgList across reinitializations.

Table 90 - SavRule Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
RuleId	UnsignedInt	key	1..4294967295		
PrefixAddr	IpPrefix	Yes			

6.5.6.2.5.1 RuleId

This attribute is the key that identifies a particular subnet prefix rule of an instance of this object.

6.5.6.2.5.2 PrefixAddr

This attribute corresponds to the IP address and prefix length of this subnet prefix rule.

6.5.6.2.6 CmtsSavControl

This object defines attributes for global Source Address Verification (SAV) configuration.

The CMTS and CCAP MUST persist the values of the attributes of the CmtsSavCtrl object across reinitializations.

References: [SECv4.0] Secure Provisioning section.

Table 91 - CmtsSavCtrl Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
CmAuthEnable	Boolean	No			true

6.5.6.2.6.1 CmAuthEnable

This attribute enables or disables Source Address Verification (SAV) for CM configured policies in the SavCmAuth object. If this attribute is set to 'false', the CM configured policies in the SavCmAuth object are ignored.

This attribute is only applicable when the SrcAddrVerificationEnabled attribute of the MdCfg object is 'true'.

References: Section 6.5.6.6.4

6.5.6.2.7 CmtsServerCfg

This object defines attributes for configuring TFTP Configuration File Security features.

The CMTS and CCAP MUST persist the values of the attributes of the CmtsServerCfg object across reinitializations.

Table 92 - CmtsServerCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
TftpOptions	EnumBits	No	hwAddr(0) netAddr(1)		"H"
ConfigFileLearningEnable	Boolean	No			true

6.5.6.2.7.1 TftpOptions

This attribute instructs the CMTS to insert the source IP address and/or MAC address of received TFTP packets into the TFTP option fields before forwarding the packets to the Config File server.

This attribute is only applicable when the TftpProxyEnabled attribute of the MdCfg object is 'true'.

Setting bit 0 configures the CMTS to insert the MAC address of received TFTP packets into the TFTP option fields.

Setting bit 1 configures the CMTS to insert the source IP address of received TFTP packets into the TFTP option fields.

References: Section 6.5.6.6.4, MdCfg

6.5.6.2.7.2 ConfigFileLearningEnable

This attribute enables and disables Configuration File Learning functionality.

If this attribute is set to 'true' the CMTS will respond with Authentication Failure in the REG-RSP message when there is a mismatch between learned config file parameters and REG-REQ parameters. If this attribute is set to 'false', the CMTS will not execute config file learning and mismatch check.

This attribute is only applicable when the TftpProxyEnabled attribute of the MdCfg object is 'true'.

References: Section 6.5.6.6.4; [SECv4.0] Secure Provisioning section; [MULPIv4.0].

6.5.6.2.8 CmtsEncrypt

This object includes an attribute that defines the order in which encryption algorithms are to be applied.

The CMTS and CCAP MUST persist the values of the attributes of the CmtsEncrypt object across reinitializations.

Table 93 - CmtsEncrypt Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
EncryptAlgPriority	TagList	No	aes128CbcMode des56CbcMode des40CbcMode		"aes128CbcMode des56CbcMode des40CbcMode"

6.5.6.2.8.1 EncryptAlgPriority

This attribute allows for configuration of a prioritized list of encryption algorithms the CMTS will use when selecting the primary SAID encryption algorithm for a given CM. The CMTS selects the highest priority encryption algorithm from this list that the CM supports. By default, the following encryption algorithms are listed from highest to lowest priority (left being the highest): 128-bit AES, 56-bit DES, 40-bit DES.

An empty list indicates that the CMTS attempts to use the latest and robust encryption algorithm supported by the CM. The CMTS will ignore unknown values or unsupported algorithms.

6.5.6.2.9 CmtsCertificate

This object defines attributes for global certificate revocation configuration.

The CMTS and CCAP MUST persist the values of the attributes of the CertificateRevocationMethod object across reinitializations.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section.

Table 94 - CmtsCertificate Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
CertRevocationMethod	Enum	No	other(1), none(2), crl(3), ocsp(4), crlAndOcsp(5)		none

6.5.6.2.9.1 CertRevocationMethod

This attribute identifies which certificate revocation method is to be used by the CMTS to verify the cable modem certificate validity. The certificate revocation methods include Certification Revocation List (CRL) and Online Certificate Status Protocol (OCSP).

The following options are available:

- The option 'other' indicates a vendor extension is in use.
- The option 'none' indicates that the CMTS does not attempt to determine the revocation status of a certificate.
- The option 'crl' indicates the CMTS uses a Certificate Revocation List (CRL) as defined by the Url attribute of the CmtsCertRevocationList object. When the value of this attribute is changed to 'crl', it triggers the CMTS to retrieve the CRL file from the URL specified by the Url attribute. If the value of this attribute is

'crl' when the CMTS starts up, it triggers the CMTS to retrieve the CRL file from the URL specified by the Url attribute.

- The option 'ocsp' indicates the CMTS uses the Online Certificate Status Protocol (OCSP) as defined by the Url attribute of the CmtsOnlineCertStatusProtocol object.

The option 'crlAndOcsp' indicates the CMTS uses both the CRL as defined by the Url attribute in the CmtsCertRevocationList object and OCSP as defined by the Url attribute in the CmtsOnlineCertStatusProtocol object.

6.5.6.2.10 CmtsCertRevocationList

This object defines a CRL location URL and periodic refresh interval value. The CRL location URL defines from where the CCAP will retrieve the CRL file. The periodic refresh interval value indicates how often the CCAP will retrieve the CRL file for updates if the tbsCertList.nextUpdate attribute in the file is absent.

This object is only applicable when the CertRevocationMethod attribute of the CmtsCertificate object is set to "crl" or "crlAndOcsp".

The CMTS and CCAP MUST persist the values of the Url and RefreshInterval attributes of the CmtsCertRevocationList object across reinitializations.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section

Table 95 - CmtsCertRevocationList Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
Url	String	No	Uniform Resource Locator		""
RefreshInterval	UnsignedInt	No	1..524160	minutes	10080

6.5.6.2.10.1 Url

This attribute contains the URL from where the CMTS will retrieve the CRL file. When this attribute is set to a URL value different from the current value, it triggers the CMTS to retrieve the CRL file from that URL. If the value of this attribute is a zero-length string, the CMTS does not attempt to retrieve the CRL.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section.

6.5.6.2.10.2 RefreshInterval

This attribute contains the refresh interval for the CMTS to retrieve the CRL (referred to in the Url attribute) with the purpose of updating its Certificate Revocation List. This attribute is meaningful if the tbsCertList.nextUpdate attribute does not exist in the last retrieved CRL.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section.

6.5.6.2.11 CmtsCmEaeExclusion

This object defines a list of CMs or CM groups to exclude from Early Authentication and Encryption (EAE). This object allows overrides to the value of EAE Control for individual CMs or group of CMs for purposes such as debugging.

The CMTS and CCAP MUST support a minimum of 30 instances of the CmtsCmEaeExclusion object.

This object is only applicable when the EarlyAuthEncryptCtrl attribute of the MdCfg object is enabled.

This object supports the creation and deletion of multiple instances.

The CMTS and CCAP MUST persist all instances of CmtsCmEaeExclusion across reinitializations.

References: Section 6.5.6.6.4; [SECv4.0] Early Authentication and Encryption section.

Table 96 - CmtsCmEaeExclusion Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
Id	UnsignedInt	key	1..4294967295		
MacAddr	MacAddress	No			'000000000000'H
MacAddrMask	MacAddress	No			'FFFFFFFFFFFF'H

6.5.6.2.11.1 Id

This key uniquely identifies the exclusion MAC address rule.

6.5.6.2.11.2 MacAddr

This attribute identifies the CM MAC address. A match is made when a CM MAC address bitwise ANDed with the MacAddrMask attribute equals the value of this attribute.

6.5.6.2.11.3 MacAddrMask

This attribute identifies the CM MAC address mask and is used with the MacAddr attribute.

6.5.6.2.12 CmtsOnlineCertStatusProtocol

This object contains an OCSP Responder URL and an attribute to bypass signature checking of the OCSP response, as detailed in [RFC 2560]. The CCAP will use the URL for OCSP communications in checking a certificate's revocation status. This object is only applicable when the CertRevocationMethod attribute of the CmtsCertificate object is set to "ocsp" or "crlAndOcsp".

The CMTS and CCAP MUST persist the values of the attributes of the CmtsOnlineCertStatusProtocol object across reinitializations.

Table 97 - CmtsOnlineCertStatusProtocol Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
Url	String	No	Uniform Resource Locator		""
SignatureBypass	Boolean	No			false

6.5.6.2.12.1 Url

This attribute contains the URL string to retrieve OCSP information. If the value of this attribute is a zero-length string, the CMTS does not attempt to request the status of a CM certificate.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section; [RFC 2560].

6.5.6.2.12.2 SignatureBypass

This attribute enables or disables signature checking on OCSP response messages.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section; [RFC 2560].

6.5.6.2.13 CmtsCmBpi2EnforceExclusion

This object defines a list of CMs or CM groups to exclude from BPI+ enforcement policies configured within the CMTS. This object allows overrides to the value of BPI+ enforcement control for individual CMs or group of CMs for purposes such as debugging. The CMTS MUST support a minimum of 30 instances of the CmtsCmBpi2EnforceExclusion object.

This object supports the creation and deletion of multiple instances.

The CMTS MUST persist all instances of CmtsCmBpi2EnforceExclusion across reinitializations.

References: Section 6.5.6.6.4; [SECv4.0] BPI+ Enforce section.

Table 98 - CmtsCmBpi2EnforceExclusion Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
MacAddr	MacAddress	Yes(key)			
MacAddrMask	MacAddress	No			'FFFFFFFFFFFF'H

6.5.6.2.13.1 MacAddr

This attribute identifies the CM MAC address. A match is made when a CM MAC address bitwise ANDed with the MacAddrMask attribute equals the value of this attribute.

6.5.6.2.13.2 MacAddrMask

This attribute identifies the CM MAC address mask and is used with the MacAddr attribute.

6.5.6.2.14 MdBpiCfg

This object is defined in the MAC Domain Configuration Information Model in Section 6.5.6.6.5.

6.5.6.3 DOCSIS Subscriber Management Configuration Information Model

The Subscriber Management capabilities of the CMTS may be leveraged to control groups of CMs for the upstream and downstream direction of flow independently. Through configuration of group labels in the CM's configuration profile, a given CM's upstream and downstream filtering can be enforced directly at the CMTS, or delegated (in the case of the upstream direction only) to the CM (refer to [CM-OSSIv4.0] for CM Protocol Filtering).

This model provides the Subscriber Management CMTS enforcement of packet filtering policies for CMs and CPE behind the CM, including maximum number of CM CPEs. The Subscriber Management model provides the CMTS with policy management of upstream and downstream filtering traffic on a CM basis through DOCSIS defined CPE types. The components of the Subscriber Management configuration model include:

- Base, default configuration parameters
- FilterGrp, list of classifiers of a filter group

Subscriber Management aligns the packet classification parameters of the filter groups with the QoS classification criteria. To that extent, as an optional CMTS feature, a Subscriber Management Filter Group ID or a set of those IDs can be associated with Upstream Drop Classifier Group ID(s) (see [MULPIv4.0]). In this situation the CMTS Subscriber Management Filter groups are provisioned to the CM in the form of Upstream Drop Classifiers (UDCs) during the registration process.

This group of configuration elements allows for the configuration of the Subscriber Management rules. The configuration specific Information Model is shown below.

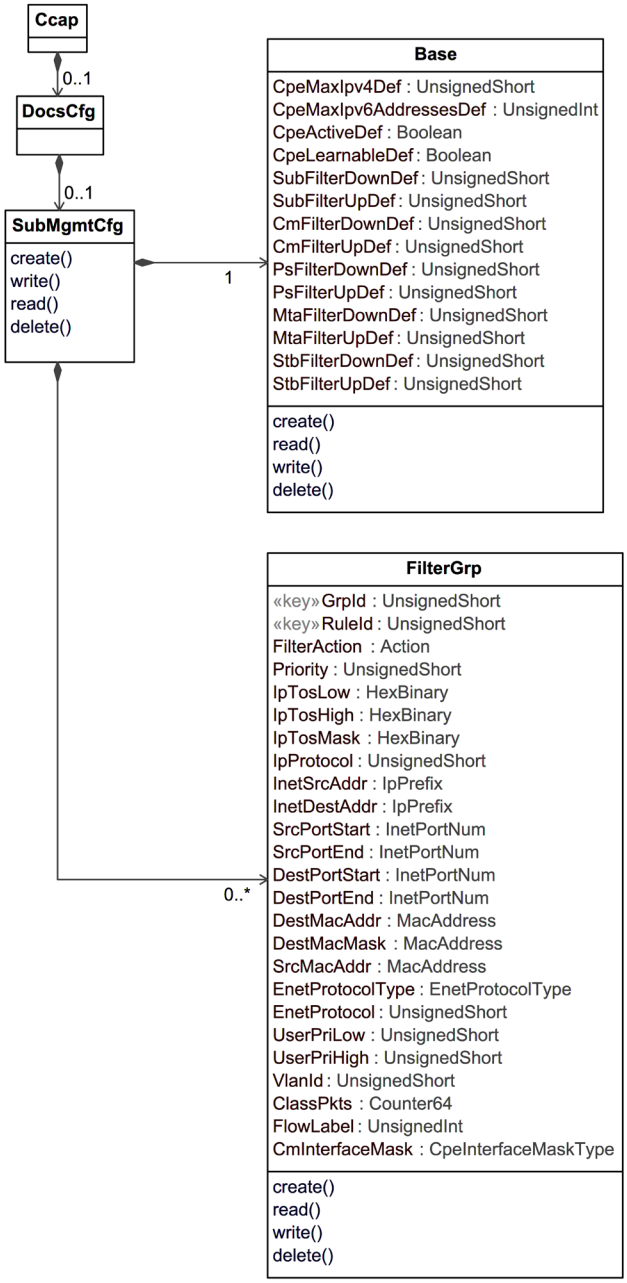


Figure 28 - DOCSIS Subscriber Management Configuration Information Model

6.5.6.3.1 Ccap

This configuration object is included in Figure 28 for reference. It is defined in Section 6.5.3.1.

6.5.6.3.2 DocsCfg

This configuration object is included in Figure 28 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.3.3 SubMgmtCfg

The SubMgmtCfg object is the primary container of DOCSIS security configuration objects. It has the following associations:

Table 99 - SubMgmtCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Base	Directed composition to Base		1	
FilterGrp	Directed composition to FilterGrp		0..*	

6.5.6.3.4 Base

The Base object defines the configuration parameters of Subscriber Management features for the CM in case the CM does not signal any of the parameters during the registration process.

Reference: [DOCS-SUBMGT3-MIB] docsSubmgt3Base group

Table 100 - Base Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
CpeMaxIpv4Def	UnsignedShort	No	0..1023		16
CpeMaxIpv6PrefixesDef	UnsignedShort	No	0..1023		3
CpeActiveDef	Boolean	No			false
CpeLearnableDef	Boolean	No			true
SubFilterDownDef	UnsignedShort	No	0..1024		0
SubFilterUpDef	UnsignedShort	No	0..1024		0
CmFilterDownDef	UnsignedShort	No	0..1024		0
CmFilterUpDef	UnsignedShort	No	0..1024		0
PsFilterDownDef	UnsignedShort	No	0..1024		0
PsFilterUpDef	UnsignedShort	No	0..1024		0
MtaFilterDownDef	UnsignedShort	No	0..1024		0
MtaFilterUpDef	UnsignedShort	No	0..1024		0
StbFilterDownDef	UnsignedShort	No	0..1024		0
StbFilterUpDef	UnsignedShort	No	0..1024		0

6.5.6.3.4.1 CpeMaxIpv4Def

This attribute represents the maximum number of IPv4 addresses allowed for the CM's CPE if not signaled in the registration process.

6.5.6.3.4.2 CpeMaxIpv6PrefixesDef

This attribute represents the maximum number of IPv6 IA_PDs (delegated prefixes) allowed for the CM's CPEs. IPv6 IA_PDs are counted against the 'CpeMaxIpv6PrefixesDef'. This contrasts with the CpeMaxIPv4AddressesDef attribute which controls the maximum number of individual IPv4 addresses. Because this attribute only counts IA_PDs against the default, IA_NA addresses and Link-Local addresses are not counted against this default limit.

6.5.6.3.4.3 CpeActiveDef

This attribute represents the default value for enabling Subscriber Management filters and controls in the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.4 CpeLearnableDef

This attribute represents the default value for enabling the CPE learning process for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.5 SubFilterDownDef

This attribute represents the default value for the subscriber (CPE) downstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.6 SubFilterUpDef

This attribute represents the default value for the subscriber (CPE) upstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.7 CmFilterDownDef

This attribute represents the default value for the CM stack downstream filter group applying to the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.8 CmFilterUpDef

This attribute represents the default value for the CM stack upstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.9 PsFilterDownDef

This attribute represents the default value for the PS or eRouter downstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.10 PsFilterUpDef

This attribute represents the default value for the PS or eRouter upstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.11 MtaFilterDownDef

This attribute represents the default value for the MTA downstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.12 MtaFilterUpDef

This attribute represents the default value for the MTA upstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.13 StbFilterDownDef

This attribute represents the default value for the STB downstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.4.14 StbFilterUpDef

This attribute represents the default value for the STB upstream filter group for the CM if the parameter is not signaled in the DOCSIS Registration process.

6.5.6.3.5 FilterGrp

The FilterGrp object describes a set of filter or classifier criteria. Classifiers are assigned by group to the individual CMs. That assignment is made via the "Subscriber Management TLVs" encodings sent upstream from the CM to the CCAP during registration, or in their absence, default values configured in the CCAP.

A Filter Group ID (GrpId) is a set of rules that correspond to the expansion of a UDC Group ID into individual UDC rules. The UDC Group IDs are linked to IDs of the FilterGrp object so the CCAP can signal those filter rules as UDCs to the CM during the registration process. Implementation of L2 classification criteria is optional for the CCAP; LLC/MAC upstream and downstream filter criteria can be ignored during the packet matching process.

Reference: [DOCS-SUBMGT3-MIB] docsSubmgt3FilterGrpTable

Table 101 - FilterGrp Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
GrpId	UnsignedShort	Key	1..1024		
RuleId	UnsignedShort	Key	1..65535		
FilterAction	Enum	No	other(0), permit(1), deny(2)		permit
Priority	UnsignedShort	No			0
IpTosLow	HexBinary	No	SIZE (1)		'00'H
IpTosHigh	HexBinary	No	SIZE (1)		'00'H
IpTosMask	HexBinary	No	SIZE (1)		'00'H
IpProtocol	UnsignedShort	No	0..257		256
InetSrcAddr	IpPrefix	No			''H
InetDestAddr	IpPrefix	No			''H
SrcPortStart	InetPortNumber	No			0
SrcPortEnd	InetPortNumber	No			65535
DestPortStart	InetPortNumber	No			0
DestPortEnd	InetPortNumber	No			65535
DestMacAddr	MacAddress	No			'000000000000'H
DestMacMask	MacAddress	No			'000000000000'H
SrcMacAddr	MacAddress	No			'FFFFFFFFFFFF'H
EnetProtocolType	Enum	No	other(1), none(2), ethertype(3), dsap(4), mac(5), all(6)		none
EnetProtocol	UnsignedShort	No			0
UserPriLow	UnsignedShort	No	0..7		0
UserPriHigh	UnsignedShort	No	0..7		7
VlanId	UnsignedShort	No	0 | 1..4094		0
ClassPkts	Counter64	No			
FlowLabel	UnsignedInt	No	0..1048575		0
CmInterfaceMask	CpeInterfaceMaskType	No			

6.5.6.3.5.1 GrpId

This key attribute is an identifier for a set of classifiers known as a filter group. Each CM may be associated with several filter groups for its upstream and downstream traffic, one group per target end point on the CM as defined in the Grp object. Typically, many CMs share a common set of filter groups. The range for this attribute is 1 to 1024 to align it with the values used in the Base Object.

6.5.6.3.5.2 RuleId

This key attribute represents an ordered classifier identifier within the group. Filters are applied in order if the Priority attribute is not supported.

6.5.6.3.5.3 FilterAction

This attribute represents the action to take upon this filter matching. 'permit' means to stop the classification matching and accept the packet for further processing. 'deny' means to drop the packet. 'other' indicates a vendor extension is in use.

6.5.6.3.5.4 Priority

This attribute defines the order in which the classifiers are compared against packets. The higher the value, the higher the priority.

6.5.6.3.5.5 IpTosLow

This attribute represents the low value of a range of ToS (Type of Service) octet values. The IP ToS octet, as originally defined in [RFC 791], has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). This attribute is defined as an 8-bit octet as per the DOCSIS Specification for packet classification.

References: [MULPIv4.0]; [RFC 791]; [RFC 3168]; [RFC 3260].

6.5.6.3.5.6 IpTosHigh

This attribute represents the high value of a range of ToS octet values. The IP ToS octet, as originally defined in [RFC 791], has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). This attribute is defined as an 8-bit octet as per the DOCSIS Specification for packet classification.

References: [MULPIv4.0]; [RFC 791]; [RFC 3168]; [RFC 3260].

6.5.6.3.5.7 IpTosMask

This attribute represents the mask value that is bitwise ANDed with ToS octet in an IP packet, and the resulting value is used for range checking of IpTosLow and IpTosHigh.

6.5.6.3.5.8 IpProtocol

This attribute represents the value of the IP Protocol field required for IP packets to match this rule. The value 256 matches traffic with any IP Protocol value. The value 257 by convention matches both TCP and UDP.

6.5.6.3.5.9 InetSrcAddr

This attribute specifies the value of the IP Source Address and mask required for packets to match this rule.

6.5.6.3.5.10 InetDestAddr

This attribute specifies the value of the IP Destination Address and mask required for packets to match this rule.

6.5.6.3.5.11 SrcPortStart

This attribute represents the low-end inclusive range of TCP/UDP source port numbers to which a packet is compared. This attribute is irrelevant for non-TCP/UDP IP packets.

6.5.6.3.5.12 SrcPortEnd

This attribute represents the high-end inclusive range of TCP/UDP source port numbers to which a packet is compared. This attribute is irrelevant for non-TCP/UDP IP packets.

6.5.6.3.5.13 DestPortStart

This attribute represents the low-end inclusive range of TCP/UDP destination port numbers to which a packet is compared. This attribute is irrelevant for non-TCP/UDP IP packets.

6.5.6.3.5.14 DestPortEnd

This attribute represents the high-end inclusive range of TCP/UDP destination port numbers to which a packet is compared. This attribute is irrelevant for non-TCP/UDP IP packets.

6.5.6.3.5.15 DestMacAddr

This attribute represents the criteria to match against an Ethernet packet MAC address bitwise ANDed with DestMacMask.

6.5.6.3.5.16 DestMacMask

An Ethernet packet matches an entry when its destination MAC address bitwise ANDed with the DestMacMask attribute equals the value of the DestMacAddr attribute.

6.5.6.3.5.17 SrcMacAddr

This attribute represents the value to match against an Ethernet packet source MAC address.

6.5.6.3.5.18 EnetProtocolType

This attribute indicates the format of the layer 3 protocol ID in the Ethernet packet. A value of 'none' means that the rule does not use the layer 3 protocol type as a matching criteria. A value of 'ethertype' means that the rule applies only to frames that contain an EtherType value. Ethertype values are contained in packets using the DEC-Intel-Xerox (DIX) encapsulation or the [RFC 1042] Sub-Network Access Protocol (SNAP) encapsulation formats. A value of 'dsap' means that the rule applies only to frames using the IEEE802.3 encapsulation format with a Destination Service Access Point (DSAP) other than 0xAA (which is reserved for SNAP). A value of 'mac' means that the rule applies only to MAC management messages for MAC management messages. A value of 'all' means that the rule matches all Ethernet packets. If the Ethernet frame contains an 802.1P/Q Tag header (i.e., EtherType 0x8100), this attribute applies to the embedded EtherType field within the 802.1p/Q header.

The value 'mac' is only used for passing UDCs to CMs during Registration. The CMTS ignores filter rules that include the value of this attribute set to 'mac' for CMTS enforced upstream and downstream subscriber management filter group rules.

The value 'other' indicates a vendor extension is in use.

References: [RFC 1042] Sub-Network Access Protocol (SNAP) encapsulation formats.

6.5.6.3.5.19 EnetProtocol

This attribute represents the Ethernet protocol type to be matched against the packets. For EnetProtocolType set to 'none', this attribute is ignored when considering whether a packet matches the current rule. If the attribute EnetProtocolType is 'ethertype', this attribute gives the 16-bit value of the EtherType that the packet needs to match in order to match the rule. If the attribute EnetProtocolType is 'dsap', the lower 8 bits of this attribute's value needs to match the DSAP byte of the packet in order to match the rule. If the Ethernet frame contains an 802.1p/Q Tag header (i.e., EtherType 0x8100), this attribute applies to the embedded EtherType field within the 802.1p/Q header.

6.5.6.3.5.20 UserPriLow

This attribute applies only to Ethernet frames using the 802.1p/Q tag header (indicated with EtherType 0x8100). Such frames include a 16-bit Tag that contains a 3-bit Priority field and a 12-bit VLAN number. Tagged Ethernet packets needs to have a 3-bit Priority field within the range of PriLow to PriHigh in order to match this rule.

6.5.6.3.5.21 UserPriHigh

This attribute applies only to Ethernet frames using the 802.1p/Q tag header (indicated with EtherType 0x8100). Such frames include a 16-bit Tag that contains a 3-bit Priority field and a 12-bit VLAN number. Tagged Ethernet packets needs to have a 3-bit Priority field within the range of PriLow to PriHigh in order to match this rule.

6.5.6.3.5.22 VlanId

This attribute applies only to Ethernet frames using the 802.1p/Q tag header. Tagged packets need to have a VLAN Identifier that matches the value in order to match the rule.

6.5.6.3.5.23 ClassPkts

This attribute counts the number of packets that have been classified (matched) using this rule entry. This includes all packets delivered to a Service Flow maximum rate policing function, whether or not that function drops the packets. Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the CM MAC Domain interface.

6.5.6.3.5.24 FlowLabel

This attribute represents the Flow Label field in the IPv6 header to be matched by the classifier.

The value zero indicates that the Flow Label is not specified as part of the classifier and is not matched against packets.

6.5.6.3.5.25 CmInterfaceMask

This attribute represents a bitmask of the CM in-bound interfaces to which this classifier applies. This attribute only applies to upstream Drop Classifiers being sent to CMs during the registration process.

6.5.6.4 DOCSIS QoS Configuration Information Model

This group of configuration elements allows for the configuration of DOCSIS QoS. The configuration-specific information model is shown below.

The QosProfile object has been deprecated and removed from Figure 29 since the DOCSIS 1.0 Class of Service (CoS) service class definition type was deprecated and is not supported in DOCSIS 4.0.

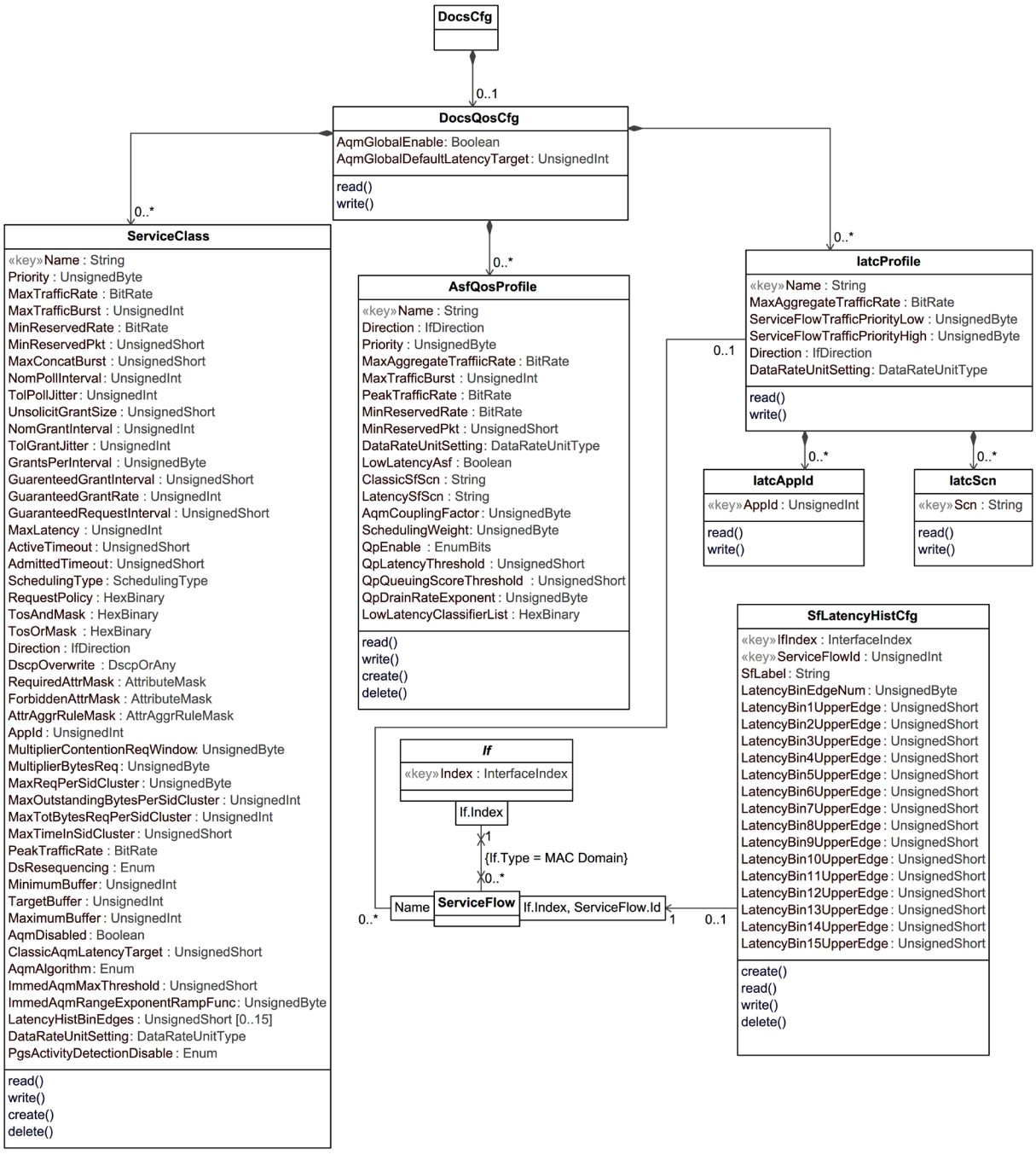


Figure 29 - DOCSIS QoS Configuration Information Model

6.5.6.4.1 DocsCfg

This configuration object is included in Figure 29 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.4.2 DocsQosCfg

The DocsQosCfg object is the primary container of DOCSIS QoS configuration objects. It also sets global parameters for DOCSIS 4.0 Active Queue Management features.

Table 102 - DocsQosCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
AqmGlobalEnable	Boolean	Yes			
AqmGlobalDefaultLatencyTarget	UnsignedInt	No		milliseconds	10

Table 103 - DocsQosCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceClass	Directed composition to ServiceClass		0..*	
AsfQosProfile	Directed composition to AsfQosProfile		0..*	
IatcProfile	Directed composition to IatcProfile		0..*	

6.5.6.4.2.1 AqmGlobalEnable

Indicates the global state of the Active Queue Management feature on the CCAP. The value true indicates that this feature can be enabled on individual service flows on the CCAP. The value false indicates that the feature is not in operation on the CCAP.

Reference: [MULPIv4.0] Active Queue Management section.

6.5.6.4.2.2 AqmGlobalDefaultLatencyTarget

This attribute configures the target latency for service flows operating under Active Queue Management.

Reference: [MULPIv4.0] Active Queue Management section.

6.5.6.4.3 ServiceClass

The ServiceClass object describes a provisioned service class on a CCAP. Each object instance defines a template for certain DOCSIS QoS Parameter Set values. When a CM creates or modifies an Admitted QoS Parameter Set for a Service Flow, it may reference a Service Class Name instead of providing explicit QoS Parameter Set values. In this case, the CCAP populates the QoS Parameter Set with the applicable corresponding values from the named Service Class. Subsequent changes to a Service Class row do not affect the QoS Parameter Set values of any service flows already admitted. A service class template applies to only a single direction, as indicated in the ServiceClassDirection attribute.

The CCAP MUST support creation and deletion of multiple instances of the ServiceClass object.

Table 104 - ServiceClass Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
Name	String	key	1..16	1		
Priority	UnsignedByte	No		1		0
MaxTrafficRate	BitRate	No		1		0
MaxTrafficBurst	UnsignedInt	No		1	bytes	See attribute description
MinReservedRate	BitRate	No		1		0
MinReservedPkt	UnsignedShort	No		1	bytes	CMTS Vendor specific
MaxConcatBurst	UnsignedShort	No		1	bytes	1522
NomPollInterval	UnsignedInt	No		1	microseconds	0
TolPollJitter	UnsignedInt	No		1	microseconds	0

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
UnsolicitGrantSize	UnsignedShort	No		1	bytes	0
NomGrantInterval	UnsignedInt	No		1	microseconds	0
TolGrantJitter	UnsignedInt	No		1	microseconds	0
GrantsPerInterval	UnsignedByte	No		1	datagrants	0
GuaranteedGrantInterval	UnsignedShort	No		1	microseconds	CMTS Vendor specific
GuaranteedGrantRate	BitRate	No		1		0
GuaranteedRequestInterval	UnsignedShort	No		1	microseconds	CMTS Vendor specific
MaxLatency	UnsignedInt	No		1	microseconds	0
ActiveTimeout	UnsignedShort	No		1	seconds	0
AdmittedTimeout	UnsignedShort	No		1	seconds	200
SchedulingType	SchedulingType	No		1		bestEffort
RequestPolicy	HexBinary	No		1		'00000000'H
TosAndMask	HexBinary	No	SIZE(1)	1		'FF'H
TosOrMask	HexBinary	No	SIZE(1)	1		'00'H
Direction	IfDirection	No		1		upstream
DscpOverwrite	DscpOrAny	No		1		-1
RequiredAttrMask	AttributeMask	No		1		'00000000'H
ForbiddenAttrMask	AttributeMask	No		1		'00000000'H
AttrAggregationMask	AttrAggrRuleMask	No		1		'00000000'H
AppId	UnsignedInt	No		1		0
MultiplierContentionReqWindow	UnsignedByte	No	4..12	1	eighths	8
MultiplierBytesReq	UnsignedByte	No	1 | 2 | 4 | 8 | 16	1		4
MaxReqPerSidCluster	UnsignedByte	No		1	requests	0
MaxOutstandingBytesPerSidCluster	UnsignedInt	No		1	bytes	0
MaxTotBytesReqPerSidCluster	UnsignedInt	No		1	bytes	0
MaxTimeInSidCluster	UnsignedShort	No		1	milliseconds	0
PeakTrafficRate	BitRate	No		1		0
DsResequencing	Enum	No	other(1), resequencingDsid(2), noResequencingDsid(3)	1		resequencingDsid
MinimumBuffer	UnsignedInt	No		1	bytes	0
TargetBuffer	UnsignedInt	No		1	bytes	0
MaximumBuffer	UnsignedInt	No	0..4294967295	1	bytes	4294967295
AqmDisabled	Boolean	No		1		'false'
ClassicAqmLatencyTarget	UnsignedShort	No	0..256	1	milliseconds	0

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
AqmAlgorithm	Enum	No	defaultAqmForSf(0), docsisPIE(1), immediateAqm(2)	1		0
ImmedAqmMaxThreshold	UnsignedShort	No		1	microseconds	1000
ImmedAqmRangeExponentRampFunc	UnsignedByte	No		1	log_2(nanoseconds)	19
LatencyHistBinEdges	UnsignedShort	No		0..15	10 microseconds	Empty array
DataRateUnitSetting	DataRateUnitType	No		1		'bps'
PgsActivityDetectionDisable	Boolean	No		1		false

6.5.6.4.3.1 Name

This key indicates the Service Class Name associated with this object instance. DOCSIS specifies that the maximum size is 16 ASCII characters including a terminating zero.

References: [MULPIv4.0] Service Class Name section in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.5.6.4.3.2 Priority

This attribute is the template for the Priority attribute of the QoS Parameter Set.

6.5.6.4.3.3 MaxTrafficRate

This attribute is the template for the MaxTrafficRate attribute of the QoS Parameter Set.

This attribute represents the 4-byte value of the maximum sustained traffic rate allowed for this Service Flow. All MAC frame data PDUs from the bytes following the MAC header HCS to the end of the CRC are included in calculating the maximum sustained traffic rate. The number of bytes forwarded is limited during any time interval. The value 0 indicates no maximum traffic rate is enforced. The value of the DataRateUnitSetting attribute defines the units of MaxTrafficRate. This attribute applies to both upstream and downstream Service Flows. This attribute also returns 0 if the referenced parameter is not present in the corresponding DOCSIS QOS Parameter Set, or if the parameter is not applicable.

6.5.6.4.3.4 MaxTrafficBurst

This attribute is the template for the MaxTrafficBurst attribute of the QoS Parameter Set. If this value is not set, the default for DOCSIS 3.0 is 3044, and for DOCSIS 4.0 the default value is 3044, or 4000 if support for extended packet size is enabled.

6.5.6.4.3.5 MinReservedRate

This attribute is the template for the MinReservedRate attribute of the QoS Parameter Set.

This attribute represents the 4-byte value of the guaranteed minimum rate allowed for this Service Flow. The value is calculated from the byte following the MAC header HCS to the end of the CRC. The value 0 indicates that no bandwidth is reserved. The value of the DataRateUnitSetting attribute defines the units of MinReservedRate. This attribute also returns 0 if the referenced parameter is not present in the corresponding DOCSIS QOS Parameter Set, or if the parameter is not applicable.

6.5.6.4.3.6 MinReservedPkt

This attribute is the template for the MinReservedPkt attribute of the QoS Parameter Set. Vendor-dependent.

6.5.6.4.3.7 MaxConcatBurst

This attribute is the template for the MaxConcatBurst attribute of the QoS Parameter Set. MaxConcatBurst only applies to pre-DOCSIS 3.1 devices.

6.5.6.4.3.8 NomPollInterval

This attribute is the template for the NomPollInterval attribute of the QoS Parameter Set.

6.5.6.4.3.9 TolPollJitter

This attribute is the template for the TolPolJitter attribute of the QoS Parameter Set.

6.5.6.4.3.10 UnsolicitGrantSize

This attribute is the template for the UnsolicitGrantSize attribute of the QoS Parameter Set.

6.5.6.4.3.11 NomGrantInterval

This attribute is the template for the NomGrantInterval attribute of the QoS Parameter Set.

6.5.6.4.3.12 TolGrantJitter

This attribute is the template for the TolGrantJitter attribute of the QoS Parameter Set.

6.5.6.4.3.13 GrantsPerInterval

This attribute is the template for the GrantsPerInterval attribute of the QoS Parameter Set.

6.5.6.4.3.14 GuaranteedGrantInterval

This attribute is the template for the GuaranteedGrantInterval attribute of the QoS Parameter Set.

6.5.6.4.3.15 GuaranteedGrantRate

This attribute is the template for the GuaranteedGrantRate attribute of the QoS Parameter Set, which specifies the minimum granting rate for an upstream PGS service flow. The value of the DataRateUnitSetting attribute defines the units of GuaranteedGrantRate.

6.5.6.4.3.16 GuaranteedRequestInterval

This attribute is the template for the GuaranteedRequestInterval attribute of the QoS Parameter Set.

6.5.6.4.3.17 MaxLatency

This attribute is the template for the MaxLatency attribute of the QoS Parameter Set.

6.5.6.4.3.18 ActiveTimeout

This attribute is the template for the ActiveTimeout attribute of the QoS Parameter Set.

6.5.6.4.3.19 AdmittedTimeout

This attribute is the template for the AdmittedTimeout attribute of the QoS Parameter Set.

6.5.6.4.3.20 SchedulingType

This attribute is the template for the SchedulingType attribute of the QoS Parameter Set. A value of 'other' indicates a vendor extension is in use.

6.5.6.4.3.21 RequestPolicy

This attribute is the template for the RequestPolicyOct attribute of the QoS Parameter Set.

6.5.6.4.3.22 TosAndMask

This attribute is the template for the TosAndMask attribute of the QoS Parameter Set.

6.5.6.4.3.23 TosOrMask

This attribute is the template for the TosOrMask attribute of the QoS Parameter Set.

6.5.6.4.3.24 Direction

This attribute is the template for the Direction attribute of the QoS Parameter Set. A value of 'other' indicates a vendor extension is in use.

6.5.6.4.3.25 DscpOverwrite

This attribute allows the overwrite of the DSCP field per [RFC 3260].

If this attribute is -1, then the corresponding TosAndMask value is set to be 'FF'H and TosOrMask is set to '00'H. Otherwise, this attribute is in the range of 0..63, and the corresponding TosAndMask value is '03'H and TosOrMask value is this attribute value shifted left by two bit positions.

6.5.6.4.3.26 RequiredAttrMask

This attribute is the template for the RequiredAttrMask attribute of the QoS Parameter Set.

6.5.6.4.3.27 ForbiddenAttrMask

This attribute is the template for the ForbiddenAttrMask attribute of the QoS Parameter Set.

6.5.6.4.3.28 AttrAggrRuleMask

This attribute is the template for the AttrAggregationMask attribute of the QoS Parameter Set.

6.5.6.4.3.29 AppId

This attribute is the template for the AppId attribute of the QoS Parameter Set.

6.5.6.4.3.30 MultiplierContentionReqWindow

This attribute is the template for the MultiplierContentionReqWindow attribute of the QoS Parameter Set.

6.5.6.4.3.31 MultiplierBytesReq

This attribute is the template for the MultiplierBytesReq attribute of the QoS Parameter Set.

6.5.6.4.3.32 MaxReqPerSidCluster

This attribute is the template for the MaxReqPerSidCluster attribute of the QoS Parameter Set. A value of 0 means unlimited.

6.5.6.4.3.33 MaxOutstandingBytesPerSidCluster

This attribute is the template for the MaxOutstandingBytesPerSidCluster attribute of the QoS Parameter Set. A value of 0 means unlimited.

6.5.6.4.3.34 MaxTotBytesReqPerSidCluster

This attribute is the template for the MaxTotBytesReqPerSidCluster attribute of the QoS Parameter Set. A value of 0 means unlimited.

6.5.6.4.3.35 MaxTimeInSidCluster

This attribute is the template for the MaxTimeInSidCluster attribute of the QoS Parameter Set. A value of 0 means unlimited.

6.5.6.4.3.36 PeakTrafficRate

This attribute is the template for the PeakTrafficRate attribute of the QoS Parameter Set.

This attribute represents the 4-byte value of the guaranteed minimum rate allowed for this Service Flow. The value is calculated from the byte following the MAC header HCS to the end of the CRC. The value 0 indicates that no bandwidth is reserved. The value of the DataRateUnitSetting attribute defines the units of PeakTrafficRate. This attribute also returns 0 if the referenced parameter is not present in the corresponding DOCSIS QOS Parameter Set, or if the parameter is not applicable.

6.5.6.4.3.37 DsResequencing

This attribute is the template for the DsResequencing attribute of the QoS Parameter Set. A value of 'other' indicates a vendor extension is in use.

6.5.6.4.3.38 MinimumBuffer

This attribute is the template for the MinimumBuffer attribute of the QoS Parameter Set.

6.5.6.4.3.39 TargetBuffer

This attribute is the template for the TargetBuffer attribute of the QoS Parameter Set. A value of 0 means that a vendor-specific default value is used.

6.5.6.4.3.40 MaximumBuffer

This attribute is the template for the MaximumBuffer attribute of the QoS Parameter Set. A value of 4294967295 means unlimited.

6.5.6.4.3.41 AqmDisabled

If AqmGlobalEnable in the DocsQosCfg object is set to 'true', this attribute indicates the state of the Active Queue Management feature for this ServiceClass. The value 'true' indicates that this feature is disabled for this service class. The value 'false' indicates that this feature is enabled for this service class. This attribute applies to both upstream and downstream service flows. If AqmGlobalEnable in the DocsQosCfg object is set to 'false', this attribute is ignored.

Reference: [MULPIv4.0] Active Queue Management section.

6.5.6.4.3.42 ClassicAqmLatencyTarget

This attribute configures the target latency for this service flow when operating under Classic Active Queue Management (e.g., DOCSIS-PIE). If the value of this attribute is 0, the CMTS will use the value of DocsQosCfg::AqmGlobalDefaultLatencyTarget for service flows operating under Classic Active Queue Management. If the value of this attribute is 256, the TLV corresponding to this attribute is not sent during service flow creation unless the corresponding TLV was sent as an overriding Service Flow parameter in the Registration Request message. This attribute applies to both upstream and downstream service flows. This attribute is only used when the Active Queue Management feature is globally enabled on the CMTS and the Active Queue Management feature is enabled for service flows in this service class (ServiceClass::AqmDisabled = 'false'). This parameter will be ignored if the AQM Algorithm used by the Service Flow is ImmediateAqm.

Reference: [MULPIv4.0] Active Queue Management section.

6.5.6.4.3.43 AqmAlgorithm

This attribute configures the AQM algorithm to be used by the Service Flow. If the AqmAlgorithm attribute is not provided, the CCAP MUST use a default value of '0'. The value '0' specifies the default AQM for the type of Service Flow, as shown below:

Table 105 - Default AQM for Type of Service Flow

Type of Service Flow	Default AQM Specified by Value 0
Single SF	docsisPIE
Classic SF of a Low Latency ASM	docsisPIE
Low Latency SF of a Low Latency ASF	ImmediateAqm

Reference: [MULPIv4.0] Active Queue Management section.

6.5.6.4.3.44 ImmedAqmMaxThreshold

This attribute configures the maximum threshold, in microseconds, of the ramp function used by the Immediate AQM algorithm and the Queue Protection algorithm.

Reference: [MULPIv4.0] Active Queue Management section.

6.5.6.4.3.45 ImmedAqmRangeExponentRampFunc

This attribute configures the range, in nanoseconds, of the ramp function used by the Immediate AQM algorithm and the Queue Protection algorithm.

6.5.6.4.3.46 LatencyHistBinEdges

This attribute provides read-create access to the CCAP to configure Downstream Queue Latency Estimates Histogram bin edges, using a method that is an alternative to using TLV Type [24/25].40.6 *Latency Histogram Encodings* defined in [MULPIv4.0] section C.2.2.9.15.6 *Latency Histogram Encodings*. The attribute is formatted as an array of unsigned 16-bit integers, each representing a histogram bin edge in units of 10 microseconds.

The size of the array can range from 0 to 15. Size 0 means the LatencyHistBinEdges array is not present or empty. The default value for this attribute is an empty array.

Configuring one or more nonzero Downstream Queue Latency Estimates Histogram bin edges causes the CCAP to calculate queue latency estimate histogram results for any downstream service flow using the Service Class parameters. If LatencyHistBinEdges is not present or empty for a ServiceClass instance, the instance has no effect on whether a Queue Latency Estimates Histogram is calculated for a service flow.

If an operator would like the CCAP to calculate the Queue Latency Estimates Histogram for a service flow that uses a particular Service Class, the operator can create an instance of the ServiceClass object and configure the LatencyHistBinEdges attribute with n bin edge values. For any downstream service flow that is subsequently created and uses the Service Class defined by the instance, the CCAP is required to calculate a Queue Latency Estimate Histogram with n + 1 bins for the service flow.

Reference: [MULPIv4.0] section C.2.2.9.15.6 Latency Histogram Encodings

6.5.6.4.3.47 DataRateUnitSetting

This attribute indicates the base unit for the Service Class traffic rate configuration attributes Maximum Sustained Traffic Rate (MaxTrafficRate), Minimum Reserved Traffic Rate (MinReservedRate), Peak Traffic Rate (PeakTrafficRate), and Guaranteed Grant Rate (GuaranteedGrantRate). The value of this attribute allows for their interpretation in units of bps, kbps, Mbps, or Gbps. The default value for DataRateUnitSetting is bps.

6.5.6.4.3.48 PgsActivityDetectionDisable

This attribute enables or disables the activity detection function for an upstream service flow with the Proactive Grant Service scheduling type.

The value 'false' configures the CMTS to switch an upstream PGS service flow between a polling mode and a granting mode based on detection of upstream activity.

The value 'true' configures the CMTS to continuously provide grants for an upstream PGS service flow that comply with the configured Guaranteed Grant Rate and Guaranteed Grant Interval parameters, regardless of upstream activity.

6.5.6.4.4 AsfQosProfile

This object describes a provisioned ASF QoS Profile (AQP) for Aggregate Service Flows (ASF) on a CCAP. Each object instance defines a template for certain DOCSIS QoS Parameter Set values. When an Aggregate Service Flow is created, it may reference an AQP Name instead of providing explicit QoS Parameter Set values. In this case, the CCAP populates the QoS Parameter Set with the applicable corresponding values from the named AQP Name or Service Class Name. Subsequent changes to an AQP Name row do not affect the QoS Parameter Set values of any service flows already admitted. An AQP template applies to only a single direction, as indicated in the Direction attribute. AsfQosProfile for ASF is an equivalent to Service Class for a Service Flow. The object as defined in this specification contains the following standardized QoS parameters defined in the table below. Other aggregate QoS parameters can be added through vendor-specific extensions.

The CCAP MUST support creation and deletion of multiple instances of the AsfQosProfile object.

Table 106 - AsfQosProfile Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	AdminString	key	1..16		
Direction	IfDirection	Yes			
Priority	UnsignedByte	No			0
MaxAggregateTrafficRate	BitRate	No			0
MaxTrafficBurst	UnsignedInt	No		bytes	3044 (extended packet size disabled) 4000 (extended packet size enabled)
PeakTrafficRate	BitRate	No			0
MinReservedRate	BitRate	No			0
MinReservedPkt	UnsignedShort	No		bytes	
DataRateUnitSetting	DataRateUnitType	No			'bps'
LowLatencyAsf	Boolean	No			true
ClassicSfScn	String	No			
LatencySfScn	String	No			
AqmCouplingFactor	UnsignedByte	No	0..255	Tenths	20
SchedulingWeight	UnsignedByte	No			230
QpEnable	EnumBits	No	queueProtection(0)		0x01 Bit 0 = Queue Protection enable (1)
QpLatencyThreshold	UnsignedShort	No		microseconds	See [MULPIv4.0] Annex C
QpQueuingScoreThreshold	UnsignedShort	No		microseconds	4000
QpDrainRateExponent	UnsignedByte	No		$\log_2$(bytes/sec)	19
LowLatencyClassifierList	HexBinary	No			See 6.5.6.4.4.19

6.5.6.4.4.1 Name

This key indicates the ASF QoS Profile Name associated with this object instance. [MULPIv4.0] defines this attribute as a null-terminated string of no more than 16 ASCII characters.

6.5.6.4.4.2 Direction

This attribute is the template for the Direction attribute of the AsfQosProfile.

6.5.6.4.4.3 Priority

This attribute is the template for the relative priority of an Aggregate Service Flow/QoS Parameter Set.

6.5.6.4.4.4 MaxAggregateTrafficRate

This attribute is the template for the Maximum Aggregate Traffic Rate attribute (maximum sustained traffic rate allowed) for this ASF/QoS Parameter Set.

This attribute represents the 4-byte value of the maximum aggregate traffic rate allowed for this ASF. All MAC frame data PDUs from the bytes following the MAC header HCS to the end of the CRC are included in calculating the maximum aggregate traffic rate. The number of bytes forwarded is limited during any time interval. The value 0 indicates no maximum traffic rate is enforced. The value of the DataRateUnitSetting attribute defines the units of MaxAggregateTrafficRate. This attribute applies to both upstream and downstream ASFs. This attribute also returns 0 if the referenced parameter is not present in the corresponding DOCSIS QOS Parameter Set, or if the parameter is not applicable.

6.5.6.4.4.5 MaxTrafficBurst

This attribute is the template for the MaxTrafficBurst attribute of the Aggregate Service Flow/QoS Parameter Set. If this value is not set, the default value is 3044, or 4000 if support for extended packet size is enabled.

6.5.6.4.4.6 PeakTrafficRate

This attribute is the template for the Peak Traffic Rate allowed for this Aggregate Service Flow/QoS Parameter Set.

This attribute represents the 4-byte value of the rate parameter 'P' of a token-bucket-based peak rate limiter for packets of this ASF. A value of 0 means the downstream peak traffic rate is not limited. The value of the DataRateUnitSetting attribute defines the units of PeakTrafficRate. This attribute also returns 0 if the referenced parameter is not present in the corresponding DOCSIS QOS Parameter Set, or if the parameter is not applicable.

6.5.6.4.4.7 MinReservedRate

This attribute is the template for the MinReservedRate attribute of the Aggregate Service Flow/QoS Parameter Set.

This attribute represents the 4-byte value of the guaranteed minimum rate allowed for this ASF. The value is calculated from the byte following the MAC header HCS to the end of the CRC. The value 0 indicates that no bandwidth is reserved. The value of the DataRateUnitSetting attribute defines the units of MinReservedRate. This attribute also returns 0 if the referenced parameter is not present in the corresponding DOCSIS QOS Parameter Set, or if the parameter is not applicable.

6.5.6.4.4.8 MinReservedPkt

This attribute is the template for the MinReservedPkt attribute of the Aggregate Service Flow/QoS Parameter Set. The default value is CMTS vendor-dependent.

6.5.6.4.4.9 DataRateUnitSetting

This attribute indicates the base unit for the AsfQosProfile traffic rate configuration attributes Maximum Aggregate Traffic Rate (MaxAggregateTrafficRate), Minimum Reserved Traffic Rate (MinReservedRate), and Peak Traffic Rate (PeakTrafficRate). The value of this attribute allows for their interpretation in units of bps, kbps, Mbps or Gbps. The default value for DataRateUnitSetting is bps.

6.5.6.4.4.10 LowLatencyAsf

This attribute indicates if the Aggregate Service Flow is being used for Low Latency services. This implies the ASF is describing a Dual Queue SF setup underneath the ASF.

6.5.6.4.4.11 ClassicSfScn

This attribute represents the Service Class Name from which the parameter set values for the classic queue will be derived.

6.5.6.4.4.12 LatencySfScn

This attribute represents the Service Class Name from which the parameter set values for the low latency queue will be derived.

6.5.6.4.4.13 AqmCouplingFactor

This attribute represents the coupling factor for the AQMs between the Classic Service Flow and the Low Latency Service Flow for this Aggregate Service Flow. The AqmCouplingFactor attribute is expressed in tenths, encoding an AQM Coupling Factor range from 0 - 25.5. If sub-TLV [70/71].42.5 *AQM Coupling Factor* is not provided to the CM and CCAP, the CM and CCAP are required to use a default value of 2 for AQM Coupling Factor, so the default value of attribute AqmCouplingFactor is 20 [MULPIv4.0].

6.5.6.4.4.14 SchedulingWeight

This attribute represents the scheduling weight, as the implied ratio (out of 256), for the Latency Queue/Service Flow (within the ASF)

6.5.6.4.4.15 QpEnable

This attribute indicates the configured Queue Protection status of this Aggregated Service Flow. If the queueProtection bit (bit 0) is set to '0', Queue Protection functionality is disabled for the Low Latency Service Flow. If the queueProtection bit is set to '1', Queue Protection is enabled for the Low Latency Service Flow.

6.5.6.4.4.16 QpLatencyThreshold

This attribute represents the latency threshold for the Queue Protection function in the Low Latency Service Flow.

References: [MULPIv4.0] Queue Protection section.

6.5.6.4.4.17 QpQueuingScoreThreshold

This attribute represents the Queuing Score Threshold for the Queue Protection function in the Low Latency Service Flow.

6.5.6.4.4.18 QpDrainRateExponent

This attribute represents the drain rate exponent for the Queue Protection function in the Low Latency Service Flow. The drain rate of the queuing score is expressed as an exponent of 2, in bytes/sec., e.g., a value of 19 means the Queue Protection function will use a value of : 2^19 bytes/sec.

6.5.6.4.4.19 LowLatencyClassifierList

Packet classifiers assigned to the Low Latency service flow. Each classifier is encoded in hexBinary according to the TLV encoding. When multiple classifiers exist for the same Latency service flow, then they are encoded as the concatenated sequence of encodings for each classifier. See [MULPIv4.0] Quality-of-Service-Related Encodings (in Annex C). Because the TLV encoding for upstream classifiers is different than for downstream classifiers, the default value for this attribute depends on the value of the Direction attribute.

This attribute is necessary to differentiate Low Latency Service Flow traffic from Classic Service Flow traffic. The minimum size of this attribute is a zero-length octet string, which could occur if the operator deletes the value. If this

attribute is not populated, all traffic for this ASF would be mapped to the Classic Service Flow. No upper limit is defined for the length of this attribute. The Low Latency Classifier definition for the type of traffic listed below is as indicated:

- EF marked traffic (IPv4): [22/23](7) [9](5) [1](3) 0xB8,0xB8, 0xFC
- EF marked traffic (IPv6): [22/23](7) [12](5) [1](3) 0xB8,0xB8, 0xFC
- Classifier for all ECT capable traffic(IPv4): [22/23](7) [9](5) [1](3) 0x01,0x01, 0x01
- Classifier for all ECT capable traffic(IPv6): [22/23](7) [12](5) [1](3) 0x01,0x01, 0x01

Default value for upstream:

0x16 0x07 0x09 0x05 0x01 0x03 0xB8 0xB8 0xFC
0x16 0x07 0x0C 0x05 0x01 0x03 0xB8 0xB8 0xFC
0x16 0x07 0x09 0x05 0x01 0x03 0x01 0x01 0x01
0x16 0x07 0x0C 0x05 0x01 0x03 0x01 0x01 0x01

Default value for downstream:

0x17 0x07 0x09 0x05 0x01 0x03 0xB8 0xB8 0xFC
0x17 0x07 0x0C 0x05 0x01 0x03 0xB8 0xB8 0xFC
0x17 0x07 0x09 0x05 0x01 0x03 0x01 0x01 0x01
0x17 0x07 0x0C 0x05 0x01 0x03 0x01 0x01 0x01

6.5.6.4.5 IatcProfile

This object represents a template for configuration of an Interface Aggregate Traffic Class. An Interface Aggregate Traffic Class (IATC) represents a grouping of one or more Service Flows mapped to a single channel or a bonding group. The IATCs enable the operators to virtually divide the bandwidth of service groups, bonding groups or channels between distinct services or users.

Table 107 - IatcProfile Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	key	1..16		
MaxAggregateTrafficRate	BitRate	No		bps, kbps, mbps, or gbps	0
ServiceFlowTrafficPriorityLow	UnsignedByte	No			0
ServiceFlowTrafficPriorityHigh	UnsignedByte	No			0
Direction	IfDirection	Yes			
DataRateUnitSetting	DataRateUnitType	No			'bps'

Table 108 - IatcProfile Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IatcAppId	Directed composition to IatcAppId		0..*	
IatcSCN	Directed composition to IatcSCN		0..*	

6.5.6.4.5.1 Name

This key indicates the IATC Profile Name associated with this object instance.

6.5.6.4.5.2 MaxAggregateTrafficRate

This attribute is the template for the Maximum Aggregate Traffic Rate attribute for this IATC object instance.

This attribute represents the 4-byte value of the maximum aggregate traffic rate allowed for this IATC instance. All MAC frame data PDUs from the bytes following the MAC header HCS to the end of the CRC are included in calculating the maximum aggregate traffic rate. The number of bytes forwarded is limited during any time interval. The value 0 indicates no maximum traffic rate is enforced. The rate is specified in units of bps, kbps, Mbps, or Gbps as specified by the DataRateUnitSetting attribute.

6.5.6.4.5.3 ServiceFlowTrafficPriorityLow and ServiceFlowTrafficPriorityHigh (separate, high >= low)

The attributes ServiceFlowTrafficPriorityLow and ServiceFlowTrafficPriorityHigh define a range of Service Flow Traffic Priority values that the CCAP will use to match service flows to the IATC profile.

6.5.6.4.5.4 Direction

This attribute is the template for the Direction attribute of the IatcProfile.

6.5.6.4.5.5 DataRateUnitSetting

This attribute indicates the base unit for the IatcProfile traffic rate configuration attribute Maximum Aggregate Traffic Rate (MaxAggregateTrafficRate). The value of this attribute allows for their interpretation in units of bps, kbps, Mbps, or Gbps. The default value for DataRateUnitSetting is bps.

6.5.6.4.6 IatcAppId

The IatcAppId object allows for the configuration of a list of one or more application IDs by which Service Flows can be matched to the IATC profile.

Table 109 - IatcAppId Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
AppId	UnsignedInt	Yes (Key)			

6.5.6.4.6.1 AppId

This attribute is the template for the AppId attribute, which represents an Application ID by which Service Flows can be matched to an IATC.

6.5.6.4.7 IatcScn

The IatcScn object allows for the configuration of a list of one or more Service Class Names by which Service Flows can be matched to the IATC profile.

Table 110 - IatcScn Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Scn	String	Yes (Key)	1..16		

6.5.6.4.7.1 Scn

This attribute is a Service Class Name by which Service Flows can be matched to IATC.

6.5.6.4.8 SfLatencyHistCfg

This object defines the latency histogram calculation structure for each downstream histogram-enabled service flow. The CMTS MUST create an active instance of the SfLatencyHistCfg object for every downstream service flow for which histogram calculation is enabled via the QoS Param Set TLV. Creating an instance of this object enables histogram calculation for the indexed service flow. Deleting an instance of this object disables histogram calculation for the indexed service flow. The CMTS MUST delete an instance of the SfLatencyHistCfg object if the indexed service flow is deleted (i.e., because of a DSD operation) or the histogram calculation is disabled via the QoS Param Set TLV (i.e., because of a DSC operation).

Prior to deactivating or deleting an instance of the SfLatencyHistCfg object, the CMTS MUST, for the indexed service flow, conclude any Latency Reporting Snapshot in progress (see Table 474 - CmtsLatencyRpt Object Attributes) and delete the corresponding instance in the SfLatencyStats object.

Bins are by definition consecutively numbered from one to sixteen. At least one and at most fifteen upper edges can be configured. Each configured upper edge is also the lower edge for the next bin (e.g., Bin 5 lower edge is defined by *LatencyBin4UpperEdge*). The lower edge of Bin 1 is defined as zero, and the upper edge of the final active bin (i.e., the bin corresponding to *LatencyBinEdgeNum* + 1) is defined as infinity. The CMTS validates the configured bin edges prior to activation.

The Service Flow Latency Estimate values corresponding to Bin N are bounded as follows: Bin N lower edge ≤ *Service Flow Latency Estimate* < Bin N upper edge.

The CCAP MUST support creation and deletion of multiple instances of the SfLatencyHistCfg object.

References: See [MULPIv4.0] Latency Reporting section.

Table 111 - SfLatencyHistCfg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	Interface index of MAC Domain Interface	N/A	
ServiceFlowId	UnsignedInt	Key	1.. 4294967295		
SfLabel	String	read-create	SIZE (0..15)		'unknown'
LatencyBinEdgeNum	UnsignedByte	read-create	0..15		0
LatencyBin1UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin2UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin3UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin4UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin5UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin6UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin7UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin8UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin9UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin10UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin11UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin12UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin13UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin14UpperEdge	UnsignedShort	read-create		10 microseconds	0
LatencyBin15UpperEdge	UnsignedShort	read-create		10 microseconds	0

Table 112 - SfLatencyHistCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceFlow	Directed association to ServiceFlow	0..1	1	

6.5.6.4.8.1 IfIndex

This key represents the ifIndex of the MAC Domain of the Service Flow.

6.5.6.4.8.2 ServiceFlowId

This key represents the Service Flow ID enabled to report queue latency.

6.5.6.4.8.3 SfLabel

This attribute represents the Service Class Name or Label (configured by the operator) to be used in Service Flow Latency Performance Reporting. The CMTS SHOULD default the SfLabel attribute to the SCN if it is known. If the SCN is not known, the CMTS MUST default the SfLabel attribute to the value "unknown". The operator can set this attribute to any string.

6.5.6.4.8.4 LatencyBinEdgeNum

This attribute represents the number of consecutively configured upper bin edges. The number of histogram bins is then *LatencyBinEdgeNum* + 1. If the number of bins edges configured is less than 15, then '*LatencyBinEdgeNum+1'* bins are valid for histogram counters.

6.5.6.4.8.5 LatencyBin1UpperEdge to LatencyBin15UpperEdge

These attributes represent the upper edges of each bin, bins 1 through 15. Configured upper bin edges are consecutive beginning with LatencyBin1UpperEdge. The histogram reporting behavior is undefined if, for bin number 'n', the bin (n) upper edge > bin (n+1) upper edge.

6.5.6.4.9 ServiceFlow

This object is defined in the DOCSIS QoS State Performance Management Information Model. Refer to Section 7.2.1.6.3 for the definition of this object. Additional object associations are defined as follows.

Table 113 - ServiceFlow Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SfLatencyHistCfg	Directed association from SfLatencyHistCfg	1	0..1	
latcProfile	Association from latcProfile	0..*	0..1	

6.5.6.5 DOCSIS Multicast QoS Configuration Information Model

Multicast configuration includes per multicast session policies to configure QoS and BPI encryption of multicast sessions. This Information Model defines the configuration requirements for multicast session QoS and privacy over the HFC by extending the DOCSIS QoS model [MULPIv4.0] and Baseline Privacy Interface (BPI) [SECv4.0] requirements, respectively. The components of the Multicast Configuration model are:

- CmtsGrpCfg, the Multicast Group Configuration rules for Multicast that includes QoS, Encryption and DSID-based Packet Header suppression,
- CmtsGrpQosCfg, the QoS policies for Multicast Sessions,
- DefGrpSvcClass, default SCN template reference for unclassified Multicast sessions,
- CmtsGrpEncryptCfg, encryption rules configuration for Multicast sessions,

The configuration of QoS for Multicast requires that the CMTS supports the CmtsGrpCfg, CmtsGrpQosCfg, GrpSvcClass, and CmtsGrpEncryptCfg objects.

The representation of GSFs for management purposes is similar to unicast service flows. A GSF is a specialization of unicast service flows; therefore, the DOCSIS QoS Model [MULPIv4.0] and the QoS management model from Section 7.2.1.6 applies to GSFs with some considerations:

- GSFs have corresponding Service Flow IDs in the downstream direction. The CMTS represents GSFs in the QoS model from Section 7.2.1.6, in particular, in ServiceFlow, PktClass, ParamSet, ServiceFlowStats, and ServiceFlowLog. GSFs are never signaled to the CM.
- GSFs have no corresponding mapping to CM MAC Addresses as unicast service flows; therefore, CmtsMacToSrvFlow does not contain information related to GSFs. Instead the GrpServiceFlow indicates the SFIDs of GSFs per-MAC domain.
- To complete the classification of the multicast traffic to a GSF, entries in the Group Configuration object are used to build a Group Classifier Rule (GCR) when there is a nonzero value for QosConfigId [MULPIv4.0].

This group of configuration elements allows for the configuration of DOCSIS Multicast QoS. The configuration specific Information Model is shown below.

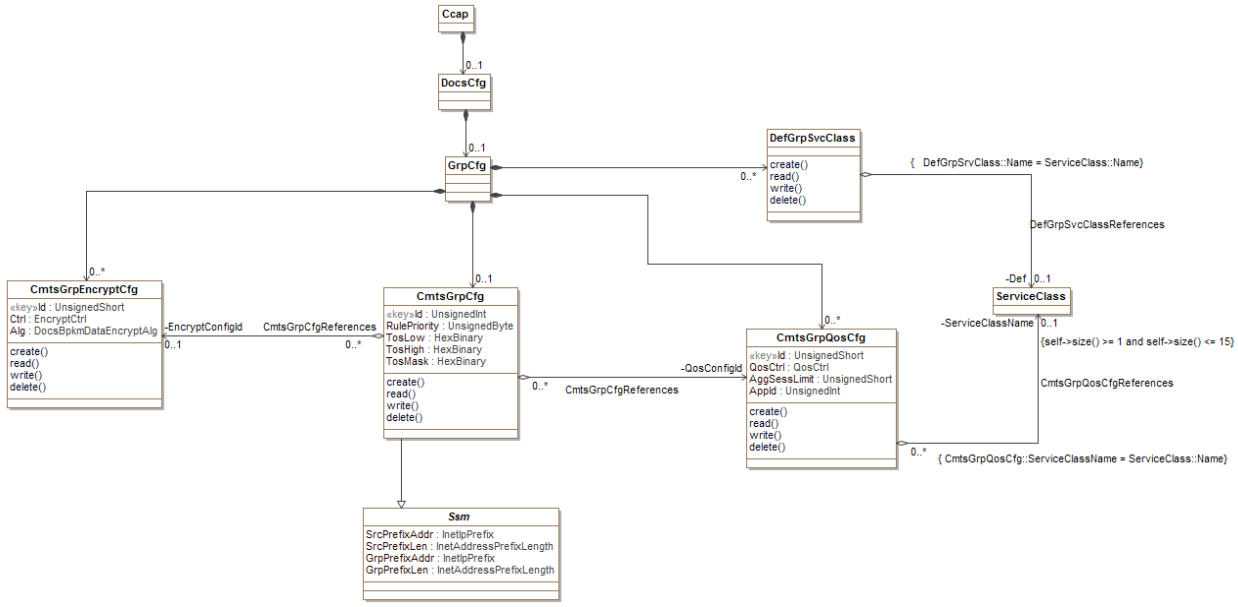


Figure 30 - DOCSIS Multicast QoS Configuration Information Model

6.5.6.5.1 Ccap

This configuration object is included in Figure 30 for reference. It is defined in Section 6.5.3.1.

6.5.6.5.2 DocsCfg

This configuration object is included in Figure 30 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.5.3 GrpCfg

The GrpCfg object is the primary container of DOCSIS Multicast QoS configuration objects. It has the following associations:

Table 114 - GrpCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsGrpCfg	Directed composition to CmtsGrpCfg		0..1	
DefGrpSvcClass	Directed composition to DefGrpSvcClass		0..*	
CmtsGrpQosCfg	Directed composition to CmtsGrpQosCfg		0..*	
CmtsGrpEncryptCfg	Directed composition to CmtsGrpEncryptCfg		0..*	

6.5.6.5.4 CmtsGrpCfg

This object controls the QoS and encryption settings for downstream forwarding of IP multicast sessions. An IP multicast session is replicated to one or more Downstream Channel Sets (DCSs), where each DCS is either a single downstream channel or a downstream bonding group of multiple channels. The CCAP determines on which DCSs to replicate a multicast session based on IP multicast membership reports ("joins") or other vendor-specific static configuration.

The CmtsGrpCfg object allows for the configuration of a range of sessions through the SrcPrefixAddr, GrpPrefixAddr, SrcPrefixLen, and GrpPrefixLen attributes, which are inherited from the Ssm object (defined in Section 6.5.6.7.7).

Cable operators can specify configuration rules for a range of multicast sessions through the tuples of (SrcPrefixAddr, SrcPrefixLen, GrpPrefixAddr, GrpPrefixLen) attributes in an entry. The QosConfigId association identifies the QoS rule, and the EncryptConfigId association identifies the encryption rule for a particular entry. Even if an entry indicates a range of multicast sessions, the Encryption rules are applied on a per-session basis. Thus, when an Operator configures Encryption for a given Group Config entry, each session has those rules applied on a per session and per replication basis. Group Encryption rules are indicated by using a non-zero value for the EncryptCfgId.

The QosCtrl attribute from the CmtsGrpQosCfg object is used to determine if the traffic for a range of multicast sessions identified by an entry in the CmtsGrpCfg object will be transmitted in an "Aggregate-Session" Group Service Flow (GSF) or will be transmitted separately for each session using "Single-Session" GSFs. Even if the range of multicast sessions are transmitted on an "Aggregate-Session" GSF, the Encryption rules are always applied individually to a multicast session on a per-session DSID basis prior to being transmitted on an "Aggregate-Session" GSF.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the following attributes to be set.

- RulePriority
- SrcAddr (inherited from the Ssm abstract object)
- GrpAddr (inherited from the Ssm abstract object)
- TosLow
- TosHigh
- TosMask

The CMTS and CCAP MUST persist all instances of the CmtsGrpCfg object across system reinitializations.

Table 115 - CmtsGrpCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedInt	key	1..4294967295		
RulePriority	UnsignedByte	Yes	0..63 | 192..255		
TosLow	HexBinary	Yes	SIZE (1)		

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TosHigh	HexBinary	Yes	SIZE (1)		
TosMask	HexBinary	Yes	SIZE (1)		

Table 116 - CmtsGrpCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsGrpQosCfg	Directed aggregation to CmtsGrpQosCfg	0..*		QosConfigId *
CmtsGrpEncryptCfg	Directed aggregation to CmtsGrpEncryptCfg	0..*	0..1	EncryptConfigId
Ssm	Specialization of Ssm			

* If no QosConfigId association is specified, all replications referenced by this CmtsGrpCfg instance will be forwarded to the default GSF. If no EncryptCfgId association is specified, no encryption will be applied to all replications derived from this GC.

6.5.6.5.4.1 Id

This attribute is the key that identifies unique instances of the CmtsGrpCfg Object.

6.5.6.5.4.2 RulePriority

This attribute indicates the priority of this entry used to resolve which instance of this object apply when a newly replicated multicast session matches multiple entries. Higher values indicate a higher priority. Valid values for this attribute are 0..63 and 192..255 in order to not conflict with CMTS internally-created instances that use the range 64..191.

6.5.6.5.4.3 TosLow

This attribute identifies the low value of a range of the ToS byte value to be defined in a packet classifier this GC instantiates in the GCR in order to limit the GCR-matched traffic to a particular set of DSCPs. This applies to the IPv4 ToS byte and the IPv6 Traffic Class byte.

The IP ToS octet, as originally defined in [RFC 791], has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]).

References: [RFC 791]; [RFC 3260]; [RFC 3168].

6.5.6.5.4.4 TosHigh

This attribute identifies the high value of a range of the ToS byte value to be defined in a packet classifier this GC instantiates in the GCR in order to limit the GCR-matched traffic to a particular set of DSCPs. This applies to the IPv4 ToS byte and the IPv6 Traffic Class byte.

The IP ToS octet, as originally defined in [RFC 791], has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]).

References: [RFC 791]; [RFC 3260]; [RFC 3168].

6.5.6.5.4.5 TosMask

This attribute identifies the mask value bitwise ANDed with a ToS byte value to be defined in a packet classifier this GC instantiates in the GCR in order to limit the GCR-matched traffic to a particular set of DSCPs. This applies to the IPv4 ToS byte and the IPv6 Traffic Class byte.

The IP ToS octet, as originally defined in [RFC 791], has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]).

References: [RFC 791]; [RFC 3260]; [RFC 3168].

6.5.6.5.5 Ssm

This configuration object is included in Figure 30 for reference. It is defined in Section 6.5.6.7.7, Ssm.

6.5.6.5.6 CmtsGrpEncryptCfg

This object controls the configuration of the Security Association (SA) and the encryption algorithm used for multicast sessions.

This object supports the creation and deletion of instances.

The CMTS and CCAP MUST persist all instances of the CmtsGrpEncryptCfg object across system reinitializations.

Table 117 - CmtsGrpEncryptCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedShort	key			
Ctrl	Enum	No	other(1), cmts(2), mgmt(3)		mgmt
Alg	Enum	No	other(1), des56CbcMode(2), des40CbcMode(3), aes128CbcMode(4)		des56CbcMode

6.5.6.5.6.1 Id

This attribute specifies the unique identifier of instances of this object.

6.5.6.5.6.2 Ctrl

This attribute controls whether the CMTS can select the encryption algorithm or if this can be set manually using the Alg attribute. If this attribute is set to 'cmts', the CMTS can select the encryption algorithm for the Security Association (SA). If this attribute is set to 'mgmt', the Alg attribute is used to define the encryption algorithm for this SA. If this attribute is set to 'other', a vendor extension is in use.

6.5.6.5.6.3 Alg

This attribute defines which encryption algorithm will be used for an SA referenced by this object when the Ctrl is set to 'mgmt'. If this attribute is set to 'other', a vendor extension is in use.

6.5.6.5.7 CmtsGrpQosCfg

This object configures the QoS for Multicast sessions replicated to any Downstream Channel Set (DCS). It does not control to which particular DCSs the CCAP replicates a multicast session.

An instance of this object is called a GQC entry. A GQC entry controls how the CCAP instantiates a Group Classifier Rule (GCR) on the DCS to match packets of the multicast session. A GCR uses source and destination IP address and ToS criteria.

A GQC entry controls how and with what QoS parameters a GSF is created on a DCS. All downstream multicast packets are scheduled on a GSF. The QoS Type attribute of the GQC entry controls whether the CCAP creates one GSF for each single IP multicast session or whether the CCAP creates one GSF for the aggregate of all sessions that match the GQC criteria. The GQC instance contains a reference to a Service Class Name QoS Parameter Set template. The Service Class defines the list of QoS parameters for the GSF(s) instantiated for the GQC entry.

A CCAP identifies one Service Class as the Default Group QoS Service Class. The CCAP instantiates a Default GSF on each single-channel DCS based on the parameters of the Default Group QoS Service Class.

The set of GCRs and GSFs instantiated on a DCS control how QoS is provided to multicast packets replicated to the DCS. For each multicast packet, the CCAP classifies the packet to the highest priority matching GCR on that DCS. The GCR refers to a single GSF, which controls the scheduling of the packets on the DCS. If the multicast packet does not match any GCR on the DCS, the packet is scheduled on the Default GSF of the DCS. The CCAP replicates unclassified multicast traffic to only DCSs consisting of a single downstream channel. Thus, the Maximum Sustained Traffic Rate QoS parameter of the Default Group Service Class limits the aggregate rate of unclassified multicast traffic on each downstream channel.

The CCAP is expected to instantiate GCRs and GSFs controlled by the entries in this table only for the duration of replication of the multicast sessions matching the entry.

This object supports the creation of multiple instances.

Creation of new instances of this object require the following objects to be set:

- ServiceClassName
- QosCtrl
- AggSessLimit

The CMTS and CCAP MUST persist all instances of the CmtsGrpQosCfg object across system reinitialization.

Table 118 - CmtsGrpQosCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedShort	key			
QosCtrl	Enum	Yes	other(1), singleSession(2), aggregateSession(3)		
AggSessLimit	UnsignedShort	Yes	1.. 65535	sessions	
AppId	UnsignedInt	Yes			0

Table 119 - CmtsGrpQosCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceClass	Directed aggregation to ServiceClass	0..*	0..1	ServiceClassName

6.5.6.5.7.1 Id

This attribute identifies a unique Group QoS Configuration object instance.

6.5.6.5.7.2 QosCtrl

This attribute identifies how Group Classifier Rules (GCRs) and Group Service Flows (GSFs) are instantiated when multiple sessions match the (S,G) criteria of this entry. If 'singleSession', the CMTS creates a unique GCR and a unique GSF for the session. If this object's value is 'aggregateSession', all sessions matching this criterion are aggregated into the same GSF. If this attribute is set to 'other', a vendor extension is in use.

6.5.6.5.7.3 AggSessLimit

This attribute identifies the maximum number of sessions that may be aggregated in an aggregated Service Flow. This value is ignored in case of a GQC entry with QosCtrl set to 'singleSession'.

6.5.6.5.7.4 AppId

This attribute allows the operator to configure a Cable Operator defined Application Identifier for multicast sessions, e.g., an Application Manager ID and Application Type. This Application Identifier can be used to influence

admission control or other policies in the CMTS that are outside of the scope of this specification. This parameter is optional in defining QoS for multicast sessions.

If the value of this attribute is different from the value of the AppId in the referenced SCN for this GQC instance, the value of this attribute is used.

References: [MULPIv4.0] Application Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex; [PCMM] Policy Server and CMTS Interface section.

6.5.6.5.8 ServiceClass

This configuration object is included in Figure 30 for reference. It is defined in Section 6.5.6.4.3, ServiceClass.

6.5.6.5.9 DefGrpSvcClass

This object provides a reference to the Default Group Service Class. The CCAP instantiates a Default GSF with the QoS param Set indicated by this Service Class Name reference on every Downstream Channel Set to which it replicates multicast packets that are otherwise unclassified by a Group Classifier Rule.

The CMTS and CCAP MUST persist the value of the attributes of the DefGrpSvcClass object across reinitializations.

Table 120 - DefGrpSvcClass Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceClass	Directed aggregation to ServiceClass		0..1	DefGrpSrvClass::Name = ServiceClass::Name

6.5.6.6 MAC Domain Configuration Information Model

The Information Model for MAC Domain configuration is shown below.

The HFC RF combining and splitting topology between a CMTS and Cable Modems results in distinct sets of CMs called Cable Modem Service Groups (CM-SGs) that are served by distinct combinations (i.e., non-overlapping subsets) of Downstream Channels and Upstream Channels. Because a MAC Domain defines a separate number space for many DOCSIS protocol elements (e.g., DSIDs, SAIDs, etc.), an operator should define separate MAC Domains that serve disjoint subsets of CM-SGs rather than a single MAC Domain for all CM-SGs.

A Downstream Bonding Group (DBG) is a set of Downstream Channels (DCs) on which the CMTS distributes packets. The CMTS enforces that all Downstream Channels of a DBG are contained within the same MAC Domain Downstream Service Group (MD-DS-SG). A CMTS permits configuration of a Downstream Channel as a member of multiple DBGs. A CMTS can restrict the assignment of Downstream Channels to DBGs based on vendor product implementation. For example, a CMTS product implementation may restrict the set of Downstream Channels that could be bonded to a given Bonded Channel Set to a subset of the downstream channels in the MAC Domain.

An Upstream Bonding Group (UBG) is a set of Upstream Channels (UCs) on which upstream data forwarding service may be provided to a single CM. The CCAP MUST reject a configuration where the Upstream Channels in an Upstream Bonding Group are not contained within the same MAC Domain Upstream Service Group (MD-US-SG). A CMTS permits configuration of an Upstream Channel as a member of multiple UBGs. A CMTS can restrict the assignment of Upstream Channels to UBGs based on vendor product implementation. For example, a CMTS product implementation could restrict the set of Upstream Channels that could be bonded to a subset of the downstream channels in the MAC Domain.

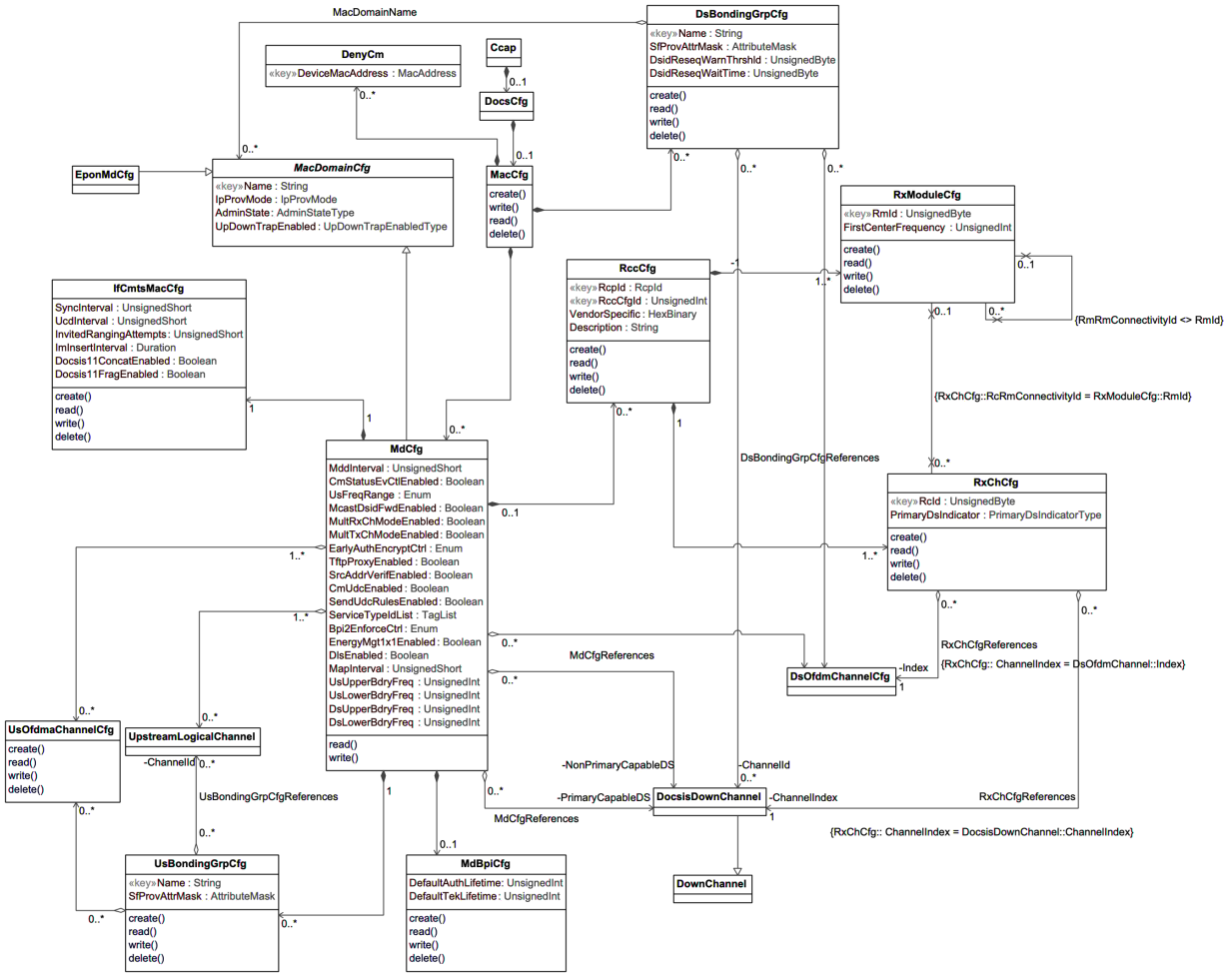


Figure 31 - MAC Domain Configuration Information Model

6.5.6.6.1 Ccap

This configuration object is included in Figure 31 for reference. It is defined in Section 6.5.3.1, Ccap Object.

6.5.6.6.2 DocsCfg

This configuration object is included in Figure 31 for reference. It is defined in Section 6.5.6.5.2, DocsCfg.

6.5.6.6.3 MacCfg

The MacCfg object is the container for DOCSIS MAC Domain configuration objects. It has the following associations:

Table 121 - MacCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
MdCfg	Directed composition to MdCfg		0..*	
DsBondingGrpCfg	Directed composition to DsBondingGrpCfg		0..*	
DenyCm	Directed composition to DenyCm		0..*	

6.5.6.6.4 MdCfg

This object contains MAC domain level control and configuration attributes.

A MAC Domain corresponds to exactly one instance of a DocsCableMacLayer interface (ifType of 127) in the ifTable. In the configuration model, MdCfg is identified with a Name that is unique within the CCAP, inherited from the MacDomainCfg abstract object. For the ifTable, the CCAP implementation selects a value of the ifIndex for the DocsCableMacLayer index. The DocsCableMacLayer ifIndex is used extensively in several reporting objects as an index for several reporting objects. The CcapInterfaceIndexMapTable, defined in Section 7.2.1.10, CCAP-MIB Performance Management Information Model, maps a DocsCableMacLayer ifIndex to a configured MdCfg instance.

Some CCAP implementations may implement the association of non-primary capable downstream channels with MAC Domain indirectly, based on RF plant topology configuration.

The CMTS and CCAP MUST persist all instances of MdCfg across reinitializations.

Table 122 - MdCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
MddInterval	UnsignedShort	No	1..2000	milli-seconds	2000
CmStatusEvCtlEnabled	Boolean	No			true
UsFreqRange	Enum	No	other(1), standard(2), extended(3)		standard
McastDsidFwdEnabled	Boolean	No			true
MultRxChModeEnabled	Boolean	No			true
MultTxChModeEnabled	Boolean	No			true
EarlyAuthEncryptCtrl	Enum	No	other(1), disableEae(2), enableEaeRangingBasedEnforcement(3), enableEaeCapabilityBasedEnforcement(4), enableEaeTotalEnforcement(5)		enableEaeRangingBasedEnforcement
TftpProxyEnabled	Boolean	No			true
SrcAddrVerifEnabled	Boolean	No			true
CmUdcEnabled	Boolean	No			false
SendUdcRulesEnabled	Boolean	No			false
ServiceTypeIdList	TagList	No	SIZE (0..256)		"H
Bpi2EnforceCtrl	Enum	No	other(1), disable(2), qosCfgFileWithBpi2AndCapabPrivSupportEnabled(3), qosCfgFileWithBpi2Enabled(4), qosCfgFile(5), total(6)		qosCfgFileWithBpi2Enabled
EnergyMgt1x1Enabled	Boolean	No			false
DlsEnabled	Boolean	No			true
MapInterval	UnsignedShort	No	500..5000	Microseconds	Default value is vendor specific,
UsUpperBdryFreq	UnsignedInt	No	See Note 1 below	MHz	

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
UsLowerBdryFreq	UnsignedInt	No	See Note 1 below	MHz	
DsUpperBdryFreq	UnsignedInt	No	See Note 1 below	MHz	
DsLowerBdryFreq	UnsignedInt	No	See Note 1 below	MHz	

Note 1: As noted in the descriptions for the BdryFreq attributes below in Sections 6.5.6.6.4.17 - 6.5.6.6.4.20, the DOCSIS 4.0 upstream and downstream channels upper and lower frequency limits are dependent on whether the system is configured for DOCSIS 3.1, FDX, or FDD/Extended Spectrum operation. Table 123 - OFDMA and OFDM Channel Boundary Type Constraints summarizes the channel frequency limits for each type of operation. For details refer to [PHYv3.1] and [PHYv4.0] as referenced in the attribute descriptions. Refer to the figure *Configurable FDX Allocated Spectrum Bandwidths* in [PHYv4.0] for a graphic representation of DOCSIS 4.0 FDX allocated spectrum bandwidths. Refer to the figure *Configurable FDD Upstream Allocated Spectrum Bandwidths* in [PHYv4.0] for a graphic representation of DOCSIS 4.0 FDD Extended Spectrum upstream allocated spectrum bandwidths.

Table 123 - OFDMA and OFDM Channel Boundary Type Constraints

	DOCSIS 3.1	FDX	FDD	All Channel Types
UsUpperBdryFreq	11.4[1]..204 MHz	204|300|396|492|684 MHz	204|300|396|492|588|684 MHz	11.4..684 MHz
UsLowerBdryFreq	5..197.6[2] MHz	108|204|300|396|492|588 MHz	108|204|300|396|492|588 MHz	5..588 MHz
DsUpperBdryFreq	132[3]..1794 MHz	204|300|396|492|684 MHz	282[4]|306|330|...|1746|1770|1794 MHz	132..1794 MHz
DsLowerBdryFreq	108..1770[5] MHz	108|204|300|492 MHz	258|282|306|…|1722|1746|1770 MHz	108..1770 MHz

[1]Upper boundary of a 6.4 MHz upstream channel starting at 5 MHz
[2]Lower boundary of a 6.4 MHz upstream channel ending at 204 MHz
[3]Upper boundary of a 24 MHz downstream channel starting at 108 MHz (Ref. PHYv3.1 Table 6 - Downstream OFDM Parameters - Channel bandwidths)
[4]Upper boundary of a 24 MHz downstream channel starting at 258 MHz
[5]Lower boundary of a 24 MHz downstream channel ending at 1794 MHz

Table 124 - MdCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
MacDomainCfg	Specialization of MacDomainCfg			
IfCmtsMacCfg	Directed composition to IfCmtsMacCfg	1	1	
UpstreamLogicalChannel	Directed aggregation to UpstreamLogicalChannel	1	0..*	
UsBondingGrpCfg	Directed composition to UsBondingGrpCfg	1	0..*	
DocsisDownChannel	Directed aggregation to DocsisDownChannel	0..1		PrimaryCapableDs
DocsisDownChannel	Directed aggregation to DocsisDownChannel	0..*		NonPrimaryCapableDs
RccCfg	Directed composition to RccCfg	0..1	0..*	
MdBpiCfg	Directed composition to MdBpiCfg		0..1	
UsOfdmaChannel	Directed aggregation to UsOfdmaChannel	1	0..*	
DsOfdmChannelCfg	Directed aggregation to DsOfdmChannelCfg	0..*		

6.5.6.6.4.1 MddInterval

This attribute configures the interval for the insertion of MDD messages in each downstream channel of a MAC Domain.

References: [MULPIv4.0] Parameters and Constants Annex.

6.5.6.6.4.2 CmStatusEvCtlEnabled

If set to 'true', this attribute enables the signaling of the CM-Status Event reporting mechanism.

References: [MULPIv4.0] CM-STATUS Event Control section.

6.5.6.6.4.3 UsFreqRange

This attribute indicates in MDD messages the upstream frequency upper band edge of an upstream channel.

A value 'standard' means Standard Frequency Range and a value 'extended' means Extended Frequency Range.

A value 'other' indicates a vendor extension is in use.

References: [MULPIv4.0] Upstream Frequency Range TLV section.

6.5.6.6.4.4 McastDsidFwdEnabled

If set to 'true', this attribute enables the CMTS to use IP Multicast DSID Forwarding (MDF) for the MAC domain.

References: [MULPIv4.0] Multicast DSID-based Forwarding (MDF) Modes section in the Compatibility with Previous Versions of DOCSIS Annex.

6.5.6.6.4.5 MultRxChModeEnabled

If set to 'true', this attribute enables Downstream Channel Bonding for the MAC Domain.

References: [MULPIv4.0] Downstream Channel Bonding section.

6.5.6.6.4.6 MultTxChModeEnabled

If set to 'true', this attribute enables Multiple Transmit Channel (MTC) Mode for the MAC Domain.

References: [MULPIv4.0] Upstream Channel Bonding section.

6.5.6.6.4.7 EarlyAuthEncryptCtrl

This attribute enables or disables early authentication and encryption (EAE) signaling for the MAC Domain. It also defines the type of EAE enforcement in the case that EAE is enabled.

If set to 'disableEAE', EAE is disabled for the MAC Domain.

If set to 'enableEaeRangingBasedEnforcement', 'enableEaeCapabilityBasedEnforcement' or 'enableEaeTotalEnforcement', EAE is enabled for the MAC Domain.

The following EAE enforcement methods are defined in the case where EAE signaling is enabled:

- The option 'enableEaeRangingBasedEnforcement' indicates EAE is enforced on CMs that perform ranging with a B-INIT-RNG-REQ message.
- The option 'enableEaeCapabilityBasedEnforcement' indicates EAE is enforced on CMs that perform ranging with a B-INIT-RNG-REQ message in which the EAE capability flag is set.

The option 'enableEaeTotalEnforcement' indicates EAE is enforced on all CMs regardless of their EAE capabilities.

A value 'other' indicates a vendor extension is in use.

References: [SECv4.0] Early Authentication and Encryption section.

6.5.6.6.4.8 TftpProxyEnabled

If set to 'true', this attribute enables TFTP Proxy functionality for the MAC Domain.

References: [SECv4.0] TFTP Configuration File Security section.

6.5.6.6.4.9 SrcAddrVerifiEnabled

If set to 'true', this attribute enables Source Address Verification (SAV) functionality for the MAC Domain.

References: [SECv4.0] Source Address Verification section.

6.5.6.6.4.10 CmUdcEnabled

If set to 'true', this attribute instructs the CMTS MAC Domain to enable Upstream Drop Classifiers (UDC) for the CMs attempting registration in this MAC Domain.

References: [MULPIv4.0], Upstream Drop Classifiers section

6.5.6.6.4.11 SendUdcRulesEnabled

If set to 'true' and when the CM signals to the CMTS 'Upstream Drop Classifier Group ID' encodings, this attribute instructs the CMTS MAC Domain to send the Subscriber Management Filters rules associated with the 'Upstream Drop Classifier Group ID' encodings to the CM in the form of UDCs when the following conditions occurs:

- The attribute CmUdcEnabled value for this MAC Domain is set to 'true', and
- The CM has the UDC capability advertised as supported.

If there is not a single Subscriber Management Filter configured in the CMTS for the CM's signaled UDC Group ID, the CMTS does not send UDC encodings to the CM.

It is vendor specific whether the CMTS maintains enforcement of the CM signaled or default Subscriber Management Filter groups in the upstream direction.

References: [MULPIv4.0], Upstream Drop Classifiers section

6.5.6.6.4.12 ServiceTypeIdList

This attribute indicates the list of Service Type IDs associated with the MAC Domain.

During the CM registration process the CMTS will attempt to redirect the CM to a MAC Domain where the CM' Service Type TLV is contained in this attribute.

References: [MULPIv4.0], Service Type Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.5.6.6.4.13 Bpi2EnforceCtrl

This attribute indicates the level of BPI+ enforcement policies with the MAC Domain.

The following BPI+ enforcement policies are defined in the case where BPI+ is enabled:

- The option 'disable' indicates that CMTS does not enforce BPI+.
- The option 'qosCfgFileWithBpi2AndCapabPrivSupportEnabled' indicates the CMTS enforces BPI+ on CMs that register with parameters indicating BPI+ is enabled (missing TLV 29 or containing TLV 29 set to enable) and with a Modem Capabilities Privacy Support TLV (5.6) set to BPI+ support.
- The option 'qosCfgFileWithBpi2Enabled' indicates the CMTS enforces BPI+ on CMs that register with parameters indicating BPI+ is enabled (missing TLV 29 or containing TLV 29 set to enable).
- The option 'qosCfgFile' indicates the CMTS enforces BPI+ on CMs that register with a DOCSIS 1.1 style configuration file. Because DOCSIS 4.0 devices will only register with a DOCSIS 1.1 style configuration file, the 'qosCfgFile' is the same as the 'total' option in DOCSIS 4.0.
- The option 'total' indicates the CMTS enforces BPI+ on all CMs.

- A value 'other' indicates a vendor extension is in use.

References: [SECv4.0] BPI+ Enforce section.

6.5.6.6.4.14 EnergyMgt1x1Enabled

This attribute indicates whether the CMTS is configured for 1x1 Energy Management Mode of operation on a per MAC Domain basis.

If this attribute is set to 'true', the CMTS is configured for 1x1 Energy Management Mode of operation on this MAC Domain. If this attribute is set to 'false', the Energy Management 1x1 Mode of operation is disabled in the CMTS on this MAC Domain.

References: [MULPIv4.0], Energy Management Capabilities section.

6.5.6.6.4.15 DlsEnabled

This attribute indicates whether the CMTS is configured for DOCSIS Light Sleep (DLS) Mode of operation on a per MAC Domain basis. If this attribute is set to 'true', the CMTS is configured for DLS Mode of operation on this MAC Domain. If this attribute is set to 'false', the DLS Mode of operation is disabled in the CMTS on this MAC Domain. References: [MULPIv4.0], DOCSIS Light Sleep (DLS) Feature.

6.5.6.6.4.16 MapInterval

This optional attribute allows configuration of the MAP interval, a target for nominal interval between MAP messages sent for all upstream channels of the selected MAC Domain. The attribute's standard range is defined as 500 .. 5000 microseconds. The CCAP MAY support a vendor-selected range for the MapInterval attribute. The selection of the default value for this attribute is left to CCAP vendor's choice. It is expected that in certain cases necessitated by the implementation or the scheduling requirements, the CCAP MAY operate with the actual MAP interval which differs from the configured value. The actual value of the MAP interval target is reported by CCAP via attributes TargetMapInterval, which are defined in Sections 7.2.1.2.5.3 and 7.2.2.8.1.27.

6.5.6.6.4.17 UsUpperBdryFreq

This attribute reports the diplexer upstream upper band edge to which the plant is configured, in MHz units.

The upstream upper band edge limit for the plant depends on the mode of operation to which DOCSIS equipment is configured to operate. Refer to [PHYv3.1] *Upstream CMTS Spectrum* section, for the upstream boundary frequency limits for the plant when equipment is configured to be compliant with the DOCSIS 3.1 and (non-FDX and non-FDD extended spectrum) DOCSIS 4.0 frequency plans. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan* section for the upstream boundary frequency limits for the plant when equipment is configured to be compliant with FDX mode. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan for FDD Operation* section for the upstream boundary frequency limits for the plant when the equipment is configured to be compliant with FDD mode.

6.5.6.6.4.18 UsLowerBdryFreq

This attribute reports the diplexer upstream lower band edge to which the plant is configured, in MHz units.

6.5.6.6.4.19 DsUpperBdryFreq

This attribute reports the diplexer downstream upper band edge to which the plant is configured, in MHz units.

The downstream upper band edge limit for the plant depends on the mode of operation to which DOCSIS equipment is configured to operate. Refer to [PHYv3.1] *Downstream CMTS Spectrum* section, for the downstream boundary frequency limits for the plant when equipment is configured to be compliant with the DOCSIS 3.1 and (non-FDX and non-FDD extended spectrum) DOCSIS 4.0 frequency plans. Refer to [PHYv4.0] *Downstream FDX CMTS Spectrum* section for the downstream boundary frequency limits for the plant when equipment is configured to be compliant with FDX mode. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan for FDD Operation* section for the downstream boundary frequency limits for the plant when the equipment is configured to be compliant with FDD mode.

6.5.6.6.4.20 DsLowerBdryFreq

This attribute reports the diplexer downstream lower band edge to which the plant is configured, in MHz units.

The downstream lower band edge limit for the plant depends on the mode of operation to which DOCSIS equipment is configured to operate. Refer to [PHYv3.1] *Downstream CMTS Spectrum* section, for the downstream boundary frequency limits for the plant when equipment is configured to be compliant with the DOCSIS 3.1 and (non-FDX and non-FDD extended spectrum) DOCSIS 4.0 frequency plans. Refer to [PHYv4.0] *Downstream FDX CMTS Spectrum* section for the downstream boundary frequency limits for the plant when equipment is configured to be compliant with FDX mode. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan for FDD Operation* section for the downstream boundary frequency limits for the plant when the equipment is configured to be compliant with FDD mode.

6.5.6.6.5 MdBpiCfg

This object provides the configuration of the Baseline Privacy key lifetimes for a MAC domain identified by the MAC Domain Name in MacDomainCfg.

Reference: [RFC 4131] docsBpi2CmtsBaseTable

Table 125 - MdBpiCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
DefaultAuthLifetime	UnsignedInt	Yes	1..604800	seconds	604800
DefaultTekLifetime	UnsignedInt	Yes	1..604800	seconds	43200

6.5.6.6.5.1 DefaultAuthLifetime

This attribute configures the default lifetime, in seconds, for new authorization keys assigned by the CMTS.

Reference: [RFC 4131] docsBpi2CmtsDefaultAuthLifetime

6.5.6.6.5.2 DefaultTekLifetime

This attribute configures the default lifetime, in seconds, for new Traffic Encryption Keys (TEKs) assigned by the CMTS.

Reference: [RFC 4131] docsBpi2CmtsDefaultTEKLifetime

6.5.6.6.6 MacDomainCfg

The MacDomainCfg abstract object contains the MAC domain attributes used by DOCSIS and EPON MAC domains.

Table 126 - MacDomainCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			
IpProvMode	Enum	Yes	other(1), ipv4Only(2), ipv6Only(3), alternate(4), dualStack(5)		
AdminState	AdminStateType	No			down
UpDownTrapEnabled	UpDownTrapEnabled	No			true

6.5.6.6.6.1 Name

The name of the MacDomain.

6.5.6.6.6.2 IpProvMode

This attribute configures the IP provisioning mode for a MAC Domain.

When this attribute is set to 'ipv4Only', the CM will acquire a single IPv4 address for the CM management stack.

When this attribute is set to 'ipv6Only', the CM will acquire a single IPv6 address for the CM management stack.

When this attribute is set to 'alternate', the CM will acquire a single IPv6 address for the CM management stack and, if failures occur, the CM will fall back to provisioning and operation with an IPv4 address.

When this attribute is set to 'dualStack', the CM will acquire both an IPv6 and IPv4 address for provisioning and operation.

When this attribute is set to 'other', the CM will acquire an IP address using a vendor-specific method.

References: [MULPIv4.0] IP Initialization Parameters TLV section.

6.5.6.6.6.3 AdminState

This attribute configures the administrative state of the MAC Domain.

6.5.6.6.6.4 UpDownTrapEnabled

This attribute configures whether linkUp/linkDown traps are enabled for this MAC Domain.

6.5.6.6.7 EponMdCfg

This configuration object is included in Figure 31 for reference. It is defined in Section 6.5.10.6.

6.5.6.6.8 IfCmtsMacCfg

This object is based on the docsIfCmtsMacTable defined in [RFC 4546]. The following modifications have been made.

- The following attributes have been removed:
  - ifIndex
  - docsIfCmtsMacCapabilities
  - docsIfCmtsMacMaxServiceIds
  - docsIfCmtsMacStorageType
- The SyncInterval attribute (docsIfCmtsSyncInterval) data type has been shortened to UnsignedShort.
- The following attributes have been added to the IfCmtsMacCfg object, and are defined here:
  - Docsis11ConcatEnabled
  - Docsis11FragEnabled

Reference: [RFC 4546], docsIfCmtsMacTable

Table 127 - IfCmtsMacCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Docsis11ConcatEnabled	Boolean	No			true
Docsis11FragEnabled	Boolean	No			true
SyncInterval	UnsignedShort	Yes		ms	
UcdInterval	UnsignedShort	Yes		ms	
InvitedRangingAttempts	UnsignedShort	Yes		Attempts	

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ImInsertInterval	Duration	Yes		Hundreds of seconds	

6.5.6.6.8.1 Docsis11ConcatEnabled

Enables and disables DOCSIS 1.1 concatenation.

6.5.6.6.8.2 Docsis11FragEnabled

Enables and disables DOCSIS 1.1 fragmentation.

6.5.6.6.8.3 SyncInterval

The interval between CMTS transmission of successive SYNC messages at this interface.

6.5.6.6.8.4 UcdInterval

The interval between CMTS transmission of successive Upstream Channel Descriptor messages for each upstream channel at this interface.

6.5.6.6.8.5 InvitedRangingAttempts

The maximum number of attempts to make on invitations for ranging requests. A value of zero means the CM will attempt to range forever.

6.5.6.6.8.6 ImInsertInterval

The amount of time to elapse between each broadcast initial maintenance grant. Broadcast initial maintenance grants are used to allow new cable modems to join the network. Zero indicates that a vendor-specific algorithm is used instead of a fixed time. The maximum amount of time permitted by the specification is 2 seconds.

6.5.6.6.9 DocsisDownChannel

This configuration object is included in Figure 31 for reference. It is defined in Section 6.5.6.9.3.

6.5.6.6.10 DownChannel

This configuration object is included in Figure 31 for reference. It is defined in Section 6.5.6.9.5.

6.5.6.6.11 DsBondingGrpCfg

The DsBondingGrpCfg object allows for the static creation of Downstream bonding groups. In some current DOCSIS 3.0 configurations, downstream channels are not tied directly to a specific MAC domain, while in others these downstream channels are an integral part of the MAC domain. For CCAP flexibility, the statically configured bonding group may be optionally explicitly associated with one or multiple MAC domains.

To configure a downstream bonding group, an instance of the DsBondingGrpCfg object is created. The attributes of the DsBondingGrpCfg are shown below. This table has been modified from the definition in OSSIv3.0.

Table 128 - DsBondingGrpCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			
SfProvAttrMask	AttributeMask	No			bonded
DsidReseqWarnThrshld	UnsignedByte	No	0..179 | 255	hundredMicroseconds	255
DsidReseqWaitTime	UnsignedByte	No	1..180 | 255	hundredMicroseconds	255

Table 129 - DsBondingGrpCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DocsisDownChannel	Directed aggregation to DocsisDownChannel	0..*	0..*	ChannelId
MacDomainCfg	Directed aggregation to MacDomainCfg		0..*	MacDomainName
DsOfdmChannelCfg	Directed aggregation to DsOfdmChannelCfg	0..*		DsBondingGrpCfgReferences

6.5.6.6.11.1 Name

The name of the downstream bonding group. This attribute is used as a key.

6.5.6.6.11.2 SfProvAttrMask

This attribute represents the Provisioned Attribute Mask encoding for the bonding group.

6.5.6.6.11.3 DsidReseqWarnThrshld

This attribute provides the DSID Resequencing Warning Threshold in hundreds of microseconds that is to be used for all DSIDs associated with this Downstream Bonding Group. The value of 255 indicates that the DSID Resequencing Warning Threshold is determined by the CMTS. The value of 0 indicates that the threshold warnings are disabled.

When the value of DsidReseqWaitTime is not equal to 0 or 255, the CCAP will ensure that the value of this object is either 255 or less than the value of DsidReseqWaitTime.

6.5.6.6.11.4 DsidReseqWaitTime

This attribute provides the DSID Resequencing Wait Time in hundreds of microseconds that is to be used for all DSIDs associated with this Downstream Bonding Group. The value of 255 indicates that the DSID Resequencing Wait Time is determined by the CMTS.

6.5.6.6.12 UsBondingGrpCfg

The UsBondingGrpCfg object allows for the static creation of upstream bonding groups. To configure an upstream bonding group, an instance of the UsBondingGrpCfg object is created. The attributes of the UsBondingGrpCfg are shown below.

Table 130 - UsBondingGrpCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			
SfProvAttrMask	AttributeMask	No			bonded

Table 131 - UsBondingGrpCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UpstreamLogicalChannel	Directed aggregation to UpstreamLogicalChannel	0..*	0..*	ChannelId
UsOfdmaChannel	Directed aggregation to UsOfdmaChannel	0..*	0..*	

6.5.6.6.12.1 Name

The name of the upstream bonding group. This attribute is used as a key.

6.5.6.6.12.2 SfProvAttrMask

This attribute represents the Provisioned Attribute Mask encoding for the bonding group.

6.5.6.6.13 UpstreamLogicalChannel

This configuration object is included in Figure 31 for reference. It is defined in Section 6.5.6.8.7.

6.5.6.6.14 RccCfg

This section defines the CCAP Receive Channel Configuration (RCC) Configuration objects.

This object creates static Receive Channel Configurations for specific downstream channel configurations, identifies the scope of the Receive Channel Configuration (RCC), and provides a top-level container for the Receive Module and Receive Channel objects. The CCAP selects an instance of this object to assign to a CM when it registers.

This object supports the creation and deletion of multiple instances.

The CMTS and CCAP MUST persist all instances of RccCfg across reinitializations.

Table 132 - RccCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
RcpId	RcpId	key			
RccCfgId	UnsignedInt	key	1..4294967295		
VendorSpecific	HexBinary	No	0..252		"H
Description	String	No	0..15		""

Table 133 - RccCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
RxModuleCfg	Directed composition to RxModuleCfg	1	1..*	
RxChCfg	Directed composition to RxChCfg	1	1..*	

6.5.6.6.14.1 RcpId

This key represents the 'Receive Channel Profile Identifier' (RCP-ID) configured for the MAC Domain indicated by this instance.

References: [MULPIv4.0] Standard Receive Channel Profile Encodings Annex.

6.5.6.6.14.2 RccCfgId

This key denotes an RCC combination assignment for a particular RcpId and is unique per combination of MAC Domain and RcpId.

6.5.6.6.14.3 VendorSpecific

This attribute contains vendor-specific information of the CM Receive Channel configuration.

References: [MULPIv4.0] Receive Channel Profile/Configuration Vendor Specific Parameters section in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.5.6.6.14.4 Description

This attribute contains a human-readable description of the CM RCP Configuration.

6.5.6.6.15 RxChCfg

The Receive Channel Configuration object permits an operator to configure how CMs registered with certain Receive Channel Profiles will configure the Receive Channels within their profile.

When a CM registers with a Receive Channel Profile (RCP) for which all Receive Channel Indices (RcIds) are configured in the Receive Module object and all Receive Channels are configured within this object, the CCAP SHOULD use the configuration within these objects to set the Receive Channel Configuration returned to the CM in a REG-RSP message.

The CCAP MAY require configuration of all pertinent Receive Module and Receive Channel instances in order to register a CM that reports a Receive Channel Profile (RCP), including any standard Receive Channel Profiles.

If the CM reports multiple RCPs and Receive Module and Receive Channel objects have instances for more than one RCP, the particular RCP selected by the CCAP is not specified. A CCAP is not restricted to assigning Receive Modules based only on the contents of this object.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the reference of a valid RccCfg instance and a reference to a ChannelIndex.

The CMTS and CCAP MUST persist all instances of RxChCfg across reinitializations.

Table 134 - RxChCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
RcId	UnsignedByte	key	1..255		
PrimaryDsIndicator	PrimaryDsIndicatorType	No			notSpecified

Table 135 - RxChCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
RxModuleCfg*	Association with RxModuleCfg	0..*	0..1	
DocsisDownChannel	Directed aggregation to DocsisDownChannel			ChannelIndex
DsOfdmChannelCfg	Directed aggregation to DsOfdmChannelCfg	0..*	1	Index

* If an RxModuleCfg is not specified, the Receive Channel Connectivity TLV is omitted from the RCC.

6.5.6.6.15.1 RcId

This key represents an identifier for the parameters of the Receive Channel instance within the Receive Channel Profile.

References: [MULPIv4.0] Receive Channel Index section in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.5.6.6.15.2 PrimaryDsIndicator

This attribute encodes the type of downstream channel. Since support for backup primary channels is not required, the CCAP MAY reject configurations where this attribute is set to 'backupPrimary' if this feature is unsupported.

6.5.6.6.16 RxModuleCfg

DOCSIS 4.0 uses simplified RCC messaging, and this object is ignored when using that mode of operation.

When operating in DOCSIS 3.0 mode, the Receive Module Configuration object permits an operator to configure how CMs with certain RCPs will configure the Receive Modules within their profile upon CM registration.

When a CM registers with an RCP for which all Receive Module Indices (RmIds) are configured in this object and all Receive Channels are configured within the Receive Channel (RxCh) object, the CCAP SHOULD use the configuration within these objects to set the Receive Channel Configuration assigned to the CM in a REG-RSP message.

The CCAP MAY require configuration of all pertinent Receive Module and Receive Channel instances in order to register a CM that reports a Receive Channel Profile.

If the CM reports multiple RCPs and Receive Module and Receive Channel objects have instances for more than one RCP reported by the CM, the particular RCP selected by the CCAP is not specified. A CCAP is not restricted to assigning Receive Modules based only on the contents of this object.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the reference of a valid RccCfg instance.

The CMTS and CCAP MUST persist all instances of RxModuleCfg across reinitializations.

Table 136 - RxModuleCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
RmId	UnsignedByte	Key	1..255		
FirstCenterFrequency	UnsignedInt	No		Hz	0

Table 137 - RxModuleCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
RxChCfg	Association with RxChCfg	0..1	0..*	
RxModuleCfg	Association with RxModuleCfg	0..1	0..*	

The CCAP MUST reject the configuration of an instance of RxModuleCfg that is associated with itself. If this object is not associated with another RxModuleCfg instance, the Receive Module Connectivity TLV is omitted from the RCC. The CCAP MUST reject the configuration of an instance of RxChCfg instances with circular references.

6.5.6.6.16.1 RmId

This key represents an identifier of a Receive Module instance within the Receive Channel Profile.

References: [MULPIv4.0] Receive Module Index in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.5.6.6.16.2 FirstCenterFrequency

This attribute represents the center frequency, in Hz, and a multiple of 62500, that indicates the low frequency channel of the Receive Module, or 0 if not applicable to the Receive Module.

References: [MULPIv4.0] Receive Module First Channel Center Frequency Assignment section in the Encodings for Configuration and MAC-Layer Messaging Annex.

6.5.6.6.17 DenyCm

This configuration object allows an operator to create a list of CM MAC addresses that are not allowed to register.

Table 138 - DenyCm Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DeviceMacAddress	MacAddress	Yes (Key)			

6.5.6.6.17.1 DeviceMacAddress

The MAC address of the CM that will be added to the deny list. This attribute is used as a key.

6.5.6.7 DOCSIS Multicast Authorization Configuration Information Model

The CCAP authorization module allows operators to selectively authorize access to multicast content for subscribers. This group of configuration elements allows for the configuration of DOCSIS Multicast Authorization. The configuration specific Information Model is shown below. This model provides the Multicast Conditional Access Model for the authorization of clients to join multicast sessions. The components of the Multicast Authorization model are:

- Ctrl, global configuration of Multicast authorization
- ProfileSessRule, DOCSIS Multicast profile-based authorization

A Multicast Authorization Profile Session rule consist of a pair source and group prefix addresses, an authorization action and a priority configured in the CMTS. This rule corresponds to the expansion of the IP Multicast Authorization Profile Name Subtype encoding signaled by the CM during registration.

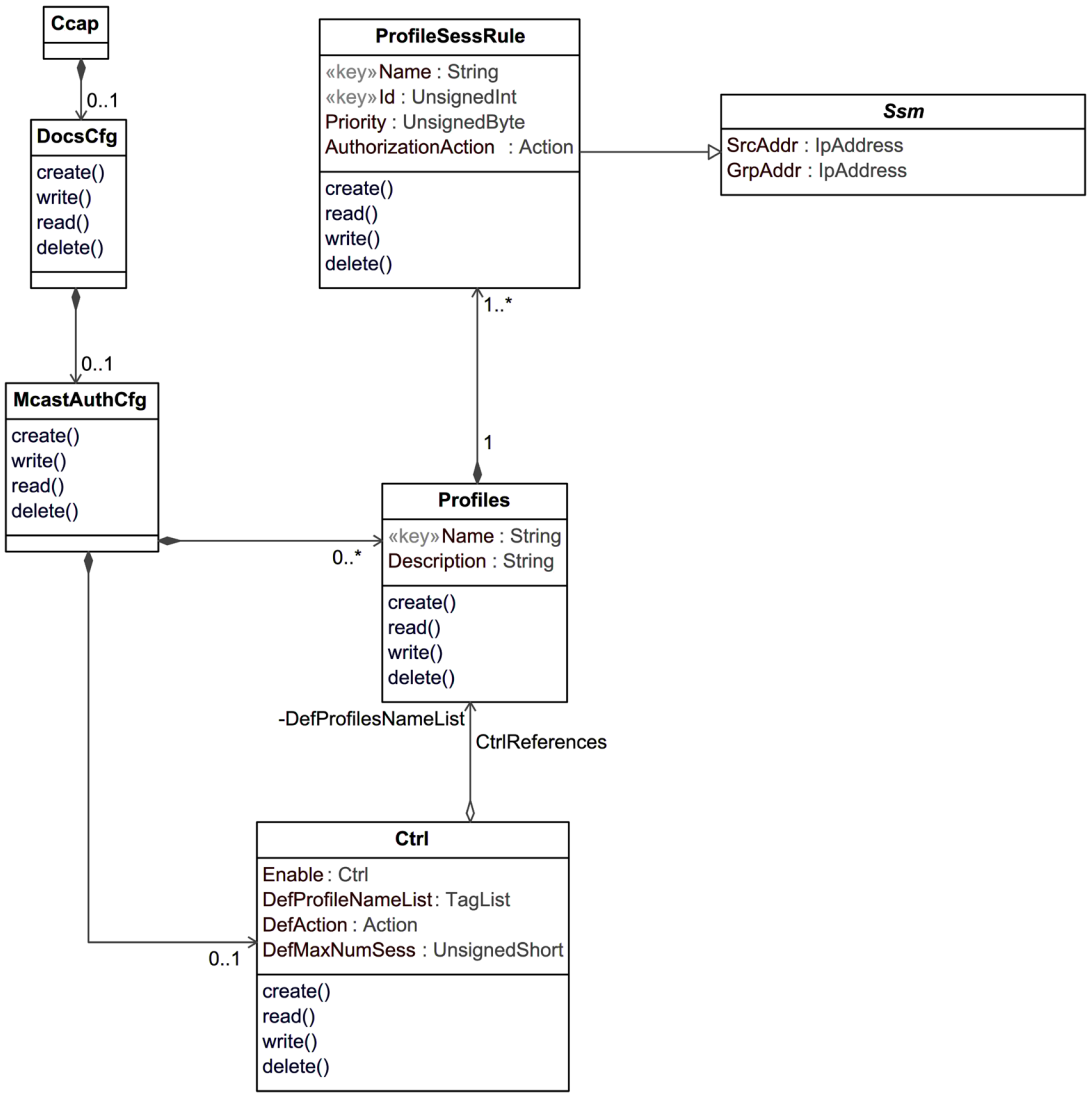


Figure 32 - DOCSIS Multicast Authorization Configuration Information Model

6.5.6.7.1 Ccap

This configuration object is included in Figure 32 for reference. It is defined in Section 6.5.3.1.

6.5.6.7.2 DocsCfg

This configuration object is included in Figure 32 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.7.3 McastAuthCfg

The McastAuthCfg object is the container for DOCSIS Multicast Authorization configuration objects. It has the following associations:

Table 139 - McastAuthCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Profiles	Directed composition to Profiles		0..*	
Ctrl	Directed composition to Ctrl		0..1	

6.5.6.7.4 Profiles

This object contains the description of the Multicast Authorization profiles for administrative purposes.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the Name and Description attributes to be set.

The CMTS and CCAP MUST persist all instances of the Profiles object across reinitializations.

Table 140 - Profiles Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
Name	String	key	SIZE (1..15)		
Description	String	Yes			

Table 141 - Profiles Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ProfileSessRule	Directed composition to ProfileSessRule	1	1..*	

6.5.6.7.4.1 Name

This attribute is a unique name or identifier for a Multicast Authorization Profile.

6.5.6.7.4.2 Description

This attribute is a human readable description of the Multicast Authorization Profile.

6.5.6.7.5 Ctrl

This object defines the CCAP global behavior for Multicast Authorization. Some parameters are included as part of the CM configuration process. In absence of those parameters, default values defined by attributes of this object are used.

The CMTS and CCAP MUST persist the values of the attributes of the Ctrl object across reinitializations.

Table 142 - Ctrl Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Enable	Enum	No	other(0), enable(1), disable(2)		disable
DefProfileNameList	TagList	No			"H
DefAction	Enum	No	other(1), accept(2), deny(3)		deny
DefMaxNumSess	UnsignedShort	No			0

Table 143 - Ctrl Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Profiles*	Directed aggregation to Profiles			DefProfilesNameList

*This association indicates which Multicast Authorization Profiles are used by the CMTS when CMs register with no Multicast Join Authorization encodings in the REG-REQ-(MP). When IP Multicast Authorization is enforced, these associations provide the default set of Multicast Authorization Profiles the CMTS enforces for a CM in case the CM did not signal a set of profiles during the registration process. If no associations are specified, the DefAction attribute determines whether a join request is authorized. If the CMTS supports more than one profile as a default, the CMTS enforces each of the profiles in order of occurrence until the maximum number of profiles is reached.

6.5.6.7.5.1 Enable

This attribute enables the enforcement of Multicast Authorization feature. When this attribute is set to 'enable', Multicast Authorization is enforced; otherwise, clients are permitted to join any IP multicast session. The factory default value of this attribute is 'disable'.

6.5.6.7.5.2 DefProfileNameList

When IP Multicast Authorization is enforced, this attribute provides the default set of Multicast Authorization Profiles the CMTS enforces for a CM in the case that this CM didn't signal a set of profiles during the registration process. If the Default Multicast Authorization Group Name is zero length string, the DefAction attribute determines whether a join request is authorized when a CM registers without a Multicast Authorization Profile Set or a list of config File Session Rules. If the CMTS supports more than 1 profile name as a default, the CMTS enforces each of the profiles in order until the maximum number of profiles is reached. This attribute indicates one or more Multicast Authorization Profiles.

6.5.6.7.5.3 DefAction

This attribute defines the default authorization action when no IP Multicast Session Rule is determined to match a client's IP multicast JOIN request. The factory default of this attribute is 'deny'.

6.5.6.7.5.4 DefMaxNumSess

This attribute indicates the default maximum number of multicast sessions that clients reached through a particular CM are allowed to join. A DefMaxNumSess value of 0 indicates that no dynamic joins are permitted. A Maximum Multicast Sessions Encoding value of 65535 (the largest valid value) indicates that the CMTS permits any number of sessions to be joined by clients reached through the CM.

References: [MULPIv4.0] Maximum Multicast Sessions section.

6.5.6.7.6 ProfileSessRule

This object defines Operator configured profiles to be matched during the authorization process.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the following attributes to be set:

- SrcAddr
- GrpAddr

Each of these attributes is inherited from the abstract Ssm object.

The CMTS and CCAP MUST persist all instances of the ProfileSessRule object across reinitializations.

Table 144 - ProfileSessRule Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	AdminString	key	SIZE (1..15)		
Id	UnsignedInt	key	1..4294967295		
Priority	UnsignedInt	No			0
AuthorizationAction	Enum	No	other(1), accept(2), deny(3)		deny

Table 145 - ProfileSessRule Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Ssm	Directed association to Ssm			DefProfilesNameList

6.5.6.7.6.1 Name

This attribute is a unique name that associates the IP Multicast Authorization Profile Name Subtype encoding signaled by CMs with a set of Multicast Authorization Profile Session Rules.

6.5.6.7.6.2 Id

This attribute provides a unique identifier for each CMTS configured Multicast Authorization Profile Session rule within a Multicast Authorization Profile Name.

6.5.6.7.6.3 Priority

This attribute configures the rule priority for the static session rule. Higher values indicate a higher priority. If more than one session rule matches a joined session, the session rule with the highest rule priority determines the authorization action.

6.5.6.7.6.4 AuthorizationAction

This attribute specifies the authorization action for a session join attempt that matches the session rule.

The value 'accept' indicates that the rule permits a matching multicast join request is allowed. The value 'deny' indicates that a matching multicast join request is denied.

6.5.6.7.7 Ssm

This abstract object holds the shared source-specific multicast session address attributes used by the ProfileSessRule and the CmtsGrpCfg objects.

Table 146 - Ssm Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SrcAddr	IpAddress	Yes			
GrpAddr	IpAddress	Yes			

6.5.6.7.7.1 SrcAddr

This attribute identifies a specific Multicast Source Address defined for this rule. A Source Address that is all zeros is defined as 'all source addresses' (*, G). Source addresses are unicast addresses.

References: [RFC 3306] sections 6 and 7.

6.5.6.7.7.2 GrpAddr

This attribute is the IP address corresponding to an IP multicast group.

6.5.6.8 DOCSIS Upstream Interface Configuration Information Model

The DOCSIS Upstream Interface configuration objects are shown in the following diagram.

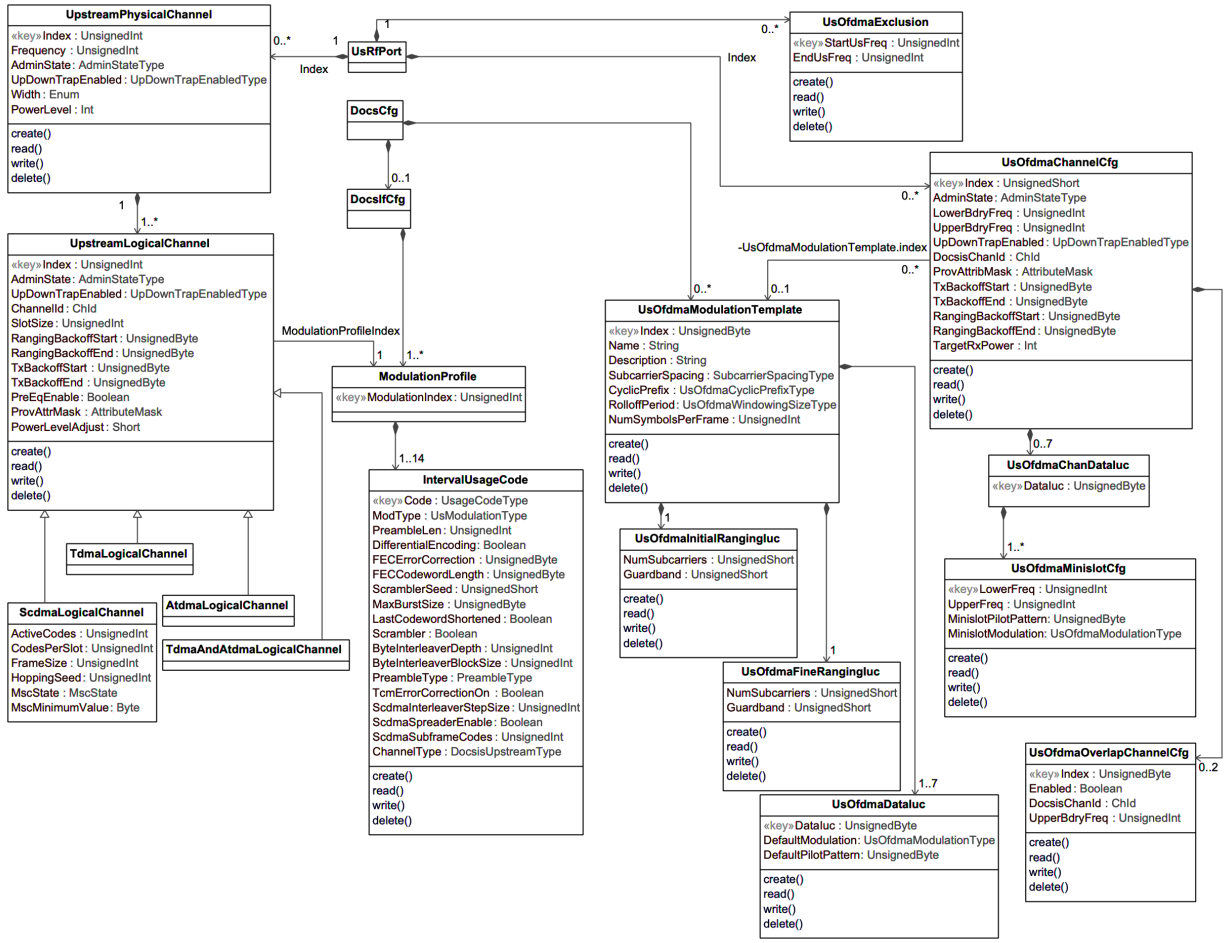


Figure 33 - DOCSIS Upstream Interface Configuration Information Model

6.5.6.8.1 DocsCfg

This configuration object is included in Figure 33 for reference. It is defined in Section 6.5.6.1.2, DocsCfg.

6.5.6.8.2 DocsIfCfg

The DocsIfCfg object is the container for the DOCSIS 3.0 upstream interface configuration objects. It has the following associations:

Table 147 - DocsIfCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ModulationProfile	Directed composition to ModulationProfile		1..*	

6.5.6.8.3 ModulationProfile

This object allows a modulation profile to be associated to a DOCSIS 3.0 upstream logical channel. It has a single attribute, ModulationIndex, which is based on the Index attribute defined in docsIfCmtsModulationTable defined in [RFC 4546].

Reference: [RFC 4546], docsIfCmtsModulationTable

Table 148 - ModulationProfile Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
ModulationIndex	UnsignedInt	Yes (key)			

Table 149 - ModulationProfile Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IntervalUsageCode	Directed composition to IntervalUsageCode		1..14	

6.5.6.8.3.1 ModulationIndex

An index into the Channel Modulation table representing a group of Interval Usage Codes, all associated with the same channel.

6.5.6.8.4 IntervalUsageCode

This object allows a list of interval usage codes to be associated with a single modulation profile. It is based on the docsIfCmtsModulationTable defined in [RFC 4546] and will be used with the following modifications for CCAP. The following attributes have been removed:

- ModulationIndex (included in the ModulationProfile object)
- StorageType
- Control
- GuardTimeSize

The IntervalUsageCode attribute has been renamed Code.

The ModType, PreambleType and ChannelType attributes have had the unknown enumerations removed and a new enumeration, other(1), added to allow for vendor extension. The enumeration definitions can be found in the following attributes table.

Reference: [RFC 4546], docsIfCmtsModulationTable

Table 150 - IntervalUsageCode Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ModType	Enum	No	other(1), qpsk(2), qam8(3), qam16(4), qam32(5), qam64(6), qam128(7)		qpsk
PreambleType	Enum	Yes	other(1), qpsk0(2), qpsk1(3)		

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ChannelType	Enum	Yes	other(1), tdma(2), atdma(3), scdma(4), tdmaAtdma(5)		

6.5.6.8.5 UsRfPort

This configuration object is included in Figure 33 for reference. It is defined in Section 6.5.4.14, UsRfPort.

6.5.6.8.6 UpstreamPhysicalChannel

The UpstreamPhysicalChannel object represents SC-QAM operation on a single upstream center frequency at a particular channel width.

Since CCAP is expected to operate with only DOCSIS 2.0 or later upstream channels, at least one UpstreamLogicalChannel object (ifType 205) is needed to be instantiated to operate within an UpstreamPhysicalChannel.

This object differs from previous objects in DOCSIS in that the desired input power is now set at the UpstreamPhysicalChannel and not on a per-UpstreamLogicalChannel instance. If the target receive power level for an individual logical channel under a physical channel is desired to be different than the target power level for the physical channel, this can be configured using the PowerLevelAdjust attribute of the UpstreamLogicalChannel object.

Table 151 - UpstreamPhysicalChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)	1..*		
Frequency	UnsignedInt	Yes	5,000,000..85,000,000	Hertz	
Width	Enum	Yes	other(1), 200000(2), 400000(3), 800000(4) 1600000(5), 3200000(6), 6400000(7)	Hertz	
AdminState	AdminStateType	No			down
UpDownTrapEnabled	UpDownTrapEnabled	No			true
PowerLevel	Int	Yes		TenthdBmV	

An UpstreamPhysicalChannel is contained by a single UsRfPort. It contains one or more UpstreamLogicalChannel objects. It is referenced by a single MacDomain.

Table 152 - UpstreamPhysicalChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UpstreamLogicalChannel	Directed composition to UpstreamLogicalChannel	1	1..*	

6.5.6.8.6.1 UpstreamPhysicalChannel Requirements

The CCAP MUST reject activation of a set of configuration objects that would cause an overlap of RF channel frequency on any single upstream RF port.

6.5.6.8.6.2 Index

This attribute uniquely identifies an SC-QAM UpstreamPhysicalChannel on its UsRfPort. Its value is between one and the maximum number of UpstreamPhysicalChannels supported on the UsRfPort, inclusive.

6.5.6.8.6.3 Frequency

This attribute configures the center frequency of the UpstreamPhysicalChannel, in Hertz. For DOCSIS 3.0 operation, the minimum permitted value is the center frequency such that the lower channel edge is 5000000 Hz and the maximum permitted value is the center frequency at which the upper channel edge is 85000000 Hz. This attribute corresponds to the docsIfUpChannelFrequency object of DOCS-IF-MIB [RFC 4546]. The CCAP MUST reject the configuration of an UpstreamPhysicalChannel instance that overlaps in frequency with another UpstreamPhysicalChannel instance on the same upstream RF port.

6.5.6.8.6.4 Width

This attribute configures the width of the UpstreamPhysicalChannel, in Hertz. While the only permitted values for DOCSIS 3.0 are 1,600,000, 3,200,000, and 6,400,000, this specification also includes widths of 200,000, 400,000, and 800,000 for backward compatibility. This attribute corresponds to the docsIfUpChannelFrequency object of DOCS-IF-MIB [RFC 4546].

The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.6.8.6.5 AdminState

This attribute configures the administrative state of this instance.

6.5.6.8.6.6 UpDownTrapEnabled

This attribute configures whether linkUp/linkDown traps are enabled for this channel.

6.5.6.8.6.7 PowerLevel

This attribute configures the desired input power level, in TenthdBmV, common to all upstream logical channels associated with this physical channel instance. This attribute represents the desired total average receive power for the channel regardless of whether there are 4.0 CMs operational on the channel. The power level for an individual logical channel can deviate from the common power level through the configuration of the PowerLevelAdjust attribute of the UpstreamLogicalChannel object.

6.5.6.8.7 UpstreamLogicalChannel

The UpstreamLogicalChannel object represents scheduled intervals of time on a single UpstreamPhysicalChannel. An SC-QAM UpstreamLogicalChannel is either SCDMA, TDMA, ATDMA, or both TDMA and ATDMA. Each UpstreamLogicalChannel is identified with a DOCSIS upstream channel ID. The MAP management messages transmitted downstream by the CCAP schedule intervals of time for each DOCSIS upstream channel ID. In the SNMP MIB, an UpstreamLogicalChannel is an interface with ifType UpstreamLogicalChannel (205).

Table 153 - UpstreamLogicalChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
AdminState	AdminStateType	No			down
UpDownTrapEnabled	UpDownTrapEnabled	No			false
ChannelId	ChId	No			0
SlotSize	UnsignedInt	Yes		ticks	
RangingBackoffStart	UnsignedByte	Yes	0..16	power of 2	
RangingBackoffEnd	UnsignedByte	Yes	0..16	power of 2	

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TxBackoffStart	UnsignedByte	Yes	0..16		
TxBackoffEnd	UnsignedByte	Yes	0..16		
PreEqEnable	Boolean	Yes			
ProvAttrMask	AttributeMask	Yes			
PowerLevelAdjust	Short	No		TenthdB	0

This object differs from the same object in previous versions of DOCSIS in that the desired common input power is now set at the Upstream Physical Channel and power level adjustments can only be configured on a per UpstreamLogicalChannel basis.

Table 154 - UpstreamLogicalChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ModulationProfile	Directed association to ModulationProfile		1	ModulationProfileIndex

6.5.6.8.7.1 Index

This key attribute uniquely identifies an SC-QAM UpstreamLogicalChannel operating on the center frequency and width of a single UpstreamPhysicalChannel. This index is in the range between one and the maximum number of UpstreamLogicalChannel objects supported by the CCAP on an UpstreamPhysicalChannel.

6.5.6.8.7.2 AdminState

This attribute stores the administrative state of the upstream logical channel.

6.5.6.8.7.3 UpDownTrapEnabled

This attribute configures whether linkUp/linkDown traps are enabled for this channel.

6.5.6.8.7.4 ChannelId

This attribute permits an operator to optionally configure the upstream channel ID signaled in the DOCSIS protocol for the UpstreamLogicalChannel. By default, the CCAP will automatically assign the DocsisUpChannelId. An operator can create or update this attribute with a value to force the CCAP to use the configured DOCSIS channel ID. A unique configured value exists within the MacDomain to which the UpstreamPhysicalChannel containing this UpstreamLogicalChannel is associated. A value of zero indicates that the CCAP should automatically assign the DOCSIS Channel ID.

6.5.6.8.7.5 SlotSize

This attribute configures the number of 6.25 microsecond ticks in each upstream minislot for the UpstreamLogicalChannel. This attribute may have different values for the different UpstreamLogicalChannel objects on the same UpstreamPhysicalChannel. This attribute is applicable to TDMA and ATDMA channel types only; its value is read and written as zero for SDCMA type channels.

6.5.6.8.7.6 RangingBackoffStart

This attribute is the initial random back-off window to use when retrying Ranging Requests. It is expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

6.5.6.8.7.7 RangingBackoffEnd

This attribute is the final random back-off window to use when retrying Ranging Requests. It is expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

6.5.6.8.7.8 TxBackoffStart

The initial random back-off window to use when retrying transmissions. Expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used. See the associated conformance object for write conditions and limitations.

6.5.6.8.7.9 TxBackoffEnd

The final random back-off window to use when retrying transmissions. Expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used. See the associated conformance object for write conditions and limitations.

6.5.6.8.7.10 PreEqEnable

This attribute enables pre-equalization on the UpstreamLogicalChannel when its value is true or disables pre-equalization when its value is false.

6.5.6.8.7.11 ProvAttrMask

This attribute configures the 32-bit Provisioned Attribute Mask for the UpstreamLogicalChannel. This is used by a CCAP to control how upstream service flows are assigned to the UpstreamLogicalChannel.

6.5.6.8.7.12 PowerLevelAdjust

This attribute configures the adjustment from the common power level configured for the physical US channel; it is expressed in TenthdB. The sum of the UpstreamPhysicalChannel PowerLevel and UpstreamLogicalChannel PowerLevelAdjust determines the expected input power level for the logical channel. If the CCAP does not support the ability to set the PowerLevelAdjust attribute to a non-zero value, the CCAP MAY log an error upon execution of a NETCONF configuration operation that contains a negative attribute value.

6.5.6.8.8 ScdmaLogicalChannel

This configuration object is constructed from the SCDMA fields of the docsIfUpstreamChannelTable defined in [RFC 4546] and [DOCS-IFEXT2-MIB], and these attributes are used with the following modification for CCAP: a value of "other" has been added to the MscState attribute's enumeration to allow for vendor extension. The enumeration definition can be found in the following attributes table.

The Scdma object is an optional grouping of additional parameters to an UpstreamLogicalChannel that is defined only for UpstreamLogicalChannel objects that reference an SCDMA modulation profile.

References: [RFC 4546], docsIfUpstreamChannelTable; [DOCS-IFEXT2-MIB]

Table 155 - ScdmaLogicalChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
MscState	Enum	No	other(1), channelEnabled(2), channelDisabled(3), dormant(4)		channelDisabled

Table 156 - ScdmaLogicalChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Units	Default Value
UpstreamLogicalChannel	Specialization of UpstreamLogicalChannel				

6.5.6.8.9 TdmaLogicalChannel

This configuration object is a specialization of the docsIfUpstreamChannelTable defined in [RFC 4546] for TDMA logical channels.

References: [RFC 4546], docsIfUpstreamChannelTable; Annex A

Table 157 - TdmaLogicalChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Units	Default Value
UpstreamLogicalChannel	Specialization of UpstreamLogicalChannel				

6.5.6.8.10 AtdmaLogicalChannel

This configuration object is a specialization of the docsIfUpstreamChannelTable defined in [RFC 4546] for ATDMA logical channels.

References: [RFC 4546], docsIfUpstreamChannelTable; Annex A

Table 158 - AtdmaLogicalChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Units	Default Value
UpstreamLogicalChannel	Specialization of UpstreamLogicalChannel				

6.5.6.8.11 TdmaAndAtdmaLogicalChannel

This configuration object is a specialization of the docsIfUpstreamChannelTable defined in [RFC 4546] for mixed TDMA/ATDMA logical channels.

References: [RFC 4546], docsIfUpstreamChannelTable; Annex A

Table 159 - TdmaAndAtdmaLogicalChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Units	Default Value
Scdma	Specialization of UpstreamLogicalChannel				

6.5.6.8.12 UsOfdmaChannelCfg

This object specifies the upstream OFDMA Parameters for a single upstream OFDMA channel.

Upstream OFDMA channel band edge limits depend on the mode of operation to which DOCSIS equipment is configured to operate. Refer to [PHYv3.1] *Upstream CM Spectrum* section, for the upstream OFDMA boundary frequency limits when equipment is configured to be compliant with the DOCSIS 3.1 and DOCSIS 4.0 frequency plans. Per [PHYv4.0], channels operating at frequencies above 108 MHz are on a 96 MHz grid. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan* section for the upstream OFDMA boundary frequency limits for the plant when equipment is configured to be compliant with FDX mode. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan for FDD Operation* section for the upstream OFDMA boundary frequency limits when the equipment is configured to be compliant with FDD mode. See Table 161 for its object associations.

Table 160 - UsOfdmaChannelCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
Index	UnsignedShort	Key				
AdminState	AdminStateType	No				down
LowerBdryFreq	UnsignedInt	Yes	5000000..588000000	1	Hz	
UpperBdryFreq	UnsignedInt	Yes	11400000..684000000	1	Hz	
UpDownTrapEnabled	UpDownTrapEnabled	No				true
DocsisChanId	ChId	No				0

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
ProvAttribMask	AttributeMask	Yes				
TxBackoffStart	UnsignedByte	Yes	0..16		power of 2	
TxBackoffEnd	UnsignedByte	Yes	0..16		power of 2	
RangingBackoffStart	UnsignedByte	Yes	0..16		power of 2	
RangingBackoffEnd	UnsignedByte	Yes	0..16		power of 2	
TargetRxPower	UnsignedInt	Yes			TenthdBmV	

Table 161 - UsOfdmaChannelCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UsOfdmaModulationTemplate*	Directed association to UsOfdmaModulationTemplate	0..*	0..1	UsOfdmaModulationTemplate.Index
UsOfdmaChanDataIuc	Directed composition to UsOfdmaChanDataIuc	1	0..7	
UsOfdmaOverlapChannelCfg	Directed composition to UsOfdmaOverlapChannelCfg	1	0..2	UsOfdmaOverlapChannelCfg Index

*A template does not need to be assigned if the vendor supports automatic profile assignment.

6.5.6.8.12.1 Index

This attribute is a key defined to provide an index into the table.

6.5.6.8.12.2 AdminState

This attribute is the admin state for the upstream OFDMA channel.

6.5.6.8.12.3 LowerBdryFreq

This attribute defines the lower frequency for the upstream channel.

Per the CM Transmitter Output Signal Characteristics table in [PHYv4.0], the minimum occupied bandwidth is 6.4 MHz and 10 MHz for 25 kHz and 50 kHz Subcarrier Spacing, respectively. Thus, for 25kHz Subcarrier Spacing the maximum value for this attribute is 197,600,000 Hz and for 50 kHz Subcarrier Spacing the maximum value for this attribute is 194,000,000 Hz.

When an OFDMA channel is configured with 25 kHz Subcarrier Spacing, the CCAP MUST reject configurations where UpperBdryFreq - LowerBdryFreq < 6.4 MHz.

Similarly, when an OFDMA channel is configured with 50 kHz Subcarrier Spacing, the CCAP MUST reject configurations where UpperBdryFreq - LowerBdryFreq < 10 MHz.

6.5.6.8.12.4 UpperBdryFreq

This optional attribute defines the upper frequency for the upstream channel. The CCAP MUST reject configurations where UpperBdryFreq - LowerBdryFreq > 96 MHz.

6.5.6.8.12.5 UpDownTrapEnabled

This attribute indicates if a trap should be sent when the Channel transitions from enable to disable and disable to enable.

6.5.6.8.12.6 DocsisChanId

This attribute permits an operator to optionally configure the upstream channel ID signaled in the DOCSIS protocol for the OFDMA upstream channel. By default, the CCAP will automatically assign the DOCSIS Channel ID. An operator can create or update this attribute with a value to force the CCAP to use the configured DOCSIS Channel ID. A unique configured value exists within the MacDomain to which the OFDMA Channel is associated for each channel in that MacDomain - SC or OFDMA. A value of zero indicates that the CCAP should automatically assign theDOCSIS Channel ID.

6.5.6.8.12.7 ProvAttribMask

This attribute configures the 32-bit Provisioned Attribute Mask for the OFDMA upstream channel. This is used by a CCAP to control how upstream service flows are assigned to the OFDMA upstream channel.

6.5.6.8.12.8 TxBackoffStart

This attribute is the initial random back-off window to use when retrying transmissions. Expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used. See the associated conformance object for write conditions and limitations.

6.5.6.8.12.9 TxBackoffEnd

This attribute is the final random back-off window to use when retrying transmissions. Expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used. See the associated conformance object for write conditions and limitations.

6.5.6.8.12.10 RangingBackoffStart

This attribute is the initial random back-off window to use when retrying Ranging Requests. It is expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

6.5.6.8.12.11 RangingBackoffEnd

This attribute is the final random back-off window to use when retrying Ranging Requests. It is expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

6.5.6.8.12.12 TargetRxPower

This attribute provides the power of the expected commanded received signal in the channel, referenced to the CCAP input. The value represents the power spectral density in an equivalent 1.6 MHz spectrum.

6.5.6.8.13 UsOfdmaChanDataIuc

This object specifies the US OFDMA data IUC whose defaults are being changed for some frequency range within the channel.

Table 162 - UsOfdmaChanDataIuc Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DataIuc	UnsignedByte	Key	5|6|9|10|11|12|13		

Table 163 - UsOfdmaChanDataIuc Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UsOfdmaMinislotCfg	Directed composition to UsOfdmaMinislotCfg	1	1..*	

6.5.6.8.13.1 DataIuc

This attribute is the data IUC being configured.

6.5.6.8.14 UsOfdmaMinislotCfg

This object defines the modulation and pilot pattern for one or more consecutively numbered minislots, where one or both of these parameters differ from the default for the OFDMA profile for this channel. The minislots affected are defined by a frequency range. If partial minislots match the frequency range, it is vendor-dependent whether those partially matching minislots use the modulation and pilot pattern as defined in this object or the modulation and pilot pattern defined by the modulation profile.

Table 164 - UsOfdmaMinislotCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
LowerFreq	UnsignedInt	Key	5000000-197600000	Hz	
UpperFreq	UnsignedInt	Yes	11400000-204000000	Hz	
MinislotPilotPattern	UnsignedByte	Yes	1..14		
MinislotModulation	UsOfdmaModulationType	Yes			

6.5.6.8.14.1 LowerFreq

This attribute defines the start frequency where the minislots will use the pilot pattern and modulation as specified by this object, instead of the defaults for the channel. LowerFreq needs to be within the frequencies allotted to the channel. The CCAP MUST reject a configuration where the lower frequency is outside of the channel frequency range.

6.5.6.8.14.2 UpperFreq

This attribute defines the end frequency where the minislots will use the pilot pattern and modulation as specified by this object, instead of the defaults for the channel. The UpperFreq value needs to be greater than or equal the LowerFreq value. The CCAP MUST reject a configuration where the upper frequency is outside of the channel frequency range.

6.5.6.8.14.3 MinislotPilotPattern

This attribute defines the pilot pattern for the minislot. All samples in the minislot have the same pilot pattern. Channels using 2k mode are restricted to patterns 1-7. In 2k mode, the CCAP MUST reject a configuration with mixture of pilot patterns 1-4 and 5-7 on the same OFDMA channel.

Channels using 4k mode are restricted to patterns 8-14. In 4k mode, the CCAP MUST reject a configuration with a mixture of pilot patterns 8-11 and 12-14 on the same OFDMA channel.

Reference: [PHYv4.0], Upstream Pilot Pattern section

6.5.6.8.14.4 MinislotModulation

This attribute defines the modulation for the minislot. All samples in the minislot have the same modulation.

6.5.6.8.15 UsOfdmaOverlapChannelCfg

This object defines configuration for Overlapping OFDMA Channels (OOC). The use case for OOC is described in [MULPIv3.1].

When the OOC capability is configured for an OFDMA Channel, the "Physical OFDMA Channel" is defined via UsOfdmaChannelCfg parameters. The Physical OFDMA Channel is the channel which corresponds directly with the PHY burst receiver. There is an implied "Base Overlap Channel" which assumes the full configuration defined

for the Physical OFDMA Channel. There may be either one or two additional Overlap Channels sharing the Physical OFDMA Channel. These Overlap Channels inherit the same configuration as the Base Overlap/Physical OFDMA Channel except that the DOCSIS Channel ID and the OFDMA Channel upper boundary frequency of each Overlap Channel need to be unique to the respective Overlap Channel. See Table 166 for its object associations.

Table 165 - UsOfdmaOverlapChannelCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
Index	UnsignedByte	Key	1..2			
Enabled	Boolean	Yes				
DocsisChanId	ChId	No				0
UpperBdryFreq	UnsignedInt	Yes	11400000..108000000	1	Hz	

Table 166 - UsOfdmaOverlapChannelCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UsOfdmaChannelCfg	Directed composition to UsOfdmaChannelCfg	1	0..2	UsOfdmaChannelCfg Index

6.5.6.8.15.1 Index

This key identifies a non-Base Overlap Channel of a specific Physical OFDMA Channel. The Base Overlap Channel configuration is considered equivalent to the Physical Channel configuration and is consequently not identified with a separate UsOfdmaOverlapChannelCfg.

6.5.6.8.15.2 Enabled

This attribute, when set to 'true', enables OOC for the Overlap Channel associated with this instance. When set to 'false', OOC is disabled for the Overlap Channel associated with this instance.

6.5.6.8.15.3 DocsisChanId

This attribute defines the upstream channel ID signaled in the DOCSIS protocol for the Overlap Channel. By default the CCAP will automatically assign the DOCSIS Channel ID. An operator can create or update this attribute with a value to force the CCAP to use the configured DOCSIS Channel ID. A unique DocsisChanId value exists for each DOCSIS upstream channel in the MAC Domain. The value zero is reserved for use when the DOCSIS Channel ID is unknown.

The CCAP MUST reject an UsOfdmaOverlapChannelCfg configuration where the specified DocsisChanId is already in use in the MAC Domain.

6.5.6.8.15.4 UpperBdryFreq

This attribute defines the upper boundary frequency of the Overlap Channel. The configured value needs to be less than or equal to the UpperBdryFreq value defined in the UsOfdmaChannelCfg of the associated Physical OFDMA Channel. It also needs to be at least a minimum distance, defined by minimum OFDMA channel sizes specified in [PHYv3.1], above the LowerBdryFreq value defined for the Physical OFDMA Channel.

The CCAP MUST reject configurations where the Overlap Channel UpperBdryFreq > the Physical Channel UpperBdryFreq.

6.5.6.8.16 UsOfdmaExclusion

This object specifies an exclusion band for an OFDMA channel. Exclusion bands can be located anywhere in the upstream spectrum and can be as small as one subcarrier.

An OFDMA channel can contain multiple exclusion bands. The CCAP uses these frequency ranges to create a list of subcarriers that fall within these frequencies that will have no signal.

The CCAP MUST reject the configuration of exclusions if the total number of active subcarriers would fall below 6400 / 25 = 256 for 25 kHz Subcarrier Spacing or below 10000 / 50 = 200 for 50 kHz Subcarrier Spacing.

Table 167 - UsOfdmaExclusion Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
StartUsFreq	UnsignedInt	Key	5000000..204000000	Hz	
EndUsFreq	UnsignedInt	Yes	5000000..204000000	Hz	

6.5.6.8.16.1 StartUsFreq

This attribute defines the beginning frequency of the exclusion band.

6.5.6.8.16.2 EndUsFreq

This attribute defines the end frequency of the exclusion band. The CCAP MUST reject configurations where EndUsFreq < StartUsFreq. The CCAP SHOULD reject configurations which contain exclusion frequency ranges that overlap. Note: If the boundary of an exclusion falls within the frequency range of a configured subcarrier, the CCAP will exclude the entire subcarrier.

6.5.6.8.17 UsOfdmaModulationTemplate

UsOfdmaModulationTemplates are global. Each defines some of the US channel parameters, plus provides a definition for the two ranging IUCs and for at least one data IUC.

Table 168 - UsOfdmaModulationTemplate Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedByte	Key			
Name	String	Yes	1..32		
Description	String	No	0..255		""
SubcarrierSpacing	Enum	Yes	other(1), 25kHz(2), 50kHz(3)		
CyclicPrefix	UsOfdmaCyclicPrefixType	Yes		Number of samples	
RolloffPeriod	UsOfdmaWindowingSizeType	Yes		Number of samples	
NumSymbolsPerFrame	UnsignedInt	Yes	6..36		

Table 169 - UsOfdmaModulationTemplate Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UsOfdmaInitialRangingIuc	Directed composition to UsOfdmaInitialRangingIuc	1	1	
UsOfdmaFineRangingIuc	Directed composition to UsOfdmaFineRangingIuc	1	1	
UsOfdmaDataIuc	Directed composition to UsOfdmaDataIuc	1	1..7	

6.5.6.8.17.1 Index

This attribute is a key defined to provide an index into the table.

6.5.6.8.17.2 Name

This attribute contains the name of this OFDMA modulation profile.

6.5.6.8.17.3 Description

This attribute contains a description of this OFDMA modulation profile.

6.5.6.8.17.4 SubcarrierSpacing

This attribute defines the subcarrier spacing and, therefore, the FFT (2k or 4k) for the channel.

6.5.6.8.17.5 CyclicPrefix

This data type is defined to specify the allowed values for applying cyclic prefix for mitigating interference due to microreflections.

6.5.6.8.17.6 RolloffPeriod

This data type is defined to specify the allowed values for applying windowing to maximize the capacity of the upstream channel.

6.5.6.8.17.7 NumSymbolsPerFrame

In [PHYv4.0], this attribute is referred to as K the "Number of symbol periods per frame." For 50 kHz Subcarrier Spacing, the CCAP MUST reject configurations where NumSymbolsPerFrame exceeds K_{max} and where K_{max} is defined in [PHYv4.0] as follows:

K_{max} = 18 for BW > 72 MHz

K_{max} = 24 for 48 MHz < BW < 72 MHz

K_{max} = 36 for BW < 48 MHz

For 25 KHz Subcarrier Spacing, the CCAP MUST reject configurations where NumSymbolsPerFrame exceeds Kmax where Kmax is defined in [PHYv4.0] as follows:

K_{max} = 9 for BW > 72 MHz

K_{max} = 12 for 48 MHz < BW < 72 MHz

K_{max} = 18 for BW < 48 MHz

Where BW is defined as the encompassed spectrum of the associated OFDMA channel.

Reference: [PHYv4.0] Minislot Structure.

6.5.6.8.18 UsOfdmaInitialRangingIuc

This object specifies an initial ranging Interval Usage Code (IUC type 3) for OFDMA US channels.

Table 170 - UsOfdmaInitialRangingIuc Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
NumSubcarriers	UnsignedShort	Yes	16..128		
GuardBand	UnsignedShort	Yes		Hz	

6.5.6.8.18.1 NumSubcarriers

This attribute defines maximum number of subcarriers for fine ranging. This is the maximum number of subcarriers for initial ranging, not including the guard band. This value is limited to a maximum of 64 subcarriers with 50 kHz subcarrier spacing and a maximum of 128 subcarriers with 25 kHz subcarrier spacing ([PHYv4.0], section Allowed Values and Ranges for Configuration Parameters).

6.5.6.8.18.2 GuardBand

This attribute is the sum of the upper and lower guard bands for initial ranging in Hz. The valid range is implementation-specific.

6.5.6.8.19 UsOfdmaFineRangingIuc

This object specifies an initial ranging Interval Usage Code (IUC type 4) for OFDMA US channels.

Table 171 - UsOfdmaFineRangingIuc Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
NumSubcarriers	UnsignedShort	Yes	16..512		
GuardBand	UnsignedInt	Yes		Hz	

6.5.6.8.19.1 NumSubcarriers

This attribute defines maximum number of subcarriers for fine ranging. The following rules apply ([PHYv4.0], Allowed Values and Ranges for Configuration Parameters):

- The maximum number of subcarriers for fine ranging, including subcarriers in the exclusion zones but excluding the guard band, cannot exceed 512 subcarriers with either 25 kHz or 50 kHz subcarrier spacing. The CCAP MUST reject a fine ranging configuration that includes more than 512 subcarriers, not including the guard band.
- The maximum number of subcarriers for fine ranging, excluding the subcarriers in the guard band and subcarriers in the exclusion bands, cannot exceed 256 subcarriers with 50 kHz subcarrier spacing and cannot exceed 512 subcarriers with 25 kHz subcarrier spacing. Note that if 512 subcarriers are used, there cannot be exclusion bands within the fine ranging signal to comply with the previous requirement. The CCAP MUST reject a fine ranging configuration that does not meet these guidelines.

6.5.6.8.19.2 GuardBand

This attribute is the sum of the upper and lower guard bands for fine ranging in Hz. The valid range is implementation specific.

6.5.6.8.20 UsOfdmaDataIuc

This object specifies a data Interval Usage Code for OFDMA upstream channels. The CCAP MUST reject configuration of a UsOfdmaModulationTemplate that does not contain an instance of IUC 13.

Table 172 - UsOfdmaDataIuc Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DataIuc	UnsignedByte	Key	5|6|9|10|11|12|13		
DefaultModulation	UsOfdmaModulationType	Yes			
DefaultPilotPattern	UnsignedByte	Yes	1..14		

6.5.6.8.20.1 DataIuc

This attribute is a key into the UsOfdmaDataIuc table. The CCAP MUST reject configurations which do not contain an instance with a value of 13 (IUC 13 represents the lowest common denominator OFDMA profile for a given upstream channel).

Reference: [MULPIv4.0], Assignment of OFDMA Upstream Data Profile (OUDP) IUCs

6.5.6.8.20.2 DefaultModulation

This attribute is the default modulation for the minislots in this US OFDMA channel.

6.5.6.8.20.3 DefaultPilotPattern

This attribute is default pilot pattern for the minislots in this US OFDMA channel. Channels using 2k mode are restricted to patterns 1-7, while channels using 4k mode are restricted to patterns 8-14 ([PHYv4.0], Upstream Pilot Pattern section). In 2k mode, the CCAP MUST reject a configuration that allows a mixture of pilot patterns 1-4 and 5-7 on the same OFDMA modulation template.

In 4k mode, the CCAP MUST reject a configuration that allows a mixture of pilot patterns 8-11 and 12-14 on the same OFDMA modulation template.

6.5.6.9 Downstream DOCSIS and Video Channel Configuration Information Model

The Downstream DOCSIS and Video Channel configuration objects are shown in the following diagram.

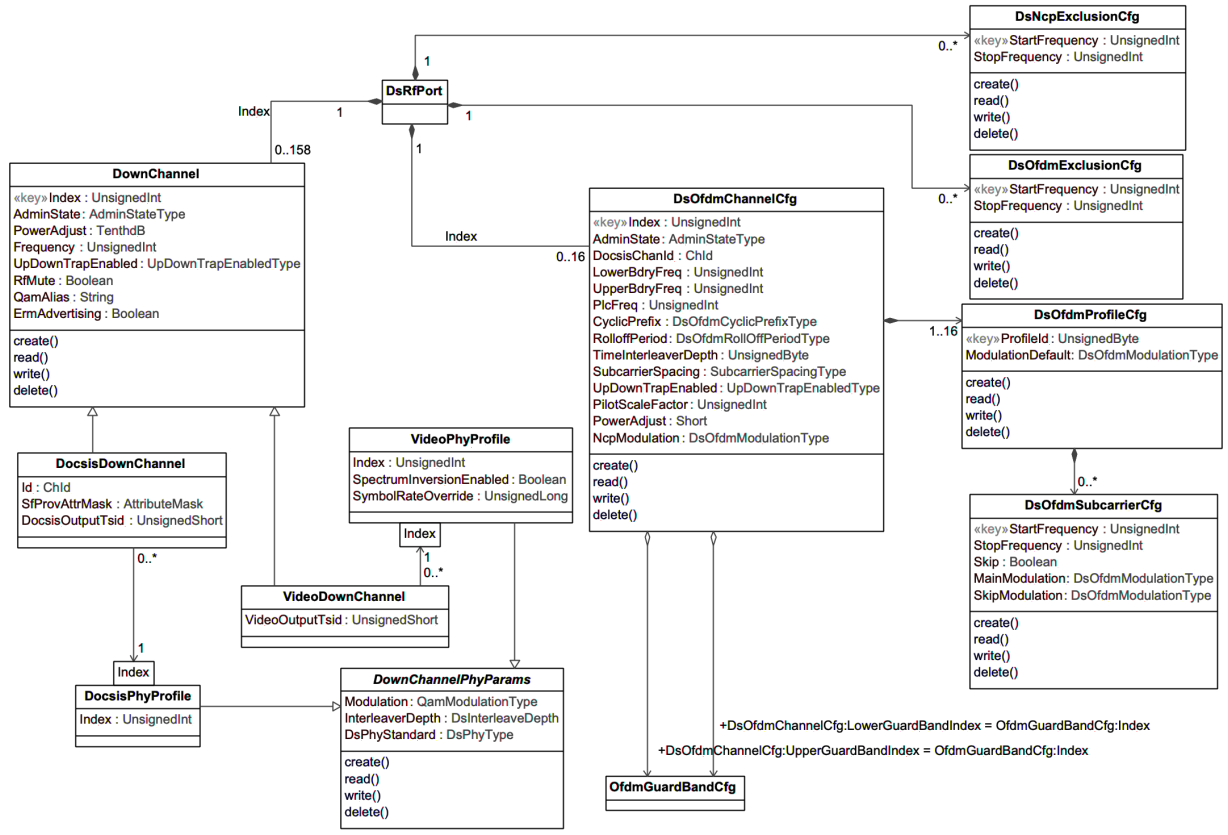


Figure 34 - Downstream DOCSIS and Video Configuration Information Model

6.5.6.9.1 DsRfPort

The DsRfPort object is defined in Section 6.5.4.11 and referenced here. The following associations are defined in Figure 25.

Table 173 - DsRfPort Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DownChannel	Composition to DownChannel	1	0..158	Index

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsOfdmChannelCfg	Composition to DsOfdmChannelCfg	1	0..16	Index
DsNcpExclusionCfg	Directed composition to DsNcpExclusionCfg	1	0..*	
DsOfdmExclusionCfg	Directed composition to DsOfdmExclusionCfg	1	0..*	

6.5.6.9.2 DownChannel

The DownChannel object contains the attributes used when configuring a QAM channel. This object is contained within a DsRfPort.

A DsRfPort contains a number of configured DownChannel objects. A DownChannel is either a VideoDownChannel or a DocsisDownChannel. The PHY parameters for a down channel are specified by associating a down channel with a PHY profile, either a VideoPhyProfile or DocsisPhyProfile, depending on the down channel type. If a PHY profile is not specified, the CCAP will provide vendor-specific PHY defaults. A DownChannel is a generalization of either a VideoDownChannel or a DocsisDownChannel.

If a Down Channel instance is managed by an ERM, it will contain ERM parameters.

Table 174 - DownChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)	0..158		
AdminState	AdminStateType	No			down
UpDownTrapEnabled	UpDownTrapEnabled	No			true
PowerAdjust	TenthdB	No		TenthdB	0
Frequency	UnsignedInt	Yes		Hertz	
RfMute	Boolean	No			false
QamAlias	String	See attribute description			""
ErmAdvertising	Boolean	Yes			

Table 175 - DownChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ErmParams	Directed composition to ErmParams		0..1	

6.5.6.9.2.1 Index

This key identifies a downstream channel on a specific downstream RF Port.

6.5.6.9.2.2 AdminState

This attribute represents the administrative status of the channel. Setting the value to down(3) results in the channel being muted. The value of testing(4) is used to generate a continuous test wave on this QAM channel.

6.5.6.9.2.3 UpDownTrapEnabled

This attribute configures whether linkUp/linkDown traps are enabled for this channel.

6.5.6.9.2.4 PowerAdjust

This attribute represents the power gain for the channel. It is expressed in TenthdB.

6.5.6.9.2.5 Frequency

This attribute specifies the center frequency of the channel. It is expressed in Hertz. The CCAP MUST reject the configuration of a DownChannel instance that overlaps in frequency with another DownChannel instance on the same downstream RF port.

6.5.6.9.2.6 RfMute

This attribute configures the mute state for the specific DownChannel. If set to true, the ifOperStatus of the VideoDownChannel or DocsisDownChannel associated with this instance of DownChannel is set to "down". If set to false, no muting takes place. Operation while muted is described in [DRFI].

6.5.6.9.2.7 QamAlias

This attribute represents the name of the QAM channel and is equivalent to the ifAlias object in the IF-MIB [RFC 4546]. A value for this attribute is required for DownChannels that are advertised to an ERM. Advertised channels are reported to the ERM via the [RMI-SDR] interface.

6.5.6.9.2.8 ErmAdvertising

This attribute represents the ERRP/ERM advertisement state of the QAM channel. If set to true, the QAM channel is advertised; otherwise it is not advertised. For ERRP, this is primarily useful when statically configuring the QAM channels and when the QAM channel is not made part of the ERM channel list. This attribute is optional for DocsisDownChannel.

6.5.6.9.2.9 ERM Management of DownChannel Instances

A CCAP that supports the Resource Management Interfaces (RMI) will support the following types of video down channels:

- Dynamically Managed: The VideoDownChannel instance is configured with an empty output transport stream and is dynamically managed by the ERM. These channels are advertised to the ERM and the ERM uses the ERM-EDGE interface to setup video sessions.
- UDP Port Mapped: The VideoDownChannel instance is configured with an output transport stream and VideoSessions that are statically mapped to a UDP port via a StaticUdpMap object instance. The CCAP listens on the configured UDP ports for narrowcast content and multiplexes packets received onto the appropriate VideoSession output transport stream on a VideoDownChannel instance. These channels are advertised to the ERM, but since they are statically provisioned, the ERM does not actively manage the channel.
- Statically Configured: The VideoDownChannel instance is configured with SPTS and MPTS program streams that make up linear broadcast content. These channels are not advertised to an ERM.

DownChannel instances in which ErmAdvertising is true are reported by the CCAP to the ERM, as described in [RMI-SDR]. The CCAP identifies a given down channel instance to the ERM by its output TSID and its QAM name (configured in the QamAlias attribute). The CCAP MUST reject the configuration of a VideoDownChannel or a DocsisDownChannel if it is advertised to the ERM but does not have both output TSID and QamAlias configured.

When a change in configuration results in the properties of an advertised down channel instance changing, the CCAP transmits its complete configuration data to the ERM, as specified in [RMI-SDR].

6.5.6.9.2.10 DownChannel Configuration Constraints

The CCAP MUST reject activation of a set of configuration objects that would attempt to enable more than one QAM channel with the same center frequency on any single downstream RF port.

There are two types of QAM in the CCAP device regarding the advertisement to the ERM.

- Pilot QAM that are advertised
- Replicated QAM that are not advertised

In the CCAP configuration model, there are two types of Output TSIDs: VideoOutputTsid, required for all VideoDownChannel instances, and DocsisOutputTsid, an optional attribute of a DocsisDownChannel. The CCAP MAY reject configurations that cause the same Output TSID value to be advertised to the same ERM more than once; therefore, exactly one pilot QAM is advertised to the ERM per replication group. If the CCAP allows configurations in which the same output TSID is configured to be advertised to the ERM for multiple down channels, then the CCAP MUST only advertise one of those TSIDs to the ERM as a pilot QAM. The CCAP will use vendor-proprietary rules to decide which QAM to advertise as the pilot in this case.

When a change in configuration results in a replicated QAM transitioning to a pilot QAM, the CCAP MUST advertise the transitioned QAM as a new resource to the ERM.

When a change in configuration results in a pilot QAM transitioning to a replicated QAM, the CCAP MUST notify the ERM and delete the corresponding QAM resource from the ERM. This notification takes place so the sessions can be properly torn down and repositioned.

When advertising the pilot QAM to the ERM, the CCAP MUST include a list all fiber nodes to which it is replicated.

Output TSIDs are unique per DsRfPort. Therefore, when the CCAP replicates a QAM, the CCAP MUST de-advertise that QAM from the ERM.

The CCAP MUST reject configurations of Output TSIDs values that are not unique on a specific DsRfPort.

The CCAP MUST support the configuration of whether or not duplicate Output TSID values are allowed on the CCAP.

6.5.6.9.2.11 Output Replication Requirements

An input transport stream is a sequence of MPEG frames received at a single IP address and UDP port by the CCAP. An input transport stream typically consists of a set of programs that are each identified by an input program number. Each input program consists of a number of elementary streams, each individually identified by a PID. An input transport stream may contain elementary streams that are not part of a program.

A VideoInputTs object configures an input transport stream. A UnicastVideoInputTs object configures a unicast input transport stream; a MulticastVideoInputTs object configures a multicast input transport stream.

An output transport stream is defined as a sequence of MPEG frames transmitted by a CCAP. An output transport stream typically consists of multiple output programs. Each output program consists of a set of elementary streams each identified by an individual PID. An output Multi-Program Transport Stream (MPTS) is an output transport stream that contains tables that identify its programs and associated elementary streams. An output TSID is a 16-bit number that uniquely identifies a MPTS in a streaming zone.

A VideoOutputTs object statically configures a video output transport stream on the CCAP. A VideoOuputTs object is identified with a CCAP-unique Index. A VideoOutputTs object is statically associated with either MptsPassThruSession instances or can be configured as an MPTS that multiplexes several ProgramSession instances and/or PidSession instances. VideoOutputTs instances are only associated with sessions, not directly with video input transport streams. A VideoOutputTs instance is associated with a VideoDownChannel instance, configured with a VideoOutputTsid that is included in its PAT, as transmitted by the CCAP.

A ProgramSession object statically configures the mapping of input transport streams to one or more VideoOutputTs instances. A PidSession object statically configures the mapping of input elementary streams to VideoOutputTs instances. An MptsPassThruSession object statically configures the mapping of an entire input MPTS to VideoOutputTs instances.

It is expected that a given MPTS identified by a unique VideoOutputTs Index can be replicated on more than one CCAP RF port. For example, a narrowcast VOD or SDV MPTS may be transmitted to two, three, or four CCAP downstream RF ports, while digital broadcast video content may be replicated to most or all CCAP downstream RF ports.

A VideoOutputTs instance is statically configured to one or more VideoDownChannel instances via its association to the VideoDownChannel instances in which it will be included. Each VideoDownChannel object represents the contents transmitted on a single RF port at a single frequency. The CCAP MUST replicate the output transport

stream represented by a VideoOutputTs object to all of the QAM channels represented by the VideoDownChannel objects to which the VideoOutputTs is associated.

Depending on CCAP vendor implementation, the CCAP MAY transmit the replicated MPEG packets of the multiplexed set of video sessions in exactly the same order.

The CCAP MUST meet all MPEG requirements, per [MPEG], for replicated video sessions.

The CCAP SHOULD allow the configuration of different frequencies and DownChannelPhyParams for different VideoDownChannels to which a VideoOutputTs instance is associated.

The CCAP MAY reject a configuration in which a VideoOutputTs is associated with VideoDownChannel instances that reside on different frequencies.

6.5.6.9.3 DocsisDownChannel

The DocsisDownChannel object is a DownChannel used exclusively for DOCSIS. The DownChannel is its generalization.

The DocsisDownChannel object is a specialization of DownChannel.

Some CCAP implementations may implement the association of non-primary capable downstream channels with MAC domain indirectly, based on RF plant topology configuration. In such a case, CCAP device may ignore configuration settings communicated through the label Non-PrimaryCapableDs. If a DocsisDownChannel is not associated with a DocsisPhyProfile instance, the CCAP provides vendor-specific PHY defaults.

Table 176 - DocsisDownChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	ChId	Yes			
SfProvAttrMask	AttributeMask	Yes			
DocsisOutputTsid	UnsignedShort	No			0

Table 177 - DocsisDownChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DownChannel	Specialization of DownChannel			
DocsisPhyProfile	Directed association to DocsisPhyProfile	0..*	1	DocsisPhyProfileIndex

6.5.6.9.3.1 Id

Unique identifier for the DocsisDownChannel. A value of 0 (zero) means that the CCAP will automatically assign the DOCSIS Channel ID.

6.5.6.9.3.2 SfProvAttrMask

This attribute contains Provisioned Attribute Mask of non-bonded service flow assignment to this channel.

6.5.6.9.3.3 DocsisOutputTsid

This attribute specifies the optional output TSID of the channel. The TSID is globally unique per CCAP. Replicated output streams share the same Output TSID.

6.5.6.9.4 VideoDownChannel

The VideoDownChannel object is a DownChannel used exclusively for video channel configuration. If a VideoDownChannel is not associated with an instance of VideoPhyProfile, the CCAP provides vendor-specific defaults.

Table 178 - VideoDownChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
VideoOutputTsid	UnsignedShort	Yes			

Table 179 - VideoDownChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DownChannel	Specialization of DownChannel			
VideoPhyProfile	Directed association to VideoPhyProfile	0..*	1	VideoPhyProfileIndex

6.5.6.9.4.1 VideoOutputTsid

This attribute specifies the output TSID of the channel and is required for a VideoDownChannel. The TSID is globally unique per CCAP. Replicated output streams share the same Output TSID.

6.5.6.9.5 DocsisPhyProfile

The DocsisPhyProfile object is a specialization of the DownChannelPhyParams object and allows PHY parameters to be specified for a DocsisDownChannel instance.

Table 180 - DocsisPhyProfile Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes			

Table 181 - DocsisPhyProfile Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DownChannelPhyParams	Specialization of DownChannelPhyParams			

6.5.6.9.5.1 Index

This attribute specifies a unique index for this instance of DocsisPhyProfile.

6.5.6.9.6 VideoPhyProfile

The VideoPhyProfile object is a specialization of the DownChannelPhyParams object and allows PHY parameters to be specified for a VideoDownChannel instance.

Table 182 - VideoPhyProfile Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes			
SpectrumInversionEnabled	Boolean	No			false
SymbolRateOverride	UnsignedLong	No		Symbols per second	

Table 183 - VideoPhyProfile Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Units	Default Value
DownChannelPhyParams	Specialization of DownChannelPhyParams				

6.5.6.9.6.1 Index

This attribute specifies a unique index for this instance of VideoPhyProfile.

6.5.6.9.6.2 SpectrumInversion

This attribute specifies RF Signal Spectrum inversion. When set to true, it indicates that the QAM channel spectrum is inverted.

6.5.6.9.6.3 SymbolRateOverride

This attribute allows the default symbol rate for the VideoPhyProfile to be overridden, expressed in symbols per second. If not specified, channels configured to use this VideoPhyProfile operate with the value specified by DOCSIS for the Annex and modulation.

6.5.6.9.7 DownChannelPhyParams

DownChannelPhyParams is an abstract object that can be used to specify the physical attributes of an SC-QAM DownChannel.

Table 184 - DownChannelPhyParams Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Modulation	Enum	No	other(1), qam64(2), qam128(3), qam256(4), qam512(5), qam1024(6)		qam256
InterleaverDepth	Enum	No	other(1), fecI8J16(2), fecI12J17(3), fecI16J8(4), fecI32J4(5), fecI64J2(6), fecI128J1(7), fecI128J2(8), fecI128J3(9), fecI128J4(10), fecI128J5(11), fecI128J6(12), fecI128J7(13), fecI128J8(14)		fecI128J1
DsPhyStandard	Enum	No	other (1), dvbc(2), j83annexB(3), j83annexC(4)		j83annexB

6.5.6.9.7.1 Modulation

Defines the modulation type used. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.6.9.7.2 InterleaverDepth

This attribute represents the interleaving depth or operation mode of the interleaver. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

This attribute is ignored when DsPhyStandard has a value other than j83annexB(3).

6.5.6.9.7.3 DsPhyStandard

This attribute specifies the standard supported by the QAM channel. A value of dvbc(2) corresponds to J.83 Annex A. The value of other(1) is used when a vendor-extension has been implemented for this attribute. **Note:** This attribute only applies to SC-QAM downstream channels, thus there is no value to represent OFDM channels.

6.5.6.9.8 DsOfdmChannelCfg

This object defines the downstream OFDM channel table. OFDM channels only carry DOCSIS traffic; they cannot be used to carry EQAM video traffic. The downstream OFDM channel bandwidth can be any value from 24MHz to 192MHz. Smaller bandwidths than 192MHz are achieved by nulling subcarriers prior to the IDFT, i.e., by adjusting the equivalent number of active subcarriers while maintaining the same subcarrier spacing of 25kHz or 50kHz.

The CCAP can be configured for up to 16 distinct data profiles. The CCAP can also be configured with a modulation order for NCP (per channel) and the list of frequency exclusions for NCP (per DS RF port). The list of NCP exclusions is specified in Section 6.5.6.9.12 DsNcpExclusionCfg.

If the CCAP does not support automatic configuration of profile 0, the CCAP MUST reject the configuration if profile 0 (aka profile A) is not configured.

If no lower or upper guard band is associated with the channel, then the width of that guard band for the channel will be automatically configured by the CCAP.

The downstream OFDM band edge limits depend on the mode of operation to which DOCSIS equipment is configured to operate. Refer to [PHYv3.1] *Downstream CM Spectrum* section, for the downstream OFDM boundary frequency limits when equipment is configured to be compliant with the DOCSIS 3.1 and (non-FDX and non-FDD extended spectrum) DOCSIS 4.0 frequency plans. Refer to [PHYv4.0] *Downstream FDX CM Spectrum* section for the downstream OFDM boundary frequency limits when equipment is configured to be compliant with FDX mode. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan for FDD Operation* section for the downstream OFDM boundary frequency limits when the equipment is configured to be compliant with FDD mode.

Table 185 - DsOfdmChannelCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Key			
AdminState	AdminStateType	No			Down(2)
DocsisChanId	ChId	No			0
LowerBdryFreq	UnsignedInt	Yes	108000000..1772000000	Hz	
UpperBdryFreq	UnsignedInt	Yes	130000000..1794000000	Hz	
PlcFreq	UnsignedInt	Yes	108000000..1788000000	Hz	
CyclicPrefix	DsOfdmCyclicPrefixType	Yes		samples	
RolloffPeriod	DsOfdmWindowingType	Yes		samples	
TimeInterleaverDepth	UnsignedByte	Yes	1..16 | 1..32	OFDM Symbols	
SubcarrierSpacing	Enum	Yes		Hz	
UpDownTrapEnabled	UpDownTrapEnabled	Yes			
PilotScaleFactor	UnsignedInt	No	48..120		48
PowerAdjust	Short	No		TenthdB	0
NcpModulation	DsOfdmModulationType	No	qpsk(3)|qam16(4)|qam64(5)		qam16(4)

Table 186 - DsOfdmChannelCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsOfdmProfileCfg	Directed composition to DsOfdmProfileCfg		1..16	
OfdmGuardBandCfg (see requirement below)	Directed aggregation to OfdmGuardBandCfg	0..*	1	DsOfdm ChannelCfg: LowerGuard BandIndex = OfdmGuard BandCfg:Index
OfdmGuardBandCfg (see requirement below)	Directed aggregation to OfdmGuardBandCfg	0..*	1	DsOfdm ChannelCfg: UpperGuard BandIndex = OfdmGuard BandCfg:Index

If there is no association to an OfdmGuardBandCfg object, the CCAP MUST calculate the appropriate guard band configuration for that channel.

6.5.6.9.8.1 Index

This attribute represents the unique index of the OFDM Downstream channel. It provides a key into the table.

6.5.6.9.8.2 AdminState

This attribute represents the admin state for the OFDM downstream channel.

6.5.6.9.8.3 DocsisChanId

This attribute represents the CMTS identification of the downstream channel within this particular MAC interface. Setting this value to zero instructs the CCAP to automatically assign the DOCSIS Channel ID.

6.5.6.9.8.4 LowerBdryFreq

This attribute defines either the lower boundary frequency of the lower guard band or (if no guard band is defined) the lower boundary frequency of the lowest active subcarrier of the OFDM downstream channel. It is intended to be aligned with the boundaries of the SC-QAM channels on defined channel frequency HFC plants. For example, for a 6 MHz plant, the boundary of a channel could be located 3 MHz away from the center frequency of a single carrier channel.

This attribute may not correspond to subcarrier frequency requirements. The CCAP may round this number up to align to subcarrier assignments for the channel.

6.5.6.9.8.5 UpperBdryFreq

This attribute defines either the upper boundary frequency of the upper guard band or (if no guard band is defined) the upper boundary frequency of the highest active subcarrier of the OFDM downstream channel. It is intended to be aligned with the boundaries of the SC-QAM channels on defined channel frequency HFC plants. For example, for a 6 MHz plant, the boundary of a channel could be located 3 MHz away from the center frequency of a single carrier channel.

This attribute may not correspond to subcarrier frequency requirements. The CCAP may round this number up to align to subcarrier assignments for the channel.

6.5.6.9.8.6 PlcFreq

This attribute represents the PHY Link Channel (PLC) frequency. It is the center frequency of the lowest subcarrier of the 6 MHz encompassed spectrum containing the PLC at its center. The frequency of this subcarrier is required to be located on a 1 MHz grid. The aim of the PLC is for the CMTS to convey to the CM the physical properties of the OFDM channel.

6.5.6.9.8.7 CyclicPrefix

This attribute represents the Cyclic prefix, which enables the receiver to overcome the effects of inter-symbol-interference and intercarrier-interference caused by micro-reflections in the channel. There are five possible values for the CP and the choice depends on the delay spread of the channel - a longer delay spread requires a longer cyclic prefix. The cyclic prefix is expressed in samples, using the sample rate of 204.8 Msamples/s and is an integer multiple of: 1/64*20µs.

6.5.6.9.8.8 RolloffPeriod

This attribute represents the roll off period or windowing which maximizes channel capacity by sharpening the edges of the spectrum of the OFDM signal. For windowing purposes another segment at the start of the IDFT output is appended to the end of the IDFT output -the roll-off postfix (RP). There are five possible values for the RP, and the choice depends on the bandwidth of the channel and the number of exclusion bands within the channel. A larger RP provides sharper edges in the spectrum of the OFDM signal; however, there is a time vs. frequency trade-off. Larger RP values reduce the efficiency of transmission in the time domain, but because the spectral edges are sharper, more useful subcarriers appear in the frequency domain. There is an optimum value for the RP that maximizes capacity for a given bandwidth and/or exclusion band scenario. The CCAP MUST reject configurations where the roll-off period is greater than the cyclic prefix.

6.5.6.9.8.9 TimeInterleaverDepth

This attribute represents the depth of the time interleaver for the OFDM downstream channel expressed as a number of symbol durations. The value ranges from one and is limited to 16 symbol duration for 25 kHz SubcarrierSpacing and to 32 symbol durations for 50 kHz SubcarrierSpacing, respectively.

6.5.6.9.8.10 SubcarrierSpacing

This attribute defines the subcarrier spacing configured on the OFDM downstream channel. If the SubcarrierSpacing is 50 kHz, then the FFT length is 4K. If the SubcarrierSpacing is 25 kHz, then the FFT length is 8K.

6.5.6.9.8.11 UpDownTrapEnabled

This attribute indicates if a trap should be sent when the Channel transitions from up to down and down to up.

6.5.6.9.8.12 PilotScaleFactor

This attribute indicates the scale factor for calculating the number of continuous pilots.

6.5.6.9.8.13 PowerAdjust

This attribute specifies the power level adjustment for this OFDM channel from the value specified by BaseChanPower. The PowerAdjust attribute (in TenthdB) is added to BaseChanPower to provide a power spectral density for the OFDM channel by defining power in every 6 MHz (CTA) channel within the OFDM channel. The CCAP Core configures power for the entire channel with PowerAdjust and BaseChanPower. PowerAdjust allows setting the OFDM channel power independent of the channel width and consistent with the definition of the BaseChanPower attribute. Tilt is applied independently of these settings.

6.5.6.9.8.14 NcpModulation

This attribute defines the NCP modulation order. The CCAP MUST reject any NcpModulation values other than qpsk(3), qam16(4), or qam64(5).

6.5.6.9.9 DsOfdmProfileCfg

This object defines the OFDM Channel Profile Table. A profile is a list of modulation orders that are defined for each of the subcarriers within an OFDM channel. The CMTS can define multiple profiles for use in an OFDM channel, where the profiles differ in the modulation orders assigned to each subcarrier. It is optional for profiles to be configured via the management system. The CMTS can configure them without management intervention.

Table 187 - DsOfdmProfileCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ProfileId	UnsignedByte	Key	0..15		
ModulationDefault	DsOfdmModulationType	Yes	None		

Table 188 - DsOfdmProfileCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsOfdmSubcarrierCfg	Directed composition to DsOfdmSubcarrierCfg		0..*	

6.5.6.9.9.1 ProfileId

This attribute is a key defined to provide an index into the table.

6.5.6.9.9.2 ModulationDefault

This attribute defines the default bit loading applied to subcarriers in the OFDM downstream channel. If a subcarrier is not configured with a specific modulation order, it will use this value. The CCAP MUST reject a modulationDefault value of zeroBitLoaded(2).

6.5.6.9.10 DsOfdmSubcarrierCfg

This object specifies the OFDM Subcarrier Configuration Table. It defines the modulation for a list of subcarriers.

Table 189 - DsOfdmSubcarrierCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
StartFrequency	UnsignedInt	Key	108000000..1770000000	Hz	
StopFrequency	UnsignedInt	Yes	108000000..1770000000	Hz	
Skip	Boolean	No			false
MainModulation	DsOfdmModulationType	Yes			
SkipModulation	DsOfdmModulationType	No			

6.5.6.9.10.1 StartFrequency

This attribute is a key defined to provide an index into the table and specifies the starting frequency for a range of frequencies allocated for data subcarriers. The CCAP MUST reject a configuration where the start frequency is outside of the channel frequency range.

6.5.6.9.10.2 StopFrequency

This attribute specifies the end frequency of a range of frequencies allocated for data subcarriers. The stop frequency is required to be at least one subcarrier width larger than the start frequency. The CCAP MUST reject a configuration where the stop frequency is outside of the channel frequency range.

6.5.6.9.10.3 Skip

This attribute indicates if the configuration uses the method of alternating modulation order between subcarriers in the defined range.

6.5.6.9.10.4 MainModulation

This attribute represents the modulation of the subcarriers. In case of skip modulation enabled, the MainModulation is the modulation order of the first, the third, the fifth, etc., subcarriers in the range.

6.5.6.9.10.5 SkipModulation

This attribute represents the modulation of every other subcarrier in the defined range.

6.5.6.9.11 DsOfdmExclusionCfg

This object specifies the Downstream OFDM Exclusion Configuration Table. This is a global table that lists excluded subcarriers that can be referenced by any Downstream RF Port.

Muted subcarriers are subcarriers that have a value of zero in the bit-loading pattern of a profile.

Table 190 - DsOfdmExclusionCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
StartFrequency	UnsignedInt	Key	108000000..1794000000	Hz	
StopFrequency	UnsignedInt	Yes	108000000..1794000000	Hz	

6.5.6.9.11.1 StartFrequency

This attribute is a key defined to provide an index into the table and specifies the starting frequency of the exclusion entry.

6.5.6.9.11.2 StopFrequency

This attribute provides the ending frequency for the exclusion entry. The stop frequency is required to be at least one subcarrier width larger than the start frequency.

6.5.6.9.12 DsNcpExclusionCfg

This object specifies the Downstream NCP Exclusion Configuration Table. This is a global table that lists excluded subcarriers that can be referenced by any Downstream RF Port.

Table 191 - DsNcpExclusionCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
StartFrequency	UnsignedInt	Key	108000000..1794000000	Hz	
StopFrequency	UnsignedInt	Yes	108000000..1794000000	Hz	

6.5.6.9.12.1 StartFrequency

This attribute is a key defined to provide an index into the table and specifies the starting subcarrier frequency of the NCP exclusion entry.

6.5.6.9.12.2 StopFrequency

This attribute provides the ending subcarrier frequency for the NCP exclusion entry.

6.5.6.9.13 OfdmGuardBandCfg

This configuration object is included in Figure 34. It is defined in Section 6.5.6.1.16.

6.5.6.10 DSG Configuration Information Model

The CCAP incorporates the DSG Agent, which is defined as the implementation of the DSG protocol within the CCAP. The DSG Agent creates the DSG Tunnel, places content from the DSG Server into the DSG Tunnel, and sends the DSG Tunnel to the DSG Client.

For CCAP, the DSG Agent configuration information model changes slightly for several tables. The information model for the CCAP is shown in the following class diagram.

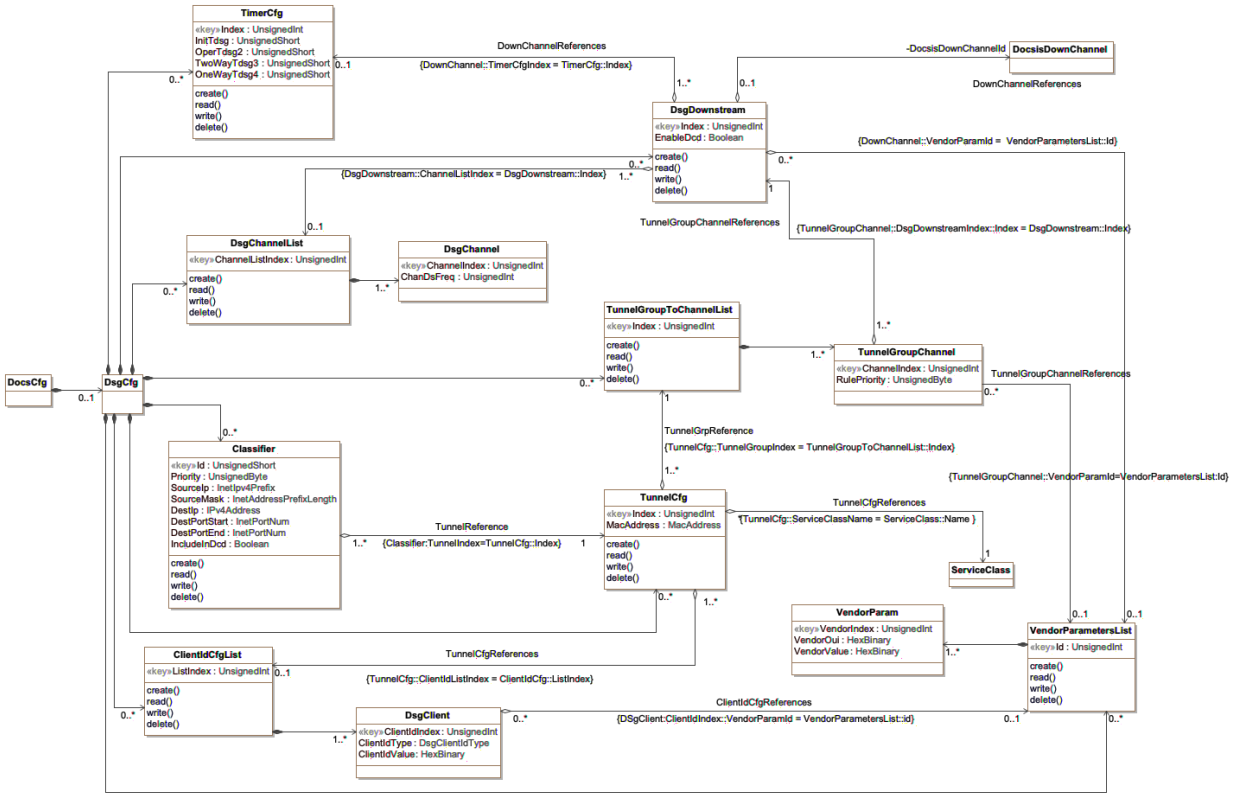


Figure 35 - DSG Configuration Information Model

6.5.6.10.1 DocsCfg

This configuration object is included in Figure 35 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.10.2 DsgCfg

The DsgCfg object is the container for DSG configuration objects. It has the following associations:

Table 192 - DsgCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TimerCfg	Directed composition to TimerCfg		0..*	
DsgDownstream	Directed composition to DsgDownstream		0..*	
DsgChannelList	Directed composition to DsgChannelList		0..*	
TunnelGroupToChannelList	Directed composition to TunnelGroupToChannelList		0..*	
Classifier	Directed composition to Classifier		0..*	
TunnelCfg	Directed composition to TunnelCfg		0..*	
ClientIdCfgList	Directed composition to ClientIdCfgList		0..*	
VendorParametersList	Directed composition to VendorParametersList		0..*	

6.5.6.10.3 TimerCfg

This configuration object is based on the dsgIfTimerTable defined in [DSG] and will be used with modifications for CCAP.

The DSG Timer Table contains timers that are sent to the DSG client(s) via the DCD message.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 193 - TimerCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
InitTdsg	UnsignedShort	No	1..65535	Seconds	2
OperTdsg2	UnsignedShort	No	1..65535	Seconds	600
TwoWayTdsg3	UnsignedShort	No		Seconds	300
OneWayTdsg4	UnsignedShort	No		Seconds	1800

6.5.6.10.3.1 Index

The index for this object.

6.5.6.10.3.2 InitTdsg

Initialization Timeout. This is the timeout period in seconds for the DSG packets during initialization of the DSG client. The default value is 2 seconds.

6.5.6.10.3.3 OperTdsg2

Operational Timeout. This is the timeout period in seconds for the DSG packets during normal operation of the DSG client. Default value is 600 seconds.

6.5.6.10.3.4 TwoWayTdsg3

Two-way retry timer. This is the retry timer that determines when the DSG client attempts to reconnect with the DSG Agent and established two-way connectivity. Default value is 300 seconds. The value 0 indicates that the client will continuously retry two-way operation.

6.5.6.10.3.5 OneWayTdsg4

One-way retry timer. This is the retry timer that determines when the client attempts to rescan for a DOCSIS downstream channel that contains DSG packets after a TimerTdsg1 or TimerTdsg2 timeout. Default value is 1800 seconds. Setting the value to 0 indicates that the client will immediately begin scanning upon TimerTdsg1 or TimerTdsg2 timeout.

6.5.6.10.4 DsgDownstream

The DsgDownstream object represents an individual downstream channel for DSG configuration purposes. It has been modified from the DSG Specification definitions.

Table 194 - DsgDownstream Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
EnableDcd	Boolean	Yes			

The DsgDownstream object has the following associations.

Table 195 - DsgDownstream Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TimerCfg	Directed aggregation to TimerCfg	1..*	0..1	
DsgChannelList	Directed aggregation to DsgChannelList	1..*	0..1	
DocsisDownChannel	Directed aggregation to DocsisDownChannel	0..1		DocsisDownChannelId
VendorParametersList	Directed aggregation to VendorParametersList	0..*	0..1	

6.5.6.10.4.1 Index

This is the key for an instance of this object.

6.5.6.10.4.2 EnableDcd

This attribute is used to enable or disable DCD messages to be sent on this downstream channel. The value is always true for those downstreams that contain DSG tunnels.

6.5.6.10.5 DocsisDownChannel

This configuration object is included in Figure 35 for reference. It is defined in Section 6.5.6.9.3.

6.5.6.10.6 DsgChannelList

This configuration object is based on the dsgIfChannelListTable defined in [DSG] and will be used with modifications for CCAP.

The DsgChannelList object allows for configuration of a list of one or multiple downstream frequencies that are carrying DSG tunnel(s). This configuration object has been modified from the DSG Specification definitions.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 196 - DsgChannelList Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ChanListIndex	UnsignedInt	Yes (Key)			

Table 197 - DsgChannelList Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsgChannel	Directed composition to DsgChannel		1..*	

6.5.6.10.6.1 ChanListIndex

The index of the down channel list.

6.5.6.10.7 DsgChannel

This configuration object allows for one or more downstream frequencies that are carrying DSG tunnel(s) to be associated with a DsgChannelList.

Table 198 - DsgChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ChannelIndex	UnsignedInt	Yes (Key)			
ChanDsFreq	UnsignedInt	No	0..1000000000	Hz	0

6.5.6.10.7.1 ChannelIndex

The index of the channel.

6.5.6.10.7.2 ChanDsFreq

The ChanDsFreq attribute represent a frequency of a downstream channel carrying DSG information. Frequency is a multiple of 62500 Hz, per [DSG].

6.5.6.10.8 TunnelGroupToChannelList

This configuration object is based on the dsgIfTunnelGrpToChannelTable defined in [DSG] and will be used with modifications for CCAP.

The TunnelGroupToChannelList object permits association of a group of DsgDownstream objects to one or more tunnels. This configuration object has been modified from the DSG Specification definitions.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 199 - TunnelGroupToChannelList Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			

The TunnelGrpToChannel object has the following associations.

Table 200 - TunnelGrpToChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TunnelGroupChannel	Directed composition to TunnelGroupChannel		1..*	

6.5.6.10.8.1 Index

This attribute is the key for this object and allows a link to an instance of a TunnelCfg object be configured.

6.5.6.10.9 TunnelGroupChannel

The TunnelGroupChannel object allows DsgDownstream objects to be associated with this group.

Table 201 - TunnelGroupChannel Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ChannelIndex	UnsignedInt	Yes (Key)			
RulePriority	UnsignedByte	No	0..255		0

The TunnelGroupChannel object has the following associations.

Table 202 - TunnelGroupChannel Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsgDownstream	Directed aggregation to DsgDownstream	1..*	1	
VendorParametersList	Directed association to VendorParametersList	0..*	0..1	

6.5.6.10.9.1 ChannelIndex

This attribute configures the linkage of a specific DsgDownstream instance to the TunnelCfg instance associated with the group.

6.5.6.10.9.2 RulePriority

The DSG rule priority determines the order in which a channel should be applied by the DSG client. The default value is 0, which is the lowest priority.

6.5.6.10.10 Classifier

This configuration object is based on the dsgIfClassifierTable defined in [DSG] and will be used with modifications for CCAP.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 203 - Classifier Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedShort	Yes (Key)			
Priority	UnsignedByte	No			0
SourceIp	Ipv4Prefix	Yes			
SourceMask	InetAddressPrefixLength	No			32
DestIp	Ipv4Address	Yes			
DestPortStart	InetPortNum	No			0
DestPortEnd	InetPortNum	No			65535
IncludeInDcd	Boolean	No			true

Table 204 - Classifier Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TunnelCfg	Directed aggregation to TunnelCfg	1..*	1	

6.5.6.10.10.1 Id

This attribute configures the linkage between the DSG tunnel for which this classifier will apply.

6.5.6.10.10.2 Priority

This attribute is used to configure the DSG rule priority that determines the order in which a channel and its associated UCIDs should be applied by the DSG client. The default value is 0, which is the lowest priority.

6.5.6.10.10.3 SourceIp

This attribute configures the source IP address for the DSG tunnel. Currently, the CCAP only supports IPv4 addresses for DSG tunnels, per [DSG].

6.5.6.10.10.4 SourceMask

This attribute configures the source IP address mask for the DSG tunnel.

6.5.6.10.10.5 DestIp

This attribute configures the destination IP address for the DSG tunnel. Currently, the CCAP only supports IPv4 addresses for DSG tunnels, per [DSG].

6.5.6.10.10.6 DestPortStart

This attribute configures the inclusive lower bound of the transport-layer source port range that is to be matched.

6.5.6.10.10.7 DestPortEnd

This attribute configures the inclusive higher bound of the transport-layer source port range that is to be matched.

6.5.6.10.10.8 IncludeInDcd

Indicates whether or not this DSG classifier will be sent in DCD messages for use as a Layer-3 and Layer-4 packet filter by the DSG eCM.

6.5.6.10.11 TunnelCfg

A TunnelCfg object allows the operator to configure DSG tunnels. Each DSG Tunnel represents a stream of packets delivered to a DSG Client in a set-top device and is configured with a single destination MAC address.

This configuration object is based on the dsgIfTunnelTable defined in [DSG] and is used with modifications.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 205 - TunnelCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
MacAddress	MacAddress	Yes			

The TunnelCfg object has the following associations.

Table 206 - TunnelCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TunnelGroupToChannelList	Directed association to TunnelGroupToChannelList	1..*	1	
ClientIdCfgList	Directed aggregation to ClientIdCfgList	1..*	0..1	
ServiceClass	Directed aggregation to ServiceClass	*	1	

6.5.6.10.11.1 Index

This attribute is the index for a tunnel that could be associated to one or more downstream channels that carry DSG tunnels.

6.5.6.10.11.2 MacAddress

This attribute configures the DSG tunnel destination MAC address.

6.5.6.10.11.3 ServiceClass

This configuration object is included in Figure 35 for reference. It is defined in Section 6.5.6.4.3.

6.5.6.10.12 ClientIdCfgList

This configuration object is based on the dsgIfClientIdTable defined in [DSG] and will be used with modifications for CCAP.

The Client Identification object contains a list of client identification types and values. Each entry in the list also contains the vendor-specific parameter identification. There could be multiple client ids associated to a tunnel, grouped by the ListIndex.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 207 - ClientIdCfgList Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ListIndex	UnsignedInt	Yes (Key)			

The ClientIdCfgList object has the following associations.

Table 208 - ClientIdCfgList Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsgClient	Directed composition to DsgClient		1..*	

6.5.6.10.12.1 ListIndex

This attribute is the key for the ClientIdCfgList object and provides the unique identifier for each client list.

6.5.6.10.13 DsgClient

The DsgClient object represents a list entry in the ClientIdCfgList object.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 209 - DsgClient Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ClientIdIndex	UnsignedInt	Yes (Key)			
ClientIdType	Enum	No	other(1), broadcast(2), macAddress(3), caSystemId(4), applicationId(5)		broadcast
ClientIdValue	HexBinary	No	size(6)		'000000000000'h

The DsgClient object has the following associations.

Table 210 - DsgClient Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VendorParametersList	Directed aggregation to VendorParametersList	0..*	0..1	

6.5.6.10.13.1 ClientIdIndex

This attribute is the key and provides the unique identifier of each DsgClient object in this instance of DsgClient.

6.5.6.10.13.2 ClientIdType

The Client Identification type. A DSG client ID of broadcast(2) is received by all DSG clients. A DSG client ID of macAddress(3) is received by the DSG client that has been assigned with this MAC address where the first 3 bytes is the Organization Unique Identifier (OUI). A DSG client ID of caSystemId(4) is received by the DSG client that has been assigned a CA_system_ID. A DSG client ID of applicationId(5) is received by the DSG client that has been assigned an application ID. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.6.10.13.3 ClientIdValue

The Client Identification Value. The content depends on the value of the dsgIfClientIdType. For dsgIfClientIdType broadcast(1), this object will have a 16-bit value whether or not it is a length 0 or length 2 broadcast ID. If the value is 0, then the encoded Type Length Value Attribute (TLV) in the DCD would be the original, zero length, broadcast ID. If the value is specified in table 5-2 of [DSG], then the TLV in the DCD would be a length 2 broadcast ID followed by the value.

For ClientIdType macAddress(2), this object is a well-known MAC address.

For ClientIdType caSystemId(3), this object is a CA System ID.

For ClientIdType applicationId(4), this object is an application ID.

Client IDs representing types broadcast(1), caSystemId(3) or applicationId(4) are encoded in DCD messages as unsigned integers and configured in this object as 6 octet string with the 2 LSB for the client ID value; e.g., an applicationId 2048 (0x0800) is encoded as '000000000800'h.

6.5.6.10.14 VendorParametersList

This configuration object is based on the dsgIfVendorParamTable defined in [DSG] and is used with the following modifications for CCAP: a VendorParam object has been created to allow a list of vendor parameters to be associated with this object.

The VendorParametersList object allows vendors to send specific parameters to the DSG clients within a DSG rule or within the DSG Configuration block in a DCD message.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

Table 211 - VendorParametersList Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VendorParam	Directed composition to VendorParam		1..*	

6.5.6.10.15 VendorParam

This configuration object is based on the dsgIfVendorParamTable defined in [DSG] and holds the attributes that define each vendor parameter.

Reference: [DSG], DOCSIS Set-top Gateway Agent MIB Definition section

6.5.6.11 PacketCable Configuration Information Model

This section defines the configuration objects needed for configuring PacketCable and PacketCable Multimedia (PCMM) services on the CCAP.

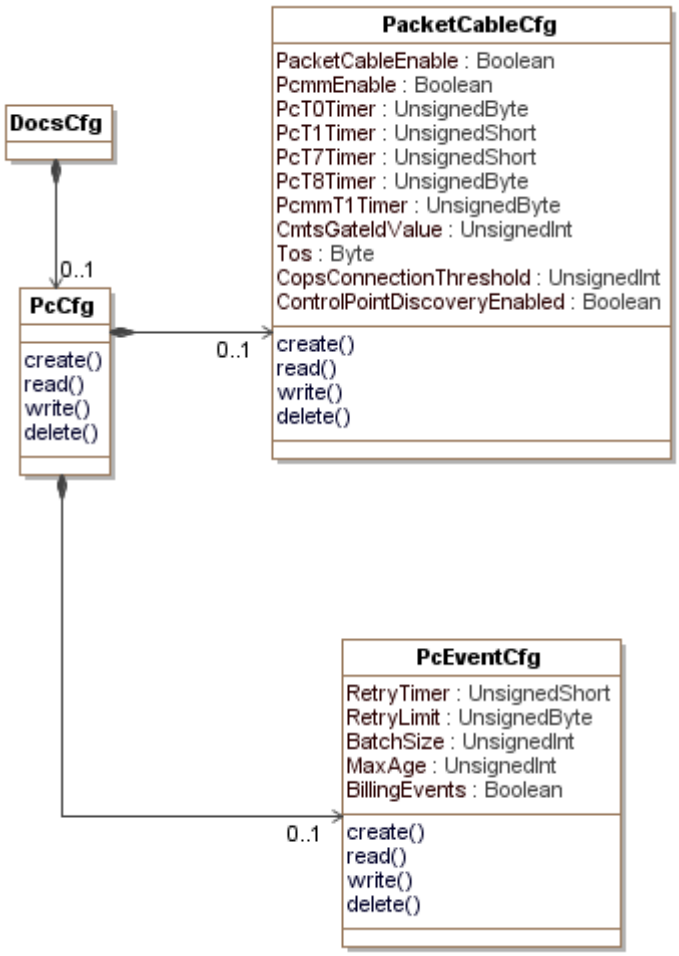


Figure 36 - PacketCable Configuration Information Model

6.5.6.11.1 DocsCfg

This configuration object is included in Figure 36 for reference. It is defined in Section 6.5.6.1.2.

6.5.6.11.2 PcCfg

The PcCfg object is the container for the PacketCable and PCMM configuration objects. It has the following associations:

Table 212 - PcCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PacketCableConfig	Directed composition from PacketCableConfig		0..1	
PcEventCfg	Directed composition from PcEventCfg		0..1	

6.5.6.11.3 PacketCableConfig

This object is used for configuring PacketCable and PCMM services on the CCAP.

Table 213 - PacketCableConfig Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
PacketCableEnable	Boolean	No			false
PcmmEnable	Boolean	No			false
PcT0timer	UnsignedByte	No		seconds	30
PcT1Timer	UnsignedShort	No		seconds	200
PcT7Timer	UnsignedShort	No		seconds	200
PcT8Timer	UnsignedByte	No		seconds	0
PcmmT1Timer	UnsignedByte	No		seconds	200
CmtsGateIdValue	UnsignedInt	Yes	0..8191		
Tos	Byte	Yes	-1 | 0..63		
CopsConnectionThreshold	UnsignedInt	Yes		connections/15 mins	
ControlPointDiscoveryEnabled	Boolean	No			false

6.5.6.11.3.1 PacketCableEnable

This configuration attribute allows the operator to enable PacketCable services on the CCAP.

6.5.6.11.3.2 PcmmEnable

This configuration attribute allows the operator to enable PacketCable Multimedia services on the CCAP.

6.5.6.11.3.3 PcT0Timer

This configuration attribute allows the operator to define the value in seconds for the PacketCable T0 timer.

6.5.6.11.3.4 PcT1Timer

This configuration attribute allows the operator to define the value in seconds for the PacketCable T1 timer.

6.5.6.11.3.5 PcT7Timer

This attribute allows for the setting of the Timeout for Admitted QoS Parameters for the service flow to the value specified for this timer. In the case of a flow with multiple sub-flows, the flow's Timeout for Admitted QoS Parameters is set to the value of timer T7 from the most recently received Gate-Set message for any subflow on the flow. The Timeout for Admitted QoS Parameters limits the period of time that the CMTS holds resources for a service flow's Admitted QoS Parameter Set while they are in excess of its Active QoS Parameter Set.

The recommended default value of this timer is 200 seconds.

6.5.6.11.3.6 PcT8Timer

This attribute configures the Timeout for Active QoS Parameters for the service flow to the value specified for this timer. In the case of a flow with multiple sub-flows, the flow's Timeout for Active QoS Parameters is set to the value of timer T8 from the most recently received Gate-Set message for any sub-flow on the flow. The Timeout for Active QoS Parameters limits the period of time resources remain unused on an active service flow.

6.5.6.11.3.7 PcmmT1Timer

This configuration attribute allows the operator to define the value in seconds for the PacketCable Multimedia T1 timer.

6.5.6.11.3.8 CmtsGateIdValue

This configuration attribute allows the operator to define the value for the CMTS ID portion of PCMM GateIds. This value is the 13 least significant bits (0-12) of the GateId.

6.5.6.11.3.9 Tos

This configuration attribute allows the operator to define the value for the Tos bits in outgoing COPS messages.

6.5.6.11.3.10 CopsConnectionThreshold

This configuration attribute allows the operator to define the threshold number of COPS connections per 15-minute interval.

6.5.6.11.3.11 ControlPointDiscoveryEnabled

This attribute enables or disables the Control Point Discovery functionality described in the PacketCable Specifications. The default value is false.

6.5.6.11.4 PcEventCfg

This object configures event messaging for PacketCable.

Table 214 - PcEventCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
RetryTimer	UnsignedShort	No	10..10000	milliseconds	3000
RetryLimit	UnsignedByte	No	0..9		3
BatchSize	UnsignedInt	Yes			
MaxAge	UnsignedInt	Yes		seconds	
BillingEvents	Boolean	No			false

6.5.6.11.4.1 RetryTimer

This configuration attribute allows the configuration of the number of seconds the CCAP should wait before sending a message that was not acknowledged.

6.5.6.11.4.2 RetryLimit

This configuration attribute allows the configuration of the number of times the CCAP should retry before sending a message.

6.5.6.11.4.3 BatchSize

This configuration attribute allows the configuration of the number of records the CCAP should bundle in a single message to a billing or Record Keeping Server (RKS).

6.5.6.11.4.4 MaxAge

This object defines the max age of messages to be sent to an RKS or billing server.

6.5.6.11.4.5 BillingEvents

This attribute tells the CCAP if it needs to send billing events to a billing server/RKS.

6.5.6.12 Load Balance Configuration Information Model

This section defines the configuration objects needed for configuring DOCSIS load balancing on the CCAP.

The [MULPIv4.0] specification Autonomous Load Balancing section defines two modes of operation for the CMTS to load balance cable modems:

- **Autonomous Load Balancing**
  Autonomous Load Balancing refers to an algorithm implemented at the CMTS whereby the CMTS directly takes actions to manage the distribution of CMs across the available channels. The specifics of the Load Balancing algorithm are left for vendor definition. Cable modems can be provisioned (either by the CM config file, or optionally, by management objects defined here) to be assigned to Restricted Load Balancing Groups, or can be automatically assigned to General Load Balancing Groups (See [MULPIv4.0] General Load Balancing Groups and Restricted Load Balancing Groups sections).

  In addition to assignment to a Load Balancing Group, each CM has certain load balancing parameters. The load balancing parameters for a CM can be configured in the CM's configuration file, optionally configured directly in the CMTS, or inherited from the configuration of the Load Balancing Group to which the CM is assigned. The CM load balancing parameters help the CMTS determine which CMs are likely candidates to be balanced across the network, as well as the initialization technique to be used in the balancing operation The Load Balancing Group defines the service group or list of channels over which the CM is allowed to be balanced within a MAC Domain. The CMTS could also provide load balancing capabilities across MAC Domains. (See [MULPIv4.0] Autonomous Load Balancing section for more details.) The management objects defined here provide a global (CMTS-wide) enable/disable for Autonomous Load Balancing, as well as the ability to enable/disable Autonomous Load Balancing on a Group-by-Group basis.

  During Autonomous Load Balancing operations, changes to plant topology, MAC Domain structure, Channel Sets, Load Balancing Groups, etc., could produce unexpected results on those operations. Therefore, it might be advisable or even required by the CMTS implementation for the operator to disable Autonomous Load Balancing prior to making such changes. Moreover, an attempt to enable Load Balancing could be rejected if the CMTS detects configuration issues that would prevent normal Load Balancing operation.

- **Externally-Directed Load Balancing**
  The Externally-Directed Load Balancing operation is performed via a management interface where the operator directs the CMTS to move a particular CM from its current channel configuration to a new channel configuration. Since Externally-Directed Load Balancing has the potential to run at cross-purposes with Autonomous Load Balancing, the CMTS is not required to support Externally-Directed Load Balancing when the Autonomous Load Balancing operation is enabled. The process of externally directing a CM to a different set of channels is also referred to as the "change-over" operation.

There are two types of Load Balancing Groups: Restricted Load Balancing Groups and General Load Balancing Groups. The Restricted Load Balancing Groups are a list of channels where the CM is confined to be balanced by the CMTS. By definition a Restricted Load Balancing Group needs to consist of a subset of channels of a single CM-SG. The General Load Balancing Group comprises all the channels within a MD-CM-SG, and as such there is a one-to-one relationship between General Load Balancing Groups and MD-CM-SGs.

As in DOCSIS 2.0, the Externally-Directed Load Balancing functionality supports single (us & ds) change-over operations (via DCC/UCC) for CMs not operating in Multiple Receive Channel mode. For CMs operating in Multiple Receive Channel mode, the DOCSIS 3.0 CMTS also supports channel-set change-over operations (via DBC or DCC and REG-RSP-MP) (see [MULPIv4.0]).

Another difference in load balancing operation between DOCSIS 2.0 and DOCSIS 3.0 is the interpretation of General and Restricted Load Balancing Groups. In DOCSIS 2.0, General Load Balancing Groups are configured explicitly by the operator. In DOCSIS 3.0, General Load Balancing Groups are generated automatically by the CMTS based on the MD-CM-SGs described in the CMTS topology configuration. In DOCSIS 2.0, the operator configures Restricted Load Balancing Groups either to resolve ambiguous plant topologies (essentially, topologies where the MD-CM-SG cannot be uniquely determined solely by the US/DS channel pair used in Initial Ranging) or to implement service-related restrictions on the set of channels available to a particular CM (e.g., business vs. residential). In DOCSIS 3.0, the topology resolution algorithm effectively eliminates the first purpose for defining Restricted Load Balancing Groups; operators would then only configure Restricted Load Balancing Groups to effect service-related restrictions. (See [MULPIv4.0]).

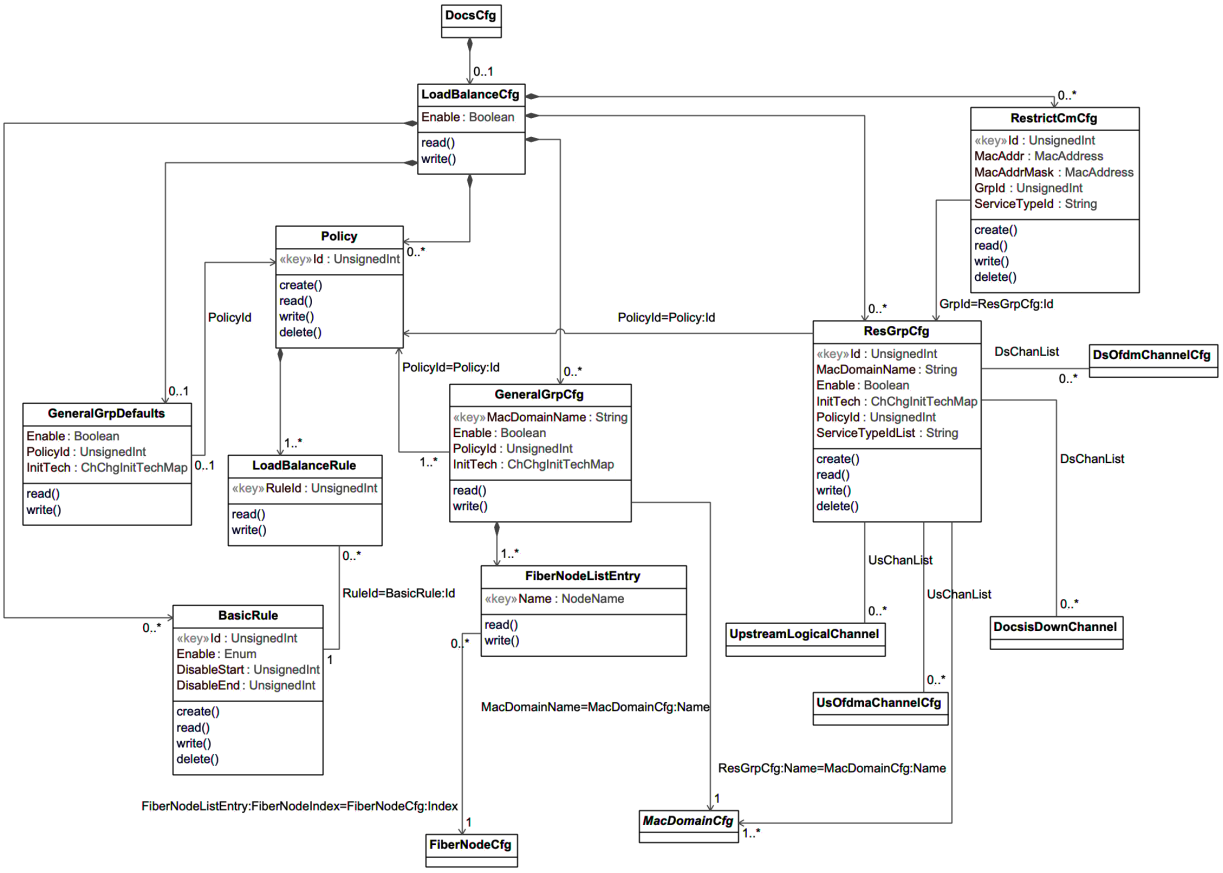


Figure 37 - Load Balance Configuration Information Model

6.5.6.12.1 DocsCfg

This configuration object is included in Figure 36 for reference. It is defined in Section 6.5.6.1.2, DocsCfg.

6.5.6.12.2 LoadBalanceCfg

This object enables and disables Autonomous Load Balancing Operations. It is based on the DOSCSIS 3.0 System object and is used with the following modification: The EnableError attribute has been removed because it does not provide enough information about what aspect of the configuration has caused enabling to fail.

Reference: [OSSIv3.0], System Object

Table 215 - LoadBalanceCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Enable	Boolean	No			true

Table 216 - LoadBalanceCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
GeneralGrpCfg	Directed composition to GeneralGrpCfg		0..*	
GeneralGrpDefaults	Directed composition to GeneralGrpDefaults		0..1	
BasicRule	Directed composition to BasicRule		0..*	

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Policy	Directed composition to Policy		0..*	
ResGrpCfg	Directed composition to ResGrpCfg		0..*	
RestrictCmCfg	Directed composition to RestrictCmCfg		0..*	

6.5.6.12.2.1 Enable

This attribute when set to 'true' enables Autonomous Load Balancing operation on the CCAP; otherwise Autonomous Load Balancing is disabled. When Autonomous Load Balancing is enabled, the CCAP MAY reject Externally-Directed Load Balancing operations. However, even when Autonomous Load Balancing is disabled, the CCAP is required to assign load balancing parameters to CMs as provisioned in the configuration file and/or RestrictCmCfg object.

6.5.6.12.3 GeneralGrpCfg

This object allows configuration of load balancing parameters for General Load Balancing Groups by way of MAC Domain-Fiber Node pairs. In many deployments, a MAC Domain-Fiber Node pair will equate to an MD-CM-SG (which always equates to a GLBG). In the case where an MD-CM-SG spans multiple Fiber Nodes, there will be multiple instances of this object that represent the General Load Balancing Group (MD-CM-SG); the CCAP MUST enforce that such instances all have the same attribute values. Any time a fiber node is associated to a MAC Domain, an instance of this object is defined by the CCAP and populated with either the same values as the other fiber nodes associated with the same MD-CM-SG (if any exist) or default values from the GeneralGrpDefaults object. Similarly, when a fiber node is no longer paired with a MAC Domain, the corresponding instance is deleted from the object.

The CMTS and CCAP MUST persist all instances of the GeneralGrpCfg object across reinitializations.

Table 217 - GeneralGrpCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
MacDomainName	String	Yes (key)			
Enable	Boolean	No			true
PolicyId	UnsignedInt	No			0
InitTech	ChChgInitTechMap	No			

Table 218 - GeneralGroupCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Policy	Association to Policy	1..*		PolicyId=Policy:Id
MacDomainCfg	Directed association to MacDomainCfg		1	MacDomainName= MacDomainCfg:Name
FiberNodeListEntry	Directed composition to FiberNodeListEntry		1..*	

6.5.6.12.3.1 MacDomainName

This key configures the MAC Domain being associated with a list of fiber nodes.

6.5.6.12.3.2 Enable

This attribute, when set to 'true', enables Autonomous Load Balancing for the General Load Balancing Group associated with this instance. When set to 'false', Autonomous Load Balancing is disabled.

6.5.6.12.3.3 PolicyId

This attribute defines the default load balancing policy for the General Load Balancing Group associated with this instance. The value 0 is reserved to indicate no policy is associated with this GeneralGrpCfg instance.

6.5.6.12.3.4 InitTech

This attribute defines the load balancing initialization technique for the General Load Balancing Group associated with this instance.

References: [MULPIv4.0] Initialization Technique

6.5.6.12.4 FiberNodeListEntry

This object configures an entry in the list of fiber node names that are associated with the configured MAC Domain.

Table 219 - FiberNodeListEntry Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	NodeName	Yes (key)			

Table 220 - FiberNodeListEntry Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
FiberNodeCfg	Directed association to FiberNodeCfg	0..*	1	FiberNodeListEntry: FiberNodeIndex= FiberNodeCfg:Index

6.5.6.12.4.1 Name

This key attribute configures the human-readable name of a FiberNode instance associated with the load balancing group.

6.5.6.12.5 GeneralGrpDefaults

This object provides the default load balancing parameters for General Load Balancing Groups (MD-CM-SGs) that are used when instances of GeneralGrpCfg are created by the CCAP.

Table 221 - GeneralGrpDefaults Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Enable	Boolean	No			true
PolicyId	UnsignedInt	No			0
InitTech	ChChgInitTechMap	No			'F8'H

Table 222 - GeneralGrpDefaults Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Policy	Directed association to Policy	0..1		PolicyId

6.5.6.12.5.1 Enable

This attribute represents the default value for the Enable attribute of the GeneralGrpCfg object.

6.5.6.12.5.2 PolicyId

This attribute represents the default value for the PolicyId attribute of the GeneralGrpCfg object. The value 0 is reserved to indicate no policy is associated with the GeneralGrpDefaults object.

6.5.6.12.5.3 InitTech

This attribute represents the default value for the InitTech attribute of the GeneralGrpCfg object.

6.5.6.12.6 BasicRule

This object represents a basic rule set applicable to a load balancing policy that references it.

The CMTS and CCAP MUST persist all instances of BasicRule object across reinitializations.

The CCAP MUST support creation and deletion of multiple instances of the BasicRule object.

Table 223 - BasicRule Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedInt	Yes (key)			
Enable	Enum	No	enabled(1), disabled(2), disabledPeriod(3)		disabled
DisableStart	UnsignedInt	No	0..86399		0
DisableEnd	UnsignedInt	No	0..86399		0

Table 224 - BasicRule Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LoadBalanceRule	Association to LoadBalanceRule	1	0..*	RuleId=BasicRule:Id

6.5.6.12.6.1 Id

This key configures a unique identifier of a load balancing rule set for this object.

6.5.6.12.6.2 Enable

This attribute when set to 'enabled' enables Autonomous Load Balancing (independently of the load balancing group enable/disable state). The rule set is disabled if set to 'disabled'. If set to 'disabledPeriod', the rule set is disabled during a period of time configured in the DisableStart and DisableEnd attributes.

6.5.6.12.6.3 DisableStart

This attribute disables load balancing from the time stated by this attribute when the attribute Enable is set to 'disablePeriod'. The time is defined in seconds since midnight. This attribute is required if the value of the Enable attribute is disabledPeriod; otherwise it is ignored.

6.5.6.12.6.4 DisableEnd

This attribute disables load balancing until the time stated by this attribute when the attribute Enable is set to 'disablePeriod'. The time is defined in seconds since midnight. This attribute is required if the value of the Enable attribute is disabledPeriod; otherwise it is ignored.

6.5.6.12.7 Policy

This object describes the set of load balancing policies. All the rules contained in a load balancing policy apply to Autonomous Load Balancing operations. Load balancing rules are defined within this specification or can be vendor-defined as well.

The CMTS and CCAP MUST persist all instances of Policy object across reinitializations.

The CCAP MUST support creation and deletion of multiple instances of the Policy object.

Table 225 - Policy Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedInt	Yes (key)	1.. 4294967295		

Table 226 - Policy Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
LoadBalanceRule	Directed composition to LoadBalanceRule		1..*	

6.5.6.12.7.1 Id

This key configures a unique identifier for this load balancing policy.

6.5.6.12.8 LoadBalanceRule

This object allows a load balancing rule to be associated with a Policy instance.

Table 227 - LoadBalanceRule Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
RuleId	UnsignedInt	Yes (key)			

6.5.6.12.8.1 RuleId

This key configures a unique identifier for this instance.

6.5.6.12.9 ResGrpCfg

This object represents the configuration of Restricted Load Balancing Groups.

The CMTS and CCAP MUST persist all instances of the ResGrpCfg object across reinitializations.

The CCAP MUST support creation and deletion of multiple instances of the ResGrpCfg object.

Table 228 - ResGrpCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedInt	Yes (key)			
MacDomainName	String	Yes			
Enable	Boolean	No			true
InitTech	ChChgInitTechMap	No			'F8'H
PolicyId	UnsignedInt	No			0
ServiceTypeIdList	String	No	0-255		""

Table 229 - ResGrpCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Policy	Directed association to Policy	0..1		PolicyId=Policy:Id
UpstreamLogicalChannel	Association to UpstreamLogicalChannel		0..*	UsChanList
DocsisDownChannel	Association to DocsisDownChannel		0..*	DsChanList
MacDomainCfg	Directed association to MacDomainCfg		1..*	ResGrpCfg:Name= MacDomainCfg:Name
UsOfdmaChannel	Association to UsOfdmaChannel		0..*	UsChanList
DsOfdmChannelCfg	Association to DsOfdmChannelCfg		0..*	DsChanList

6.5.6.12.9.1 Id

This key configures a unique index assigned to the Restricted Load Balancing Group by the user for provisioning purposes. This value is unique within a CCAP and is matched with the CM signaled Load Balancing Group ID TLV value when determining the CM Load Balancing Group assignment based on such TLV value.

References: [MULPIv4.0], Channel Assignment During Registration section.

6.5.6.12.9.2 MacDomainName

This attribute configures the MAC domain where the Restricted Load balancing Group applies. A zero-length string indicates that vendor-specific mechanisms are used to define the Restricted Load Balancing Group. For example, to provide Load Balancing Groups across MAC domains.

6.5.6.12.9.3 Enable

This attribute when set to 'true' enables Autonomous Load Balancing on this Restricted Load Balancing Group. The value 'false' disables the load balancing operation on this group.

6.5.6.12.9.4 InitTech

This attribute represents the initialization techniques that the CCAP can use to load balance cable modems in the Load Balancing Group.

By default, this object is initialized with all the defined bits having a value of '1'.

Multiple bits can be set to 1 to allow the CCAP to select the most suitable technique in a proprietary manner.

A value with all bits '0' means no channel changes allowed.

References: [MULPIv4.0], Initialization Technique.

6.5.6.12.9.5 PolicyId

This attribute represents the default load balancing policy of this Restricted Load Balancing Group. A policy is described by a set of conditions (rules) that govern the load balancing process for a cable modem. The CCAP assigns this Policy ID value to a cable modem associated with the group ID when the cable modem does not signal a Policy ID during registration. The Policy ID value is intended to be a numeric reference to an instance of the Policy object. The Policy ID of value 0 is reserved to indicate no policy is associated with the load balancing group.

6.5.6.12.9.6 ServiceTypeIdList

This attribute represents a space separated list of ServiceType IDs that will be compared against the cable modem provisioned Service Type ID to determine the most appropriate Restricted Load Balancing Group.

References: [MULPIv4.0], Channel Assignment During Registration section

6.5.6.12.10 RestrictCmCfg

This object configures a list of cable modems being statically provisioned at the CCAP to a Restricted Load Balancing Group.

The CCAP MUST support creation and deletion of multiple instances of the RestrictCmCfg object.

Table 230 - RestrictCmCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Id	UnsignedInt	Yes (key)			
MacAddr	MacAddress	No			'000000000000'H
MacAddrMask	MacAddress	No			
GrpId	UnsignedInt	No			
ServiceTypeId	String	No	0-16		""

Table 231 - RestrictCmCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ResGrpCfg	Directed association to ResGrpCfg			GrpId=ResGrpCfg:Id

6.5.6.12.10.1 Id

This key represents the unique identifier of an instance of this object. The CCAP maintains a unique instance per MAC Address/MAC Address Mask combination.

6.5.6.12.10.2 MacAddr

This attribute represents the MAC Address of the cable modem within the Restricted Load Balancing Group.

6.5.6.12.10.3 MacAddrMask

This attribute corresponds to a bit mask acting as a wild card to associate a cable modem MAC addresses to a Restricted Load Balancing Group ID referenced by a restricted group Id or a Service Type ID. The cable modem matching criteria is performed by bit-ANDed the cable modem MAC address with the MacAddrMask attribute and being compared with the bit-ANDed of attributes MacAddr and MacAddrMask. A cable modem MAC address look up is performed first with instances containing this attribute value not null; if several entries match, the largest consecutive bit match from MSB to LSB is used. Empty value is equivalent to the bit mask all in ones.

6.5.6.12.10.4 GrpId

This attribute represents the Restricted Load Balancing Group identifier of this entry associated with the cable modem MAC address - MAC address mask combination. If this attribute is not configured, this instance is matched only against the ServiceTypeId value.

6.5.6.12.10.5 ServiceTypeId

This attribute represents the Service Type Id associated with this cable modem MAC address - MAC Address mask combination. If this attribute is not configured, this instance is matched only against the GrpId value; if both GrpId and this attribute are not present, the instance is ignored for matching purposes.

6.5.7 CCAP Network Configuration Information Model

This section is a collection of configuration objects that are specific to the chassis and not to DOCSIS or video services on a CCAP.

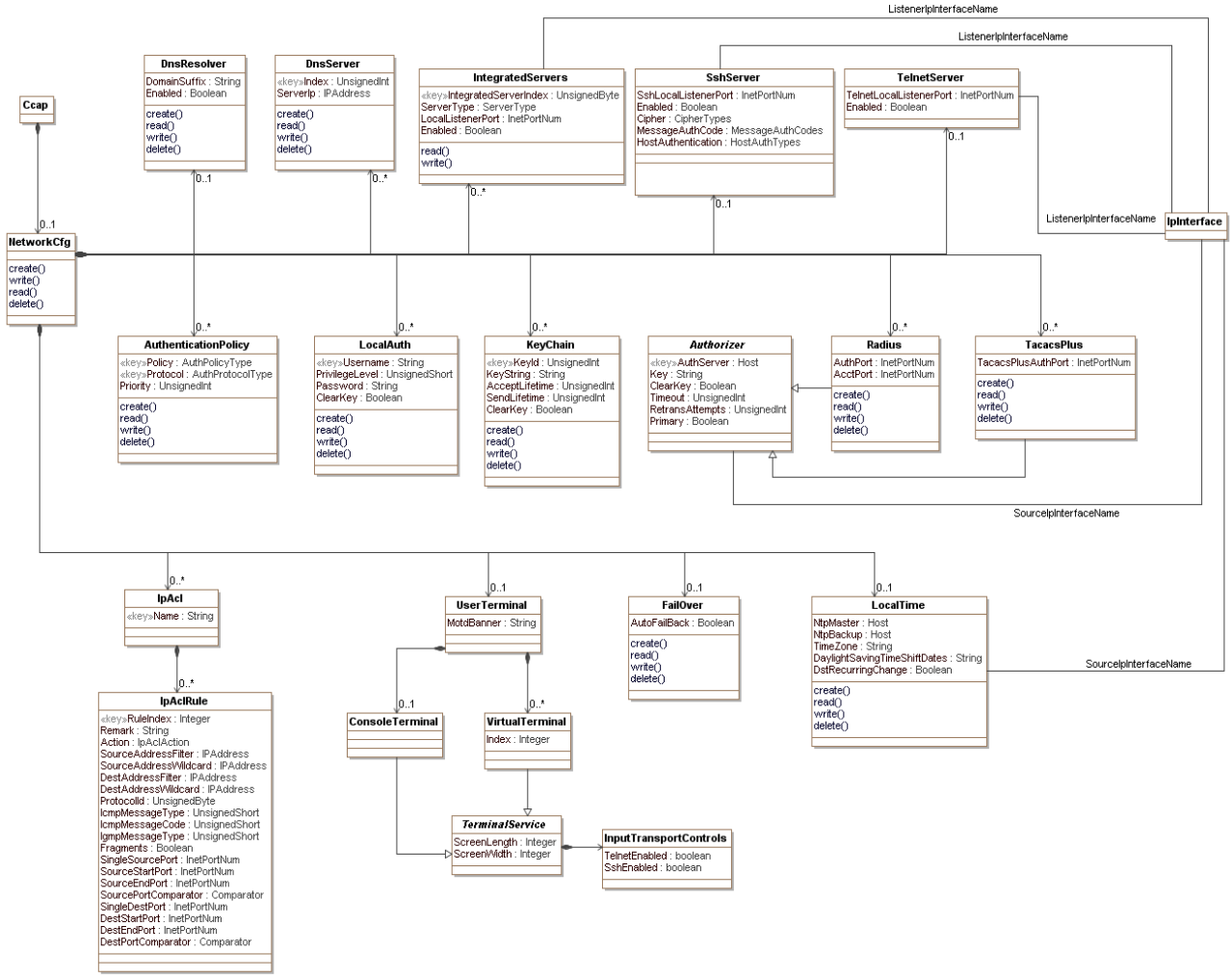


Figure 38 - CCAP Network Configuration Information Model

6.5.7.1 Ccap

This configuration object is included in Figure 38 for reference. It is defined in Section 6.5.3.1.

6.5.7.2 NetworkCfg

The NetworkCfg object is the primary container of network configuration objects. It has the following associations:

Table 232 - NetworkCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DnsResolver	Directed composition to DnsResolver		0..1	
DnsServer	Directed composition to DnsServer		0..*	
IntegratedServers	Directed composition to Integrated Servers		0..*	
SshServer	Directed composition to SshServer		0..1	
TelnetServer	Directed composition to TelnetServer		0..1	
AuthenticationPolicy	Directed composition to AuthenticationPolicy		0..*	
LocalAuth	Directed composition to LocalAuth		0..*	

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Radius	Directed composition to Radius		0..*	
TacacsPlus	Directed composition to TacacsPlus		0..*	
KeyChain	Directed composition to KeyChain		0..*	
IpAcl	Directed composition to IpAcl		0..*	
UserTerminal	Directed composition to UserTerminal		0..1	
FailOver	Directed composition to FailOver		0..1	
LocalTime	Directed composition to Time		0..1	

6.5.7.3 DnsResolver

This object allows the configuration of DNS servers and the configuration of default domain suffix information. The objects in this configuration object are scalars.

Table 233 - DnsResolver Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DomainSuffix	String	Yes			
Enabled	Boolean	No			true

6.5.7.3.1 DomainSuffix

The attribute DomainSuffix configures a Domain Suffix that should be post-pended to any hostname lookup that does not consist of a Fully Qualified Domain Name (FQDN).

6.5.7.3.2 Enabled

This attribute configures if the associated domain suffix should be applied to hostnames that do not include an FQDN.

6.5.7.4 DnsServer

This object allows the configuration of the different DNS Servers that the CCAP can use to get Domain Name Resolution.

Table 234 - DnsServer Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
ServerIp	IpAddress	Yes			

6.5.7.4.1 Index

This attribute configures the index for this instance of DnsServer.

6.5.7.4.2 ServerIp

This attribute configures the IP address of the DNS server used by the CCAP for DNS resolution. No distinction is made for IPv6 or IPv4 addresses here.

6.5.7.5 IntegratedServers

This configuration object defines the types of servers integrated into the CCAP and their respective administrative states. At run time an object for each server type will be instantiated with its IANA-defined default port; see [PORT

NUMS]. To define a different default port, the operator will update the existing IntegratedServers object for that server type with the new port number specified.

Table 235 - IntegratedServers Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
IntegratedServerIndex	UnsignedByte	Yes (Key)			
ServerType	Enum	Yes	other(1), ftp(2), http(3), netconf(4)		
LocalListenerPort	InetPortNum	No			See attribute description
Enabled	Boolean	No			false

Table 236 - IntegratedServers Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with an IpInterface			ListenerIpInterfaceName

When an IP interface is selected, this specifies the IP interface on which the server listens. If an IP interface is not specified, the behavior of the CCAP is vendor specific.

6.5.7.5.1 IntegratedServerIndex

This attribute configures a unique identifier for this IntegratedServers instance.

6.5.7.5.2 ServerType

This attribute configures the type of server being configured on the CCAP. The value of other(1) is used when a vendor-extension has been implemented for this attribute. The CCAP MAY support a NETCONF server-type option.

6.5.7.5.3 LocalListenerPort

This attribute configures the TCP or UDP port number on which the server listens. The CCAP MUST assign the default value as the IANA-assigned port number associated with the ServerType selected, as defined in [PORT NUMS].

6.5.7.5.4 Enabled

This attribute configures the running state of the server. True means that the server will actively listen on the specified port. False means that the specific server is disabled.

6.5.7.6 SshServer

This configuration object defines an integrated SSHv2 server in the CCAP. The CCAP SSH server MUST support SSH version 2 as defined in [RFC 4250], [RFC 4251], [RFC 4252], [RFC 4253], and [RFC 4254].

This configuration object allows different combinations of cipher, message authentication code, and host authentication code to be configured; however, a CCAP might not support all possible combinations of these three attributes.

Table 237 - SshServer Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SshLocalListenerPort	InetPortNum	No			22
Enabled	Boolean	No			false
Cipher	EnumBits	No	other(0), reserved(1), aes128(2), aes192(3), aes256(4), reserved(5), blowfish(6), cast(7), twofish128(8), twofish192(9), twofish256(10)		aes256
MessageAuthCode	EnumBits	No	other(0), reserved(1), reserved(2), reserved(3), reserved(4), ripemd-160(5), sha2-256(6), sha2-512(7)		vendor-specific
HostAuthentication	Enum	No	other(0), none(1), ssh-dss(2), ssh-rsa(3), pgp-sign-rsa(4), pgp-sign-dss(5)		None

Table 238 - SshServer Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with an IpInterface			ListenerIpInterfaceName

When an IP interface is selected, this specifies the IP interface on which the server listens. If an IP interface is not specified, the behavior of the CCAP is vendor-specific.

6.5.7.6.1 LocalListenerPort

This object configures the TCP or UDP port number on which the server listens.

6.5.7.6.2 Enabled

This attribute configures the running state of the server. True means that the server will actively listen on the specified port. False means that the specific server is disabled.

6.5.7.6.3 Cipher

This attribute configures the set of encryption algorithms that are allowed on the SSH interface. SSH will use the enabled set of algorithms to negotiate the algorithm to use with the connecting client. The CCAP system MUST log an event with severity level "Error" (Event ID:70000110) reporting the configuration file name and unsupported algorithm(s) if the configuration file enables a cipher algorithm that is not supported. The bit setting of "other" can be used to enable an algorithm supported by the CCAP that is not in the defined list.

6.5.7.6.4 MessageAuthCode

This attribute configures the set of message authentication algorithms that are allowed on the SSH interface. SSH will use the enabled set of algorithms to negotiate the algorithm to use with the connecting client to ensure message integrity. The CCAP system MUST log an event with severity level "Error" (Event ID: 70000111) reporting the configuration file name and unsupported algorithm(s) if the configuration file enables a MAC algorithm that is not supported. The bit setting of "other" can be used to enable an algorithm supported by the CCAP that is not in the defined list.

6.5.7.6.5 HostAuthentication

This attribute enables SSH host authentication using public keys in a specified format. It is assumed that user authentication will be configured in the same way as other CCAP interfaces. The file format for key storage is outside the scope of this specification.

6.5.7.7 TelnetServer

This configuration object defines an integrated Telnet server in the CCAP.

Table 239 - TelnetServer Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TelnetLocalListenerPort	InetPortNum	No			23
Enabled	Boolean	No			false

Table 240 - TelnetServer Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with an IpInterface			ListenerIpInterfaceName

When an IP interface is selected, this specifies the IP interface on which the server listens. If an IP interface is not specified, the behavior of the CCAP is vendor-specific.

6.5.7.7.1 LocalListenerPort

This object configures the TCP or UDP port number on which the server listens.

6.5.7.7.2 Enabled

This attribute configures the running state of the server. True means that the server will actively listen on the specified port. False means that the specific server is disabled.

6.5.7.8 AuthenticationPolicy

This configuration object allows the configuration of authentication policy. The Priority attribute controls which service is used first for authenticating users.

Table 241 - AuthenticationPolicy Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Policy	Enum	Yes (Key)	other(1), login(2), privilegedMode(3)		
Protocol	Enum	Yes (Key)	other(1), radius(2), tacacsPlus(3), localAuth(4), none(5)		
Priority	UnsignedInt	Yes			

6.5.7.8.1 Policy

This attribute is the first part of the key and configures the policy type for the specified protocol. The privilegedMode(3) option is an administrative role that allows the user to execute all available commands. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.7.8.2 Protocol

This attribute is the second part of the key and represents the protocol used for authentication. The value of other(1) is used when a vendor extension has been implemented for this attribute.

6.5.7.8.3 Priority

This attribute sets a priority for the protocol selected. Higher numbers are higher priority. A specified policy cannot have the same priority across multiple protocols.

6.5.7.9 LocalAuth

This object configures the local user accounts and privilege levels.

Table 242 - LocalAuth Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Username	String	Yes (Key)			
PrivilegeLevel	UnsignedShort	Yes	0..15		
Password	String	Yes			
ClearKey	Boolean	Yes			

6.5.7.9.1 UserName

This attribute configures the "login" name to be used.

6.5.7.9.2 PrivilegeLevel

This attribute corresponds to the user's privilege level. The highest number provides the most user privileges.

6.5.7.9.3 Password

This attribute corresponds to the user's password. Upon export, the CCAP MUST export the Password attribute of the LocalAuth object encrypted with a vendor-specific algorithm.

6.5.7.9.4 ClearKey

This attribute indicates whether the Password attribute is included in the configuration based on the YANG model in the clear (true) or encrypted (false). This attribute defines the status of the password (encrypted or decrypted), not

whether the device should export the password in the clear or encrypted. Regardless of the value of this setting, the password will always be exported as encrypted.

6.5.7.10 Authorizer

The Authorizer abstract class holds common attributes used for configuring TACACS+ and Radius services for the CCAP.

Table 243 - Authorizer Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
AuthServer	Host	Yes (Key)			
Key	String	Yes			
ClearKey	Boolean	Yes			
Timeout	Byte	No		seconds	3
RetransAttempts	UnsignedByte	No			1
Primary	Boolean	No			false

Table 244 - Authorizer Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with an IpInterface			SourceIpInterfaceName

This association specifies the IP interface to use as the source interface. If an IP interface is not specified, the behavior of the CCAP is vendor-specific.

6.5.7.10.1 AuthServer

This key attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the Auth Server.

The CCAP MUST support configuring an IP address for the Authorizer AuthServer attribute.

The CCAP SHOULD support configuring an FQDN for the Authorizer AuthServer attribute.

6.5.7.10.2 Key

This attribute corresponds to the shared secret that is used to encrypt the communication.

Upon export, the CCAP MUST export the Key attribute of the TacacsPlus object encrypted with a vendor-specific algorithm.

6.5.7.10.3 ClearKey

This attribute indicates whether the Key attribute is included in the configuration file based on the YANG model in the clear (true) or encrypted (false). This attribute defines the status of the key (encrypted or decrypted), not whether the device should export the key in the clear or encrypted. Regardless of the value of this setting, the key will always be exported as encrypted.

6.5.7.10.4 Timeout

This attribute defines the number of seconds before a connection is declared inactive.

6.5.7.10.5 RetransAttempts

This attribute defines the number of retransmissions before giving up the connection.

6.5.7.10.6 Primary

This attribute designates whether this TACACS instance is the primary or backup server.

6.5.7.11 Radius

This configuration object creates the configuration for Radius servers.

Table 245 - Radius Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
AuthPort	InetPortNum	No	0..65535		1812
AcctPort	InetPortNum	No	0..65535		1813

Table 246 - Radius Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Authorizer	Specialization of Authorizer			

6.5.7.11.1 AuthPort

This attribute defines the TCP port on which AAA authentication and authorization are performed.

6.5.7.11.2 AcctPort

This attribute defines the TCP port on which AAA accounting is performed.

6.5.7.12 TacacsPlus

This configuration object configures TACACS+ services for the CCAP.

Table 247 - TacacsPlus Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TacacsPlusAuthPort	InetPortNum	No	0..65535		49

Table 248 - TacacsPlus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Authorizer	Specialization of Authorizer			

Specifies the IP interface to use as the source interface. If an IP interface is not specified, the behavior of the CCAP is vendor-specific.

6.5.7.12.1 TacacsPlusAuthPort

This attribute defines the TCP port used for communicating with the AAA server.

6.5.7.13 KeyChain

The KeyChain object allows the CCAP to be configured with different Ripv2 key change information.

Table 249 - KeyChain Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
KeyId	UnsignedInt	Yes (Key)	0..2147483647		
KeyString	String	Yes	1..79		
AcceptLifetime	UnsignedInt	Yes	0..2147483647	seconds	
SendLifetime	UnsignedInt	No	0..2147483647	seconds	0
ClearKey	Boolean	Yes			

6.5.7.13.1 KeyId

This attribute configures a KeyId used in RipV2 route updates.

6.5.7.13.2 KeyString

This attribute configures the actual key used for this instance. This value has to be the same on both the sender and receiver of the RIPv2 route.

6.5.7.13.3 AcceptLifetime

This attribute configures the accept lifetime value in seconds for the key in this instance.

6.5.7.13.4 SendLifetime

This attribute configures the send lifetime value in seconds for the key in this instance. A value of 0 (zero) means that there is no lifetime limit.

6.5.7.13.5 ClearKey

This attribute indicates whether the KeyString attribute is included in the configuration based on the YANG model in the clear (true) or encrypted (false). This attribute defines the status of the key (encrypted or decrypted), not whether the device should export the key in the clear or encrypted. Regardless of the value of this setting, the key will always be exported as encrypted.

6.5.7.14 IpAcl

This configuration object defines the attributes for the IP Access Control List object. This object defines an extended access control list.

Table 250 - IpAcl Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)	1..32		

Table 251 - IpAcl Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpAclRule	Directed composition to IpAclRule		0..*	

6.5.7.14.1 Name

This attribute configures a unique identifier for an instance of this object.

6.5.7.15 IpAclRule

This configuration object defines an access control list rule contained within an IpAcl instance. Multiple rules can be contained within an IpAcl instance.

When the ACL rule is processed, the system will only match on the values configured in the rule. If an attribute is not provided in the configuration instance file, the CCAP will match any value for that attribute. For example, if ProtocolId is not specified, then any value for protocol Id in the packet will match the filter. If the CCAP rejects the configuration of an IpAclRule, the CCAP SHOULD also reject the IpAcl instance that contains the rule.

A configured instance of the IpAclRule object either holds a Remark or an Action. If it contains a Remark, then only the RuleIndex and Remark attributes are allowed. If the instance contains and Action, the Remark attribute is not allowed, but all other attributes can be included, as described in the following sections.

Table 252 - IpAclRule Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
RuleIndex	Int	Yes (Key)			
Remark	String	No			
Action	Enum	No	other(1), deny(2), permit(3)		
SourceAddressFilter	IpAddress	No[1]			
SourceAddressWildcard	IpAddress	No[2]			
DestAddressFilter	IpAddress	No[1]			
DestAddressWildcard	IpAddress	No[3]			
ProtocolId	UnsignedByte	No			
IcmpMessageType	UnsignedShort	No	0..255		
IcmpMessageCode	UnsignedShort	No	0..255		
IgmpMessageType	UnsignedShort	No	0..255		
Fragments	Boolean	No			false
SingleSourcePort	InetPortNum	No			
SourceStartPort	InetPortNum	No			
SourceEndPort	InetPortNum	No			
SourcePortComparator	Enum	No	other(1), lessThan(2), greaterThan(3), equals(4), notEqual(5)		equals(4)
SingleDestPort	InetPortNum	No			
DestStartPort	InetPortNum	No			
DestEndPort	InetPortNum	No			
DestPortComparator	Enum	No	other(1), lessThan(2), greaterThan(3), equals(4), notEqual(5)		equals(4)

Table Notes:

[1] If an Action is being configured, either SourceAddressFilter or DestAddressFilter is required for the configuration of this object, however both are not required. If an Action is configured and neither the SourceAddressFilter nor the DestAddressFilter value is provided in the configuration instance file, the CCAP MUST reject the configuration of the IpAclRule instance.

[2] If a SourceAddressFilter is configured, then the corresponding SourceAddressWildcard attribute also has to be configured.

[3] If a DestAddressFilter is configured, then the corresponding DestAddressWildcard attribute also has to be configured.

6.5.7.15.1 RuleIndex

This attribute configures a unique identifier for the ACL rule. This value also sets the order in which rules are executed, with lower numbers executing first. The CCAP MAY restrict a range of indexes to a specific set of ACL attributes in a vendor-proprietary way.

6.5.7.15.2 Remark

This attribute provides a textual string that explains the intent of a group of ACL rules. When the Remark attribute is configured, only the RuleIndex attribute is allowed to be configured within that instance; if additional attributes are configured, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.3 Action

This attribute configures the action the CCAP takes when the ACL rule matches a packet. This and all of the following attributes are only valid if a Remark attribute has not been configured.

6.5.7.15.4 SourceAddressFilter

This attribute defines an IP addresses to match the source address in the packet; it is used in conjunction with the SourceAddressWildcard attribute. The value can be an IPv4 or IPv6 address.

When both source and destination address filters are specified, each configured value has to be of the same IP type (either IPv4 or IPv6). If a DestAddressFilter is also specified, the CCAP MUST reject the IpAclRule configuration if the address types do not match.

6.5.7.15.5 SourceAddressWildcard

The SourceAddressWildcard attribute defines which bits of the packet's source IP address are matched to the SourceAddressFilter attribute. The usage of the IP address wildcard differs from most typical applications where IP addresses are masked. Rather than restricting the defined IP address to a range of addresses by masking off the lowest significant bits of the address, the IP address mask is used as a wildcard.

Each bit in the SourceAddressWildcard set to zero indicates that the corresponding bit position in the packet's source IP address needs to exactly match the bit value in the corresponding bit position in the SourceAddressFilter. Each wildcard bit set to one indicates that both a zero bit and a one bit in the corresponding position of the packet's IP address will be considered a match to this access list entry. In other words, "ones" are places in bit positions that should be ignored. The set of "ones" does not have to start at LSB, nor has to cover consecutive bit positions. For example, a value of 0.0.255.1 is valid for an IPv4 wildcard.

For example, to configure the AclRule to match any IPv4 source address, a value of 0.0.0.0 would be configured in the SourceAddressFilter attribute and a value of 255.255.255.255 would be configured in the SourceAddressWildcard attribute.

A value of 0.0.0.0 for SourceAddressWildcard attribute signifies that the IP ACL will match packet to a specific host IP address specified in SourceAddressFilter attribute.

6.5.7.15.6 DestAddressFilter

This attribute defines an IP addresses to match the destination address in the packet; it is used in conjunction with the DestAddressWildcard attribute. The value can be an IPv4 or IPv6 address.

When both source and destination address filters are specified, each configured value has to be of the same IP type (either IPv4 or IPv6). If a SourceAddressFilter is also specified, the CCAP MUST reject the IpAclRule configuration if the IP address types do not match.

6.5.7.15.7 DestAddressWildcard

The DestAddressWildcard attribute defines which bits of the packet's source IP address are matched to the DestAddressFilter attribute. The usage of the IP address wildcard differs from most typical applications where IP

addresses are masked. Rather than restricting the defined IP address to a range of addresses by masking off the lowest significant bits of the address, the IP address mask is used as a wildcard.

The rules for matching are identical to those described for SourceAddressWildcard.

6.5.7.15.8 ProtocolId

This attribute defines an IP protocol number for the filter to match when the protocol is not ICMP or IGMP.

If the protocol is ICMP or IGMP, one of the following attributes will be configured instead:

- IcmpMessageType
- IgmpMessageType

6.5.7.15.9 IcmpMessageType

This attribute defines the ICMP message type for the filter to match. For the ICMP protocol, the ProtocolId attribute is not used. If both the ProtocolId and IcmpMessageType attributes are provided in an IpAclRule instance, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.10 IcmpMessageCode

This attribute is only applicable if an IcmpMessageType has been configured. When this attribute is defined, the CCAP will filter packets that match the configured ICMP message type and message code. If the IcmpMessageCode attribute is provided in an IpAclRule instance, but the IgmpMessageType attribute is not, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.11 IgmpMessageType

This attribute defines the IGMP message type for the filter to match. For the IGMP protocol, the ProtocolId attribute is not used. If both the ProtocolId and IgmpMessageType attributes are provided in an IpAclRule instance, the CCAP MUST reject the configuration of the IpAclRule instance. If both the IcmpMessageType and IgmpMessageType attributes are provided in an IpAclRule instance, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.12 Fragments

This attribute determines whether the ACL rule is applied to all fragments of a fragmented packet, or only to the initial fragment. A setting of false means that only the initial fragment is filtered.

6.5.7.15.13 SingleSourcePort

This attribute defines a single source port number for the ACL rule. The CCAP will filter a packet that comes from this source port.

For source port filtering, either the SingleSourcePort attribute, or the SourceStartPort and SourceEndPort attributes (i.e., a port range) is configured. If the SingleSourcePort and SourceStartPort attributes are provided in an IpAclRule instance, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.14 SourceStartPort

This attribute defines the starting source port number for a range of ports defined for the ACL rule. When the SourceStartPort attribute is configured, the SourceEndPort attribute is also required. If the SourceStartPort attribute is provided in an IpAclRule instance, but a SourceEndPort attribute is not, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.15 SourceEndPort

This attribute defines the ending source port number for a range of ports defined for the ACL rule. The value of this attribute has to be greater than the value in the SourceStartPort. If the SourceEndPort attribute is provided in an

IpAclRule instance, but the SourceStartPort is not, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.16 SourcePortComparator

This attribute defines how the filter matches a specified SingleSourcePort. This attribute is not valid if a SourceStartPort and SourceEndPort are provided. The filter can match if the source port number of the packet is less than, greater than, equal to, or not equal to the defined source port number.

The CCAP MUST support the "less than", "greater than", and "not equal to" settings when a SingleSourcePort attribute is provided.

6.5.7.15.17 SingleDestPort

This attribute defines a single destination port number for the ACL rule. The CCAP will filter a packet that has this destination port.

For destination port filtering, either the SingleDestPort attribute, or the DestStartPort and DestEndPort attributes (i.e., a port range) are configured. If the SingleDestPort and DestStartPort attributes are provided in an IpAclRule instance, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.18 DestStartPort

This attribute defines the starting destination port number for a range of ports defined for the ACL rule. When the DestStartPort attribute is configured, the DestEndPort attribute is also required. If the DestStartPort attribute is provided in an IpAclRule instance, but a DestEndPort attribute is not, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.19 DestEndPort

This attribute defines the ending destination port number for a range of ports defined for the ACL rule. The value of this attribute has to be greater than the value in the DestStartPort. If the DestEndPort attribute is provided in an IpAclRule instance, but the DestStartPort is not, the CCAP MUST reject the configuration of the IpAclRule instance.

6.5.7.15.20 DestPortComparator

This attribute defines how the filter matches a specified SingleDestPort. The filter can match if the destination port number of the packet is less than, greater than, equal to, or not equal to the defined destination port.

The CCAP MUST support the "less than", "greater than", and "not equal to" settings when a SingleDestPort attribute is provided.

6.5.7.16 UserTerminal

This container object configures the user terminal instances for the CCAP, both the ConsoleTerminal instance and VirtualTerminal instances.

Table 253 - UserTerminal Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
MotdBanner	String	No			""

Table 254 - UserTerminal Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TerminalService	Specialization of TerminalService			

6.5.7.16.1 MotdBanner

This attribute configures the contents of a message of the day banner that displays to the user when the user logs into a virtual terminal.

6.5.7.17 VirtualTerminal

This object configures a virtual terminal interface on the CCAP.

Table 255 - VirtualTerminal Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	Int	Yes			

Table 256 - VirtualTerminal Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TerminalService	Specialization of TerminalService			

6.5.7.17.1 Index

This attribute configures a unique index for this virtual terminal instance.

6.5.7.18 ConsoleTerminal

This object configures the console terminal interface on the CCAP.

Table 257 - ConsoleTerminal Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TerminalService	Specialization of TerminalService			

6.5.7.19 TerminalService

This abstract object holds attributes used to configure the console terminal and virtual terminal instances.

Table 258 - TerminalService Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ScreenLength	Int	No		Lines	24
ScreenWidth	Int	No		Columns	80

Table 259 - TerminalService Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
InputTransportControls	Directed composition to InputTransportControls			

6.5.7.19.1 ScreenLength

This attribute configures the number of lines on the screen of the terminal instance.

6.5.7.19.2 ScreenWidth

This attribute configures the number of columns on the screen of the terminal instance.

6.5.7.20 InputTransportControls

This object configures SSH and Telnet settings for a virtual terminal instance.

Table 260 - InputTransportControls Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TelnetEnabled	Boolean	No			false
SshEnabled	Boolean	No			false

6.5.7.20.1 TelnetEnabled

This attribute configures whether Telnet is enabled on the virtual terminal interface.

6.5.7.20.2 SshEnabled

This attribute configures whether SSH is enabled on the virtual terminal interface.

6.5.7.21 FailOver

This object configures the automatic fail-over operation of the CCAP.

Table 261 - FailOver Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
AutoFailBack	Boolean	No			true

6.5.7.21.1 AutoFailBack

This attribute configures whether or not the CCAP automatically switches back to a line card after a failover event. If true, when the failed card is operational, the CCAP will begin using that card again. If False, the operator will have to perform the failback operation.

6.5.7.22 LocalTime

The LocalTime object allows the configuration of a Primary and Secondary NTP server, as well as other local time attributes. This object does not fully configure all NTP client parameters. Vendors may provide additional configuration objects to fully configure the NTP and SNTP protocols if desired.

Table 262 - LocalTime Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
NtpMaster	Host	Yes			
NtpBackup	Host	No			
TimeZone	String	No			00
DaylightSavingTimeShiftDates	String	No			3.2.0/02.00, 11.1.0/02.00, 01
DstRecurringChange	Boolean	No			false

Table 263 - LocalTime Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with an IpInterface			SourceIpInterfaceName

This association specifies the IP interface to use as the source interface. If an IP interface is not specified, the behavior of the CCAP is vendor-specific.

6.5.7.22.1 NtpMaster

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the master NTP server.

The CCAP MUST support configuring an IP address for the LocalTime NtpMaster server attribute.

The CCAP SHOULD support configuring an FQDN for the LocalTime NtpMaster server attribute.

6.5.7.22.2 NtpBackup

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the backup NTP server.

The CCAP MUST support configuring an IP address for the LocalTime NtpBackup server attribute.

The CCAP SHOULD support configuring an FQDN for the LocalTime NtpBackup server attribute.

6.5.7.22.3 TimeZone

This attribute represents the offset value to the local time to arrive at UTC Time. The value has the following format:

hh[:mm] - the hour

(0 <= hh <= 24) - required, minutes

(0 <= mm <= 59) - the mm (minutes) is optional. The hour can be preceded by a minus sign (-).

6.5.7.22.4 DaylightSavingTimeShiftDates

This attribute indicates when to change to and from daylight saving (or summer) time. The value has the form: date1/time1,date2/time2,offset. The first date describes when the change from standard to daylight saving time occurs, and the second date describes when the change back happens.

Each time field describes when, in current local time, the change to the other time is made. The format of date is the following: m.w.d - The dth day (0 <= d <= 6) of week w of month m of the year (1 <= w <= 5, 1 <= m <= 12, where week 5 means "the last d day in month m", which may occur in the fourth or fifth week). Week 1 is the first week in which the dth day occurs. Day zero is Sunday.

The time format is the following: hh:mm - The offset value is the value that needs to be added to the local time to arrive at UTC Time during the daylight-saving time. The offset value has the following format: hh[:mm].

The default value is the second Sunday in March (start) and the first Sunday in November (end).

6.5.7.22.5 DstRecurringChange

This attribute controls whether the CCAP automatically adjusts the time to Daylight Saving Time (DST). If enabled, the CCAP will adjust the time based on the value of the DaylightSavingTimeCalendar attribute.

6.5.7.23 IpInterface

This configuration object is included in Figure 38 for reference. It is defined in Section 6.5.8.5.

6.5.8 Interface Configuration Information Model

Interfaces in the CCAP are different than ports, in that they are intended to be Layer 3 entities. The following information model shows the relationships for interfaces in the CCAP.

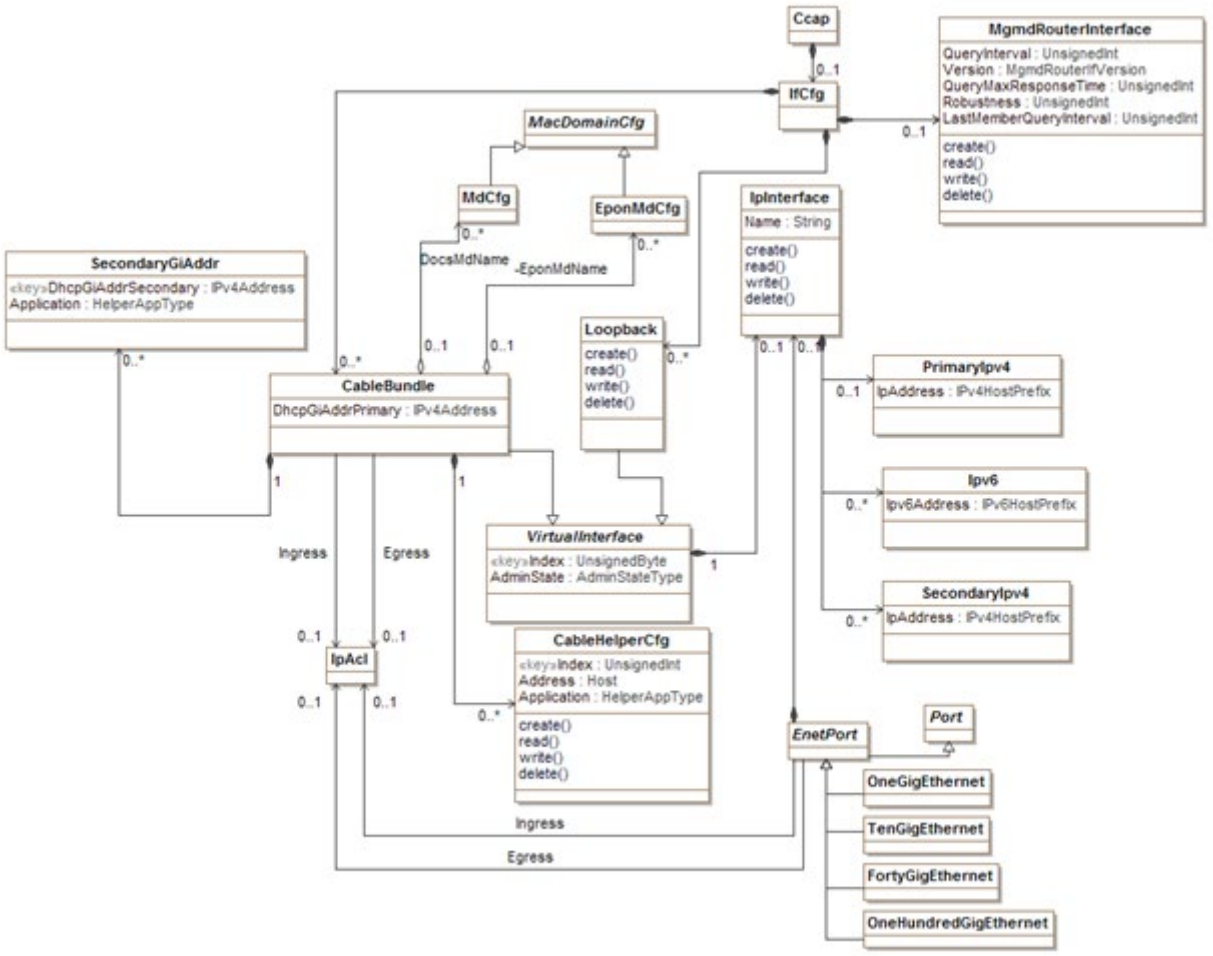


Figure 39 - Interface Configuration Information Model

6.5.8.1 Ccap

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.3.1.

6.5.8.2 IfCfg

The IfCfg object is the primary container of interface configuration objects.

Table 264 - IfCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CableBundle	Directed composition to CableBundle		0..*	
Loopback	Directed composition to Loopback		0..*	
MgmdRouterInterface	Directed composition to MgmdRouterInterface		0..1	

6.5.8.3 Loopback

A loopback interface is a logical interface that is not tied to a specific hardware port. The CCAP MUST support a loopback interface to provide a virtual interface to assist in overall system configuration.

Table 265 - Loopback Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
VirtualInterface	Specialization of VirtualInterface			

6.5.8.4 VirtualInterface

The VirtualInterface abstract object contains attributes shared by CCAP virtual interfaces (Loopback and CableBundle).

Table 266 - VirtualInterfaceObject Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedByte	Yes (Key)			
AdminState	AdminStateType	No			down

Table 267 - VirtualInterface Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Directed composition to IpInterface	1	0..1	

6.5.8.4.1 Index

The index for the VirtualInterface instance.

6.5.8.4.2 AdminState

This attribute configures the administrative state of the virtual interface.

6.5.8.5 IpInterface

IpInterface is an object used to configure an IP interface on the CCAP. Attributes from this object are used by the CableBundle, Loopback, and EnetPort objects. For a CCAP operating in non-routing mode, an IpInterface instance need not be configured for CableBundle objects.

Table 268 - IpInterface Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			

IpInterface has several associations.

Table 269 - IpInterface Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PrimaryIpv4	Directed composition to PrimaryIpv4		0..1	
Ipv6	Directed composition to Ipv6		0..*	
SecondaryIpv4	Directed composition to SecondaryIpv4		0..*	

6.5.8.5.1 Name

The name for this instance of an interface. This name is used to reference a specific IpInterface instance and associate it with the referring object.

6.5.8.6 PrimaryIpv4

The PrimaryIpv4 object allows a primary IPv4 interface address to be configured.

Table 270 - PrimaryIpv4 Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
IpAddress	Ipv4HostPrefix	Yes			

6.5.8.6.1 IpAddress

This attribute configures the IPv4 address and prefix for this instance.

6.5.8.7 Ipv6

The PrimaryIpv6 object allows a primary IPv6 interface address to be configured. For IPv6 addresses, the concept of primary and secondary does not apply; for this reason, a list of IPv6 addresses may be configured.

Table 271 - Ipv6 Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Ipv6Address	Ipv6HostPrefix	Yes			

6.5.8.7.1 Ipv6Address

This attribute configures the IPv6 address and prefix for this instance.

6.5.8.8 SecondaryIpv4

The SecondaryIpv4 object allows secondary IPv4 addresses to be configured.

Table 272 - SecondaryIpv4 Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
IpAddress	Ipv4HostPrefix	Yes			

6.5.8.8.1 IpAddress

This attribute configures the IPv4 address and prefix for this instance.

6.5.8.9 CableBundle

A CableBundle is a compact way of assigning Layer 3 network addresses to a set of Layer 2 interfaces. This allows the bundled Layer 2 interfaces to share a common pool of IPv4 Subnets or IPv6 prefixes so that these IP address resources can be efficiently used by the CCAP operating in routing mode.

Table 273 - CableBundle Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DhcpGiAddrPrimary	Ipv4Address	Yes			

A CableBundle can only be associated with MAC domains of a given type; the CCAP MUST reject the configuration of a CableBundle instance in which both an MdCfg and an EponMdCfg have been configured.

Table 274 - CableBundle Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
MdCfg	Directed aggregation to MdCfg	0..1	0..*	DocsMdName
EponMdCfg	Directed aggregation to EponMdCfg	0..1	0..*	EponMdName
CableHelperCfg	Directed composition to CableHelperCfg	1	0..*	
SecondaryGiAddr	Directed composition to SecondaryGiAddr	1	0..*	
IpAcl	Directed association to IpAcl		0..1	Ingress
IpAcl	Directed association to IpAcl		0..1	Egress

6.5.8.9.1 DhcpGiAddrPrimary

This attribute configures how the DHCP relay agent populates the GiAddr for relayed DHCP traffic on the CCAP in routing mode.

6.5.8.10 CableHelperCfg

The CableHelperCfg configuration object allows the operator to configure different Cable Helper addresses for DHCP Clients. The CCAP operating in routing mode ties these Cable Helper addresses to the CableBundle interfaces and the MAC Domains they service.

Table 275 - CableHelperCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)			
Address	Host	Yes			
Application	Enum	No	other(1) host(2) mta(3) stb(4) cm(5) all(6)		all

6.5.8.10.1 Index

The index for the CableHelperCfg instance.

6.5.8.10.2 Address

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the DHCP server configured as a cable helper.

The CCAP MUST support configuring an IP address for the CableHelperCfg Address attribute.

The CCAP SHOULD support configuring an FQDN for the CableHelperCfg Address attribute.

6.5.8.10.3 Application

This attribute configures the device class for which this cable helper configuration applies. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.8.11 SecondaryGiAddr

This object allows a secondary GiAddr to be configured for a CableBundle instance.

Table 276 - SecondaryGiAddr Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DhcpGiAddrSecondary	Ipv4Address	Yes (Key)			
Application	Enum	No	other(1) host(2) mta(3) stb(4) cm(5) all(6)		 all

6.5.8.11.1 DhcpGiAddrSecondary

This attribute configures how the DHCP relay agent populates the secondary GiAddr for relayed DHCP traffic on the CCAP in routing mode.

6.5.8.11.2 Application

This attribute configures the device class for which this GiAddr instance applies. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.8.12 MacDomainCfg

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.6.6.6.

6.5.8.13 EponMdCfg

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.10.6.

6.5.8.14 MdCfg

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.6.6.4.

6.5.8.15 EnetPort

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.4.16.

6.5.8.16 OneGigEthernet

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.4.17.

6.5.8.17 TenGigEthernet

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.4.18.

6.5.8.18 FortyGigEthernet

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.4.19.

6.5.8.19 OneHundredGigEthernet

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.4.20.

6.5.8.20 Port

This configuration object is included in Figure 39 for reference. It is defined in Section 6.5.4.10.

6.5.8.21 MgmdRouterInterface

This configuration object allows for configuration of the CCAP IP Multicast Router. These configuration objects are defined in the Multicast Group Membership Discovery MIB, [RFC 5519]. The table shown here is derived from this MIB.

Table 277 - MgmdRouterInterface Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
QueryInterval	UnsignedInt	No		seconds	125
Version	Enum	No	other(1), igmpv1(2), igmpv2OrMldv1(3), igmpv3OrMldv2(4)		igmpv2OrMldv1
QueryMaxResponseTime	UnsignedInt	No	0..31744	tenths of seconds	100
Robustness	UnsignedInt	No	1..225		2
LastMemberQueryInterval	UnsignedInt	No	0..31744	tenths of seconds	10

6.5.8.21.1 QueryInterval

The frequency in seconds at which IGMP or MLD Host-Query packets are transmitted on this interface.

6.5.8.21.2 Version

The version of MGMD that is running on this interface. Value 2 applies to IGMPv1 routers only. Value 3 applies to IGMPv2 and MLDv1 routers, and value 4 applies to IGMPv3 and MLDv2 routers.

This object can be used to configure a router capable of running either version. For IGMP and MLD to function correctly, all routers on a LAN need to be configured to run the same version on that LAN.

6.5.8.21.3 QueryMaxResponseTime

The maximum query response interval in seconds advertised in MGMDv2 or IGMPv3 queries on this interface.

6.5.8.21.4 Robustness

The robustness variable utilized by an MGMDv3 host in sending state-change reports for multicast routers. To ensure the state-change report is not missed, the host retransmits the state-change report [mgmdHostInterfaceVersion3Robustness - 1] times. The variable needs to be a non-zero value.

6.5.8.21.5 LastMemberQueryInterval

The Last Member Query Interval is the Max Query Response Interval in tenths of a second inserted into group-specific queries sent in response to leave group messages and is also the amount of time between group-specific query messages. This value may be tuned to modify the leave latency of the network. A reduced value results in reduced time to detect the loss of the last member of a group. The value of this object is irrelevant if mgmdRouterInterfaceVersion is 1.

6.5.9 Management Configuration Information Model

The management configuration objects configure fault management and SNMP for the CCAP.

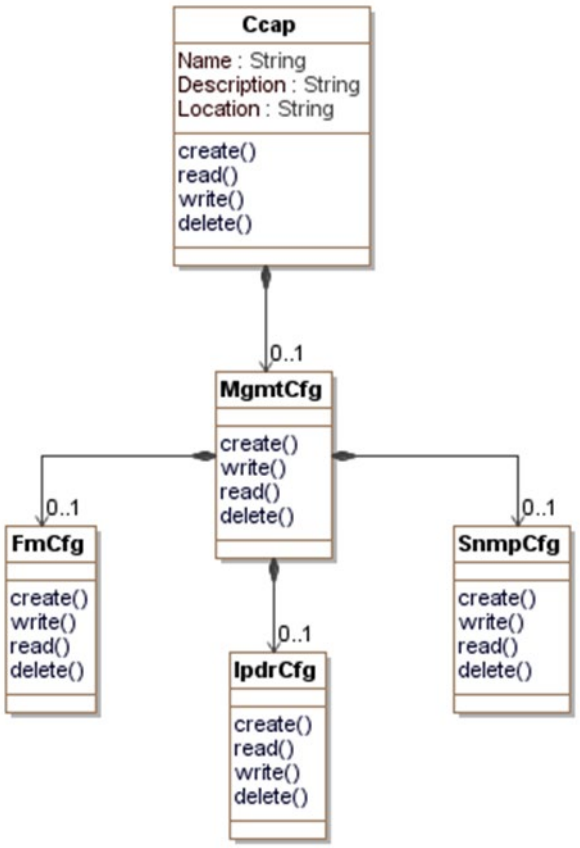


Figure 40 - Management Configuration Information Model

6.5.9.1 Ccap

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.3.1.

6.5.9.2 MgmtCfg

The MgmtCfg object is the primary container of the management configuration objects. It has the following associations:

Table 278 - MgmtCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
FmCfg	Directed composition to FmCfg		0..1	
SnmpCfg	Directed composition to SnmpCfg		0..1	
IpdrCfg	Directed composition to IpdrCfg		0..1	

6.5.9.3 FmCfg

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.9.6.2.

6.5.9.4 SnmpCfg

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.9.7.2.

6.5.9.5 IpdrCfg

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.9.8.2.

6.5.9.6 Fault Management Configuration Information Model

The CCAP will employ much of the event reporting methods that have long been a part of DOCSIS and PMI. This section will detail the configuration portions of the event reporting infrastructure which have been adapted from [OSSIv3.0]. The Information model for these configured objects is shown below.

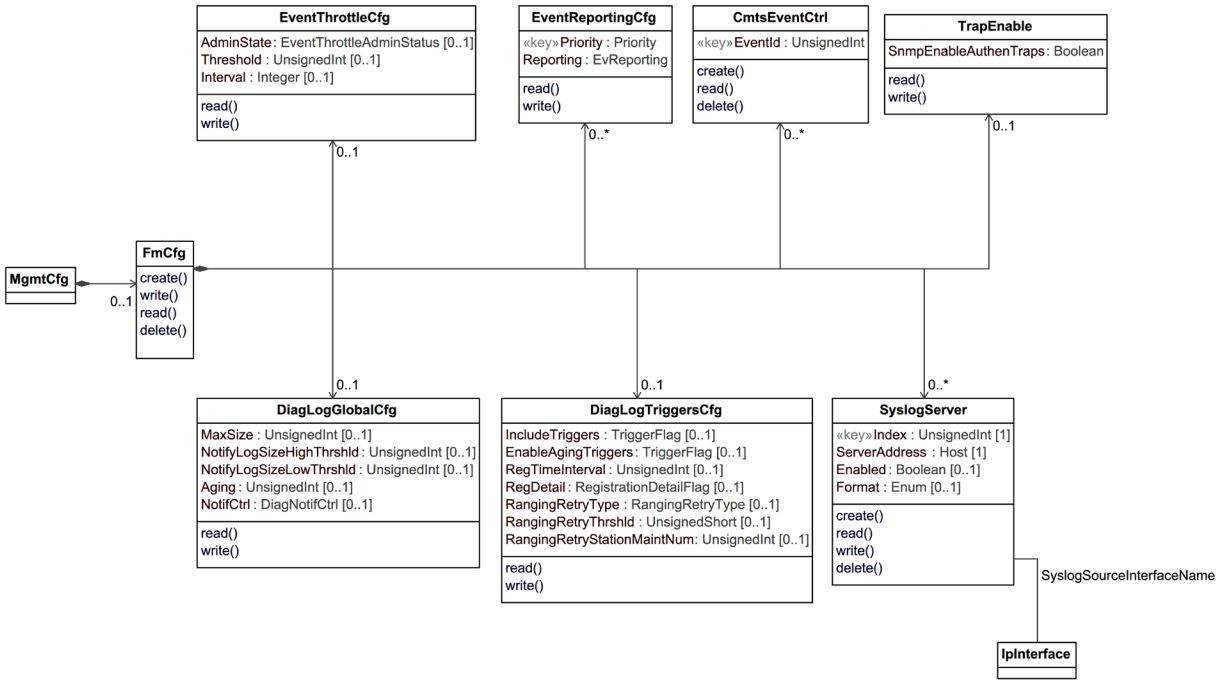


Figure 41 - Fault Management Configuration Information Model

These objects allow the operator to configure logging for various events so these issues can be tracked.

6.5.9.6.1 MgmtCfg

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.9.2.

6.5.9.6.2 FmCfg

The FmCfg object is the primary container of fault management configuration objects.

The Diagnostic Log is one of the DOCSIS Fault Management functions. The Diagnostic Log allows operators to diagnose and troubleshoot potential problems with Cable Modems (CMs), CMTS cable interfaces, or the cable plant by detecting and tracking CMs that have intermittent connectivity problems or unstable operations including:

- CM repeated registration
- Station Maintenance retry

Only detected CMs are reported in the Diagnostic Log for further analysis. Diagnostic Log entries are aged out based on the configuration of the specific aging attributes. The FmCfg contains the configuration objects for the Diagnostic Log function.

The FmCfg has the following associations:

Table 279 - FmCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EventThrottleCfg	Directed composition to EventThrottleCfg	1	0..1	
EventReportingCfg	Directed composition to EventReportingCfg	1	0..*	
CmtsEventCtrl	Directed composition to CmtsEventCtrl	1	0..*	
TrapEnable	Directed composition to TrapEnable	1	0..1	
DiagLogGlobalCfg	Directed composition to DiagLogGlobalCfg	1	0..1	
DiagLogTriggersCfg	Directed composition to DiagLogTriggersCfg	1	0..1	
SyslogServer	Directed composition to SyslogServer	1	0..*	

6.5.9.6.3 EventThrottleCfg

This configuration object is based on the docsDevEvent group defined in [RFC 4639] and uses the following attributes without modification for CCAP:

- AdminStatus (renamed AdminState)
- Threshold
- Interval

Reference: [RFC 4639], docsDevEvent Group

6.5.9.6.4 EventReportingCfg

This configuration object is based on the docsDevEvControlTable object defined in [RFC 4639] and will be used without modification for CCAP.

Reference: [RFC 4639], docsDevEvControlTable

6.5.9.6.5 CmtsEventCtrl

This object represents the control mechanism to enable the dispatching of events based on the Event Id. The following rules define the event control behavior:

- If the CmtsEventCtrl object has no instances or contains an instance with Event ID 0, then all events matching the Local Log settings of docsDevEvReporting are sent to local log ONLY.
- Additionally, if the CmtsEventCtrl object contains configured instances, then Events matching the Event Ids configured in the object are sent according to the settings of the docsDevEvReporting object, i.e., Traps, Syslog, etc.

The CMTS and CCAP MUST persist all instances of CmtsEventCtrl across reinitializations.

Table 280 - CmtsEventCtrl Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
EventId	UnsignedInt	key			

6.5.9.6.5.1 EventId

This key represents the Event ID of the event being enabled for delivery to a dispatch mechanism (e.g., syslog).

References: Annex D, Format and Content for Event, SYSLOG, and SNMP Notification (Normative).

6.5.9.6.6 TrapEnable

This configuration object contains attributes which allow enabling or disabling of SNMP Notifications. The SnmpEnableAuthenTraps attribute is taken from [RFC 3418] and will be used without modification for the CCAP.

Reference: [RFC 3418], snmpEnableAuthenTraps

6.5.9.6.7 DiagLogGlobalCfg

The following read-only attributes have been removed:

- CurrentSize
- LastResetTime
- LastClearTime

This object defines the parameters to manage and control the instantiation of CMs in the Diagnostic Log object.

The CMTS and CCAP MUST persist the values of the attributes of the DiagLogGlobalCfg object across reinitializations.

Table 281 - DiagLogGlobalCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
MaxSize	UnsignedInt	No	1..4294967295	instances	100
NotifyLogSizeHighThrshld	UnsignedInt	No	1..4294967295	instances	80
NotifyLogSizeLowThrshld	UnsignedInt	No	1..4294967295	instances	60
Aging	UnsignedInt	No	15..86400	minutes	10080
NotifCtrl	EnumBits	No	highThresholdReached(0) lowThresholdReached(1) full(2)		"H

6.5.9.6.7.1 MaxSize

This attribute indicates the maximum number of CM instances that can be reported in the Log.

6.5.9.6.7.2 NotifyLogSizeHighThrshld

This attribute is the Log high threshold value. When the number of instances in the Log exceeds this value, the CMTS will trigger a HighThreshold event.

6.5.9.6.7.3 NotifyLogSizeLowThrshld

This attribute is the Log low threshold value. When the number of instances in Log drops to this value, the CMTS will trigger a LowThreshold event, but only if the Log number of instances previously exceeded the NotifyLogSizeHighThrshld value.

6.5.9.6.7.4 Aging

This attribute defines a period of time after which an instance in the Log and its corresponding LogDetail instance (if present) are removed unless the Log instance is updated by an enabled trigger detection process.

6.5.9.6.7.5 NotifCtrl

This attribute is used to enable diagnostic log related notifications. Setting bit 0 enables notification for reaching log size high threshold. Setting bit 1 enables notification for returning back to log size low threshold after reaching log size high threshold. Setting bit 2 enables notification for Diagnostic Log size full.

6.5.9.6.8 DiagLogTriggersCfg

This object defines the parameters to configure the Diagnostic Log triggers. One or more triggers can be configured to define the actions of creating or updating CM entries into the Diagnostic Log.

The CMTS and CCAP MUST persist the values of the attributes of the DiagLogTriggersCfg object across reinitializations.

Table 282 - DiagLogTriggersCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
IncludeTriggers	TriggerFlag	No			'C0'H
EnableAgingTriggers	TriggerFlag	No			''H
RegTimeInterval	UnsignedInt	No	60..86400	seconds	90
RegDetail	EnumBits	No	initialRanging(1) rangingAutoAdjComplete(2) startEae(3) startDhcpv4(4) startDhcpv6(5) dhcpv4Complete(6) dhcpv6Complete(7) startConfigFileDownload(8) configFileDownloadComplete(9) startRegistration(10) registrationComplete(11) bpiInit(12) operational(13)		''H
RangingRetryType	Enum	No	consecutiveMiss(1) missRatio(2)		1
RangingRetryThrshld	UnsignedByte	No	3..12		6
RangingRetryStationMaintNum	UnsignedShort	No	60..65535		90

6.5.9.6.8.1 IncludeTriggers

This attribute turns individual diagnostic triggers on and off at a given time when each trigger is set to '1' or '0', respectively.

6.5.9.6.8.2 EnableAgingTriggers

This attribute enables and disables the aging of individual triggers at a given time when each trigger is set to '1' or '0' respectively. If a log entry is added by multiple triggers, and aging is disabled for one of those triggers, the CMTS MUST NOT age out such entry.

6.5.9.6.8.3 RegTimeInterval

This attribute is an operator empirically derived, worst-case number of seconds which the CM requires to complete registration. If the CM has not completed the registration stage within this registration time interval, the CM will be added to the Diagnostic Log.

6.5.9.6.8.4 RegDetail

This attribute provides for setting a bit representing a CM registration state to enable counting the number of times the CMTS determines that such CM reaches that state as the last state before failing to proceed further in the registration process and within the time interval considered for the CM registration trigger detection.

The meaning of the bit positions (left to right) are as follows:

- initialRanging(1)
- rangingAutoAdjComplete(2)
- startEae(3)
- startDhcpv4(4)

- startDhcpv6(5)
- dhcpv4Complete(6)
- dhcpv6Complete(7)
- startConfigFileDownload(8)
- configFileDownloadComplete(9)
- startRegistration(10)
- registrationComplete(11)
- bpiInit(12)
- operational(13)

6.5.9.6.8.5 RangingRetryType

This attribute selects the type of ranging retry trigger to be enable in the Diagnostic Log. A CM failure to perform ranging when a ranging opportunity is scheduled by the CMTS is counted as ranging miss. The ranging retry trigger can be configured to either look at consecutive ranging misses or ranging miss ratio over total number of station maintenance opportunities for a certain time period. Setting this object to 'consecutiveMiss' will select consecutive ranging misses as ranging retry trigger criteria. Setting this object to 'missRatio' will select ranging miss ratio as ranging retry criteria.

6.5.9.6.8.6 RangingRetryThrshld

This attribute indicates the maximum number of consecutive intervals in which the CMTS does not detect a CM acknowledgement of a MAC-layer station maintenance message before the CM is added to the Diagnostic Log. The value of RangingRetryType decides if consecutive ranging miss or ranging miss ratio is used as trigger.

6.5.9.6.8.7 RangingRetryStationMaintNum

This attribute indicates the number of station maintenance opportunities to monitor for the ranging retry trigger. This value implies time intervals in a certain range. DOCSIS specifies that the CMTS schedules ranging opportunities to CMs be sufficiently smaller than T4. There is no fixed formula to derive at a fixed time interval, that is, how many ranging opportunities may be offered to a CM by the CMTS; hence, using the number of station maintenance opportunities provides a ratio with the fixed denominators, while also taking the time factor into consideration.

6.5.9.6.9 SyslogServer

The SyslogServer object allows the configuration of remote Syslog Servers. The CCAP supports a minimum of 4 Syslog Servers.

Table 283 - SyslogServer Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedInt	Yes (Key)	1..*		
ServerAddress	Host	Yes			
Enabled	Boolean	No			false
Format	Enum	No	rfc3164(0), rfc5424(1)		rfc3164

Table 284 - SyslogServer Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with an IpInterface			SyslogSourceInterfaceName

6.5.9.6.9.1 Index

This key represents the unique identifier of an instance in this object.

6.5.9.6.9.2 ServerAddress

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the Syslog server. If DNS is supported, this attribute can contain the DNS domain name of the Syslog server.

The CCAP MUST support configuring an IP address for the Syslog ServerAddress attribute.

The CCAP SHOULD support configuring an FQDN for the Syslog ServerAddress attribute.

6.5.9.6.9.3 Enabled

Indicates if the Syslog server is used for sending Syslog messages or is disabled.

6.5.9.6.9.4 Format

This attribute selects the message format the CCAP is to use when it sends a Syslog message.

Value rfc3164(0) configures the CCAP to use the Syslog message format defined by [RFC 3164] 'The BSD syslog Protocol'.

Value rfc5424(1) configures the CCAP to use the Syslog message format defined by [RFC 5424] 'The Syslog Protocol'. The CCAP is not required to support the RFC-5424-defined Syslog message format, as specified in Section 9.2.2.1.3 Syslog. If the CCAP does not support RFC-5424-defined Syslog message format, it is left to vendor implementation whether to implement SyslogServer::Format with only enum rfc3164 or not implement the SyslogServer::Format attribute.

6.5.9.7 SNMP Agent Configuration Information Model

The configuration objects for the CCAP SNMP Agent are shown below. This is only a policy configuration, but can be matched to full SNMPv3 implementations using similar procedures as done for TLV 38, 53, and 54 described in [OSSIv3.0].

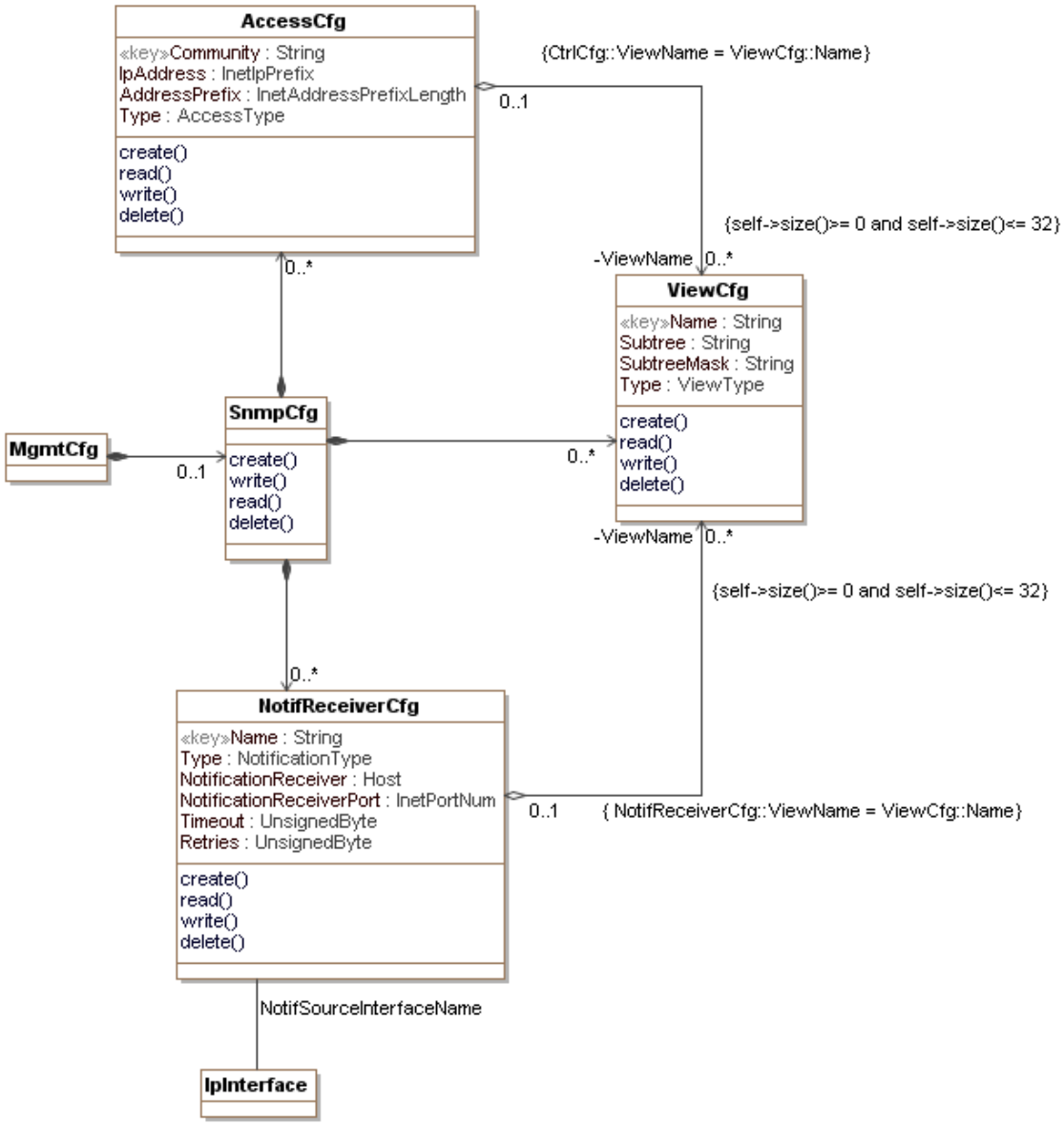


Figure 42 - SNMP Agent Configuration Information Model

6.5.9.7.1 MgmtCfg

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.9.2.

6.5.9.7.2 SnmpCfg

The SnmpCfg object is the primary container of SNMP configuration objects. It has the following associations:

Table 285 - SnmpCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
AccessCfg	Directed composition to AccessCfg		0..*	
ViewCfg	Directed composition to ViewCfg		0..*	

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
NotifReceiverCfg	Directed composition to NotifReceiverCfg		0..*	

6.5.9.7.3 AccessCfg

This object defines the configuration of access control for SNMPv1/v2c received request messages. When an SNMP request message is received, the system checks the validity of the request by matching the community string, source (IP address, subnet), access type and view restrictions for included SNMP OIDs in the request.

Table 286 - AccessCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Community	String	Yes (Key)	1..32		
IpAddress	InetIpPrefix	Yes			
AddressPrefix	InetAddressPrefixLength	Yes			
Type	Enum	No	readOnly(1), readWrite(2)		readOnly

Table 287 - AccessCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ViewCfg	Directed aggregation to ViewCfg	0..1	0..*	ViewName

6.5.9.7.3.1 Community

The community string defined for the access control rule.

6.5.9.7.3.2 IpAddress

The address used in conjunction with the AddressPrefix attribute used to validate the source of an incoming SNMP request.

6.5.9.7.3.3 AddressPrefix

The prefix to apply to the IpAddress attribute for matching valid sources for the SNMP requests.

6.5.9.7.3.4 Type

Defines the type of access granted to the SNMP request. An enumeration of "other" was purposefully excluded from this enumeration.

6.5.9.7.4 ViewCfg

This object defines a View consisting of a single OID subtree matching rule for inclusion or exclusion as part of a SNMP message processing procedure such as access authorization or dispatch or notifications.

Table 288 - ViewCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)			
Subtree	String	Yes			
SubtreeMask	String	Yes			

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Type	Enum	Yes	other(1), included(2), excluded(3)		

6.5.9.7.4.1 Name

The administrative name of an instance of this object.

6.5.9.7.4.2 Subtree

The OID subtree to be matched for the access view. This attribute is formatted as the text representation of an ASN.1 OID following the ABNF notation below:

Subtree = empty | OID [.OID]*

OID = number; 0..128

The matching procedures are borrowed from [RFC 3414] for tree views matching with the difference that the configuration elements use a text notation to represent OIDs and OID masks. See the SubtreeMask attribute definition for further information.

6.5.9.7.4.3 SubtreeMask

A mask to match OIDs for inclusion or exclusion as part of the view. This attribute definition is borrowed from [RFC 3414]. The only difference is that instead of bits per OID, a byte of value 0 or 1 is used to represent this attribute.

Each byte value 1 indicates the inclusion of the corresponding OID position in the Subtree attribute, while the value 0 indicates no need to match. See [RFC 3414] for details.

6.5.9.7.4.4 Type

Indicates inclusion or exclusion of the subtree for the defined view.

6.5.9.7.5 NotifReceiverCfg

This object defines where to send notifications. When an event is to be dispatched as a notification, the system checks for instances of this object that have the notification OID associated with the event as part of their Inclusion list in their ViewCfg instances. The system then sends notifications based on the matched occurrences per their configured parameters.

If an instance of NotifSourceInterfaceName is not configured, then selection of notification source interface is vendor proprietary.

Table 289 - NotifReceiverCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Name	String	Yes (Key)	1..32		
Type	Enum	No	snmpV1Trap(1), snmpV2cTrap(2), snmpV2Inform(3)		snmpV2cTrap
NotificationReceiver	Host	Yes			
NotificationReceiverPort	InetPortNum	No			162
Timeout	UnsignedByte	No		seconds	1
Retries	UnsignedByte	No			3

Table 290 - NotifReceiverCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ViewCfg	Directed aggregation to ViewCfg	0..1	0..*	ViewName
IpInterface	Association with IpInterface			NotifSourceInterfaceName

6.5.9.7.5.1 Name

The administrative name of an instance in this object.

6.5.9.7.5.2 Type

Indicates the type of SNMP notification being sent:

- snmpV1Trap: SNMP v1 trap
- snmpV2cTrap: SNMP v2c trap
- snmpV2cInform: SNMP v2c Inform

An enumeration of "other" was purposefully excluded from this enumeration.

6.5.9.7.5.3 NotificationReceiver

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the notification receiver.

The CCAP MUST support configuring an IP address for the NotifReceiverCfg NotificationReceiver attribute.

The CCAP SHOULD support configuring an FQDN for the NotifReceiverCfg NotificationReceiver attribute.

6.5.9.7.5.4 Port

The UDP port the notification receiver listens on for messages.

6.5.9.7.5.5 Timeout

The time in seconds the sender waits for receiving confirmation for a notification being sent. This attribute is meaningful only when the attribute Type is set to snmpV2cInform(4); otherwise it is ignored.

6.5.9.7.5.6 Retries

The number of retries the sender will attempt in case of it has not received confirmation of inform reception. This attribute is meaningful only when the attribute Type is set to snmpV2cInform(4); otherwise it is ignored.

6.5.9.8 IPDR Exporter Configuration Information Model

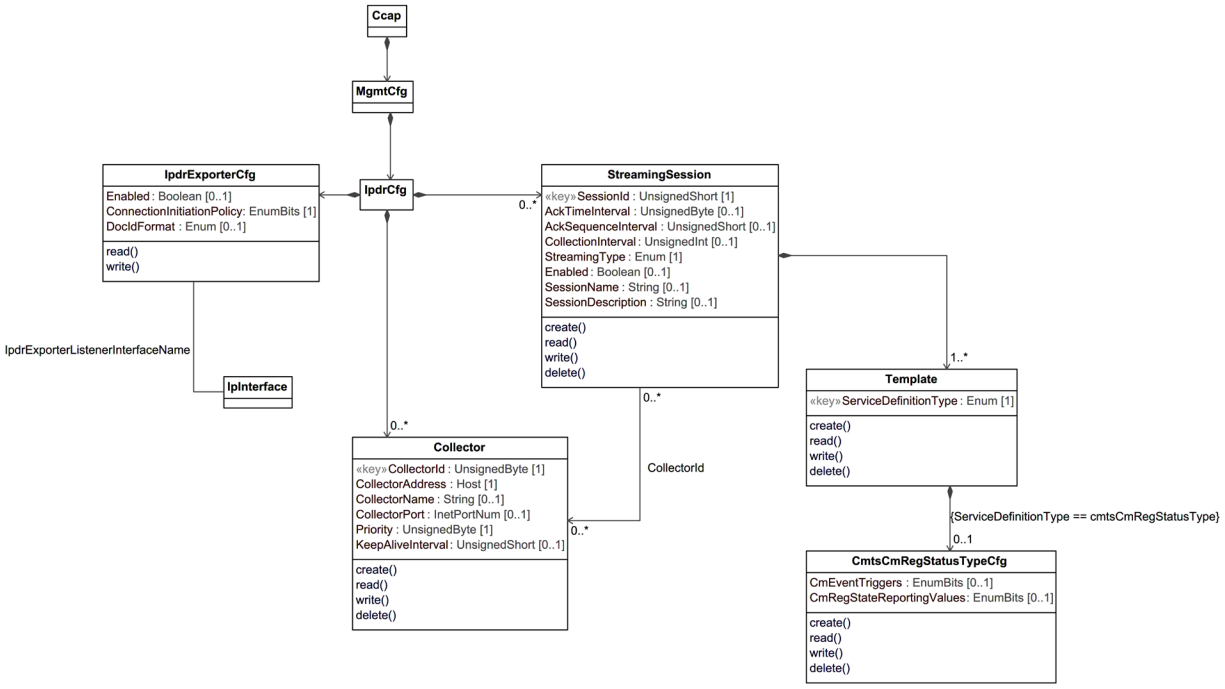


Figure 43 - IPDR Exporter Configuration Information Model

6.5.9.8.1 MgmtCfg

This configuration object is included in Figure 40 for reference. It is defined in Section 6.5.9.2.

6.5.9.8.2 IpdrCfg

The IpdrCfg object is the top-level container for the CCAP IPDR Exporter configuration objects. It has the following associations:

Table 291 - IpdrCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpdrExporterCfg	Directed composition to IpdrExporterCfg		1	
StreamingSession	Directed composition to StreamingSession		0..*	
Collector	Directed composition to Collector		0..*	

6.5.9.8.3 IpdrExporterCfg

The IpdrExporterCfg object provides configuration of the CCAP IPDR Exporter function.

Table 292 - IpdrExporterCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
Enabled	Boolean	No		0..1		true
ConnectionInitiationPolicy	EnumBits	Yes	collectorInitiated(0), exporterInitiated(1)	1		
DocIdFormat	Enum	No	uuidCableLabs(0), uuidVersion1Rfc4122(1)	0..1		'uuidCableLabs'

Table 293 - IpdrExporterCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpInterface	Association with IpInterface			IpdrExporterListenerInterfaceName

When an IP interface is selected, this specifies the IP interface on which the IPDR server listens. If an IP interface is not specified, the behavior of the CCAP is vendor-specific.

6.5.9.8.3.1 Enabled

This attribute configures whether or not the IPDR Exporter is enabled. When this attribute is set to 'true', at least one Collector is required to be provisioned in the Collector object.

The CCAP MUST reject an attempt to set Enabled to 'true' if no IPDR Collector has been provisioned.

6.5.9.8.3.2 ConnectionInitiationPolicy

This attribute configures the connection initiation policy for the IPDR Exporter.

Setting 'collectorInitiated' bit 0 will enable in-bound connections to the IPDR Exporter originated from an IPDR Collector specified in the Collector object.

Setting 'exporterInitiated' bit 1 will enable out-bound connections originated by the IPDR Exporter to an IPDR Collector specified in the Collector object.

Setting both bits will enable bidirectional connection initiation where either the IPDR Exporter or the IPDR Collector can initiate and establish a connection.

When the Enabled attribute is set to 'true', the CCAP MUST reject a configuration request where both ConnectionInitiationPolicy bits are set to zero. This attribute requires at least one of the bits to be enabled when the Enabled attribute is 'true'.

6.5.9.8.3.3 DocIdFormat

This attribute configures the IPDR document docId format in use by the IPDR Exporter.

'uuidCableLabs' – The IPDR Exporter will construct IPDR documents using the original CableLabs defined UUID.

'uuidVersion1Rfc4122' – The IPDR Exporter will construct IPDR documents using the Version 1 UUID variant as defined in [RFC 4122].

Refer to the Service Definition Instance Documents section for the definition of each format.

6.5.9.8.4 StreamingSession

The StreamingSession object is used to configure global IPDR connection attributes. A typical use case is for a single Template to be associated with a StreamingSession.

This object supports the creation and deletion of multiple instances.

Table 294 - StreamingSession Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
SessionId	UnsignedShort	Yes (Key)		1		
AckTimeInterval	UnsignedByte	No	1..60	0..1	seconds	30
AckSequenceInterval	UnsignedShort	No	1..500	0..1	records	200
CollectionInterval	UnsignedInt	No	0..86400	0..1	seconds	
StreamingType	Enum	Yes	other(1), timeInterval(2), adHoc(3), event(4), timeEvent(5)	1		
Enabled	Boolean	No		0..1		True
SessionName	String	No	SIZE(0..255)	0..1		""
SessionDescription	String	No	SIZE(0..255)	0..1		""

Table 295 - StreamingSession Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Template	Directed composition to Template		1..*	
Collector	Directed association to Collector	0..*	0..*	CollectorId

6.5.9.8.4.1 SessionId

This attribute configures the ID for this session instance.

6.5.9.8.4.2 AckTimeInterval

This attribute configures the interval in seconds in which the CCAP IPDR exporter waits for an acknowledgment.

6.5.9.8.4.3 AckSequenceInterval

This attribute configures the maximum number of unacknowledged records that can be sent by the CCAP IPDR exporter before receiving an acknowledgement.

6.5.9.8.4.4 CollectionInterval

Where StreamingType is configured as 'timeInterval', this attribute configures the interval in seconds at which IPDR information is extracted from the CCAP management objects and transmitted to the IPDR Collector.

Where StreamingType is configured as 'timeEvent', this attribute identifies the interval at which the CCAP IPDR Exporter will close the IPDR session to allow IPDR session processing to occur. Records created by Service Definitions supporting timeEvent are sent when the event is generated.

This attribute is not applicable when the StreamingType is configured as 'other', 'adHoc' or 'event'.

6.5.9.8.4.5 StreamingType

This attribute configures the type of IPDR streaming used for the session. See the IPDR Service Definition Schemas in Section 8 for the streaming types supported by each Service Definition. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.9.8.4.6 Enabled

This attribute controls whether the IPDR Session is enabled or disabled.

6.5.9.8.4.7 SessionName

This attribute configures a human-readable ASCII name for the IPDR Session.

6.5.9.8.4.8 SessionDescription

This attribute configures a human-readable ASCII description for the IPDR Session.

6.5.9.8.5 Template

The Template object allows the configuration of an individual IPDR session for a given IPDR connection.

This object supports the creation and deletion of multiple instances.

Table 296 - Template Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
ServiceDefinitionType	Enum	Yes (Key)	other(1), cmtsCmServiceFlowType(2), cmtsCmRegStatusType(3), cmtsCmUsStatsType(4), cmtsDsUtilStatsType(5), cmtsUsUtilStatsType(6), cmtsTopologyType(7), cpeType(8), diagLogType(9), diagLogDetailType(10), diagLogEventType(11), samisType1(12), samisType2(13), spectrumMeasurementType(14) ipMulticastStatsType(15) cmtsCmDsOfdmProfileStatusType(16) cmtsCmDsOfdmStatusType(17) cmtsCmUsOfdmaProfileStatusType(18) cmtsCmUsOfdmaStatusType(19) dsOfdmProfileStatsType(20) usOfdmaProfileStatsType(21)	1		

Table 297 - Template Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmRegStatusTypeCfg	Directed composition to CmtsCmRegStatusTypeCfg		0..1	ServiceDefinitionType == cmtsCmRegStatusType

6.5.9.8.5.1 ServiceDefinitionType

This attribute configures the service type definition for this IPDR session. See the IPDR Service Definition Schemas in Section 8 for the definitions and schemas of the types defined in this enumeration. The value of other(1) is used when a vendor-extension has been implemented for this attribute.

6.5.9.8.6 CmtsCmRegStatusTypeCfg

The CmtsCmRegStatusTypeCfg object provides configuration of the DOCSIS CMTS CM Registration Status Service Definition. This object is only applicable when the Template::ServiceDefinitionType is cmtsCmRegStatusType(3).

This object supports the creation and deletion of a single instance.

Table 298 - CmtsCmRegStatusTypeCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
CmEventTriggers	EnumBits	No	cmEmStats(1), cmDsProfileIdList(2), cmUsProfileIucList(3), cmPartialSvcState(4)	0..1		"H
CmRegStateReportingValues	EnumBits	No	other(0), initialRanging(1), rangingAutoAdjComplete(2), startEae(3), startDhcpV4(4), startDhcpV6(5), dhcpV4Complete(6), dhcpV6Complete(7), startConfigFileDownload(8), configFileDownloadComplete(9), startRegistration(10), registrationComplete(11), operational(12), bpiInit(13), forwardingDisabled(14), rfMuteAll(15)	0..1		Vendor-specific

6.5.9.8.6.1 CmEventTriggers

This attribute configures which additional CM events trigger generation and reporting of DOCSIS CMTS CM Registration Status Service Definition (CMTS-CM-REG-STATUS-TYPE) records. Setting a bit for a specified CM event type will enable triggering and reporting of the CMTS-CM-REG-STATUS-TYPE record by the IPDR Exporter when the event is detected. The event triggers are defined as:

'cmEmStats' – Triggers IPDR record generation for changes in the CmtsCmEmStats object.

'cmDsProfileIdList' – Triggers IPDR record generation for changes in the DsProfileIdList attribute of the CmtsCmRegStatus object.

'cmUsProfileIucList' – Triggers IPDR record generation for changes in the UsProfileIucList attribute of the CmtsCmRegStatus object.

'cmPartialSvcState' – Triggers IPDR record generation for changes in the PartialSvcState attribute of the CmtsCmRegStatus object.

6.5.9.8.6.2 CmRegStateReportingValues

This attribute configures which CM registration state values, as defined in CmtsCmRegStatus::Value, will trigger the generation and reporting of DOCSIS CMTS CM Registration Status Service Definition (CMTS-CM-REG-STATUS-TYPE) records. Setting a bit for a specified CM registration state value will enable triggering and reporting of the CMTS-CM-REG-STATUS-TYPE record by the IPDR Exporter.

6.5.9.8.7 Collector

The Collector object allows the operator to configure an IPDR Collector. At least one Collector is required when the IpdrExporterCfg::Enabled attribute is set to 'true'.

This object supports the creation and deletion of multiple instances.

Table 299 - Collector Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Multiplicity	Units	Default Value
CollectorId	UnsignedByte	Yes (Key)		1		
CollectorAddress	Host	Yes		1		
CollectorName	String	No		0..1		""
CollectorPort	InetPortNum	No		0..1		4737
Priority	UnsignedByte	Yes		1		
KeepAliveInterval	UnsignedShort	No		0..1	seconds	20

6.5.9.8.7.1 CollectorId

This key attribute configures a unique identifier for this IPDR Collector instance.

6.5.9.8.7.2 CollectorAddress

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the IPDR Collector from which the CCAP will accept a connection.

The CCAP MUST support configuring an IP address for the IPDR Collector CollectorAddress attribute.

The CCAP SHOULD support configuring an FQDN for the IPDR Collector CollectorAddress attribute.

6.5.9.8.7.3 CollectorName

This attribute configures a name for the IPDR Collector.

6.5.9.8.7.4 CollectorPort

This attribute configures the port used by the IPDR Collector to communicate with the CCAP. The default for this is 4737.

6.5.9.8.7.5 Priority

This attribute configures the priority of this IPDR Collector. The priority is used to elect the primary and active IPDR Collector. The IPDR Collector with the lowest priority is elected.

6.5.9.8.7.6 KeepAliveInterval

This attribute configures the CCAP IPDR Exporter's keep alive interval. This interval is the time in seconds at which IPDR "KEEP ALIVE" messages are sent from the CCAP IPDR Exporter to the IPDR Collector during periods of inactivity.

6.5.10 CCAP EPON Configuration Information Model

For DOCSIS EPON provisioning and management, the CCAP MUST meet the requirements in [DPoE OSSIv1.0]. The EPON configuration objects are shown in the following diagram.

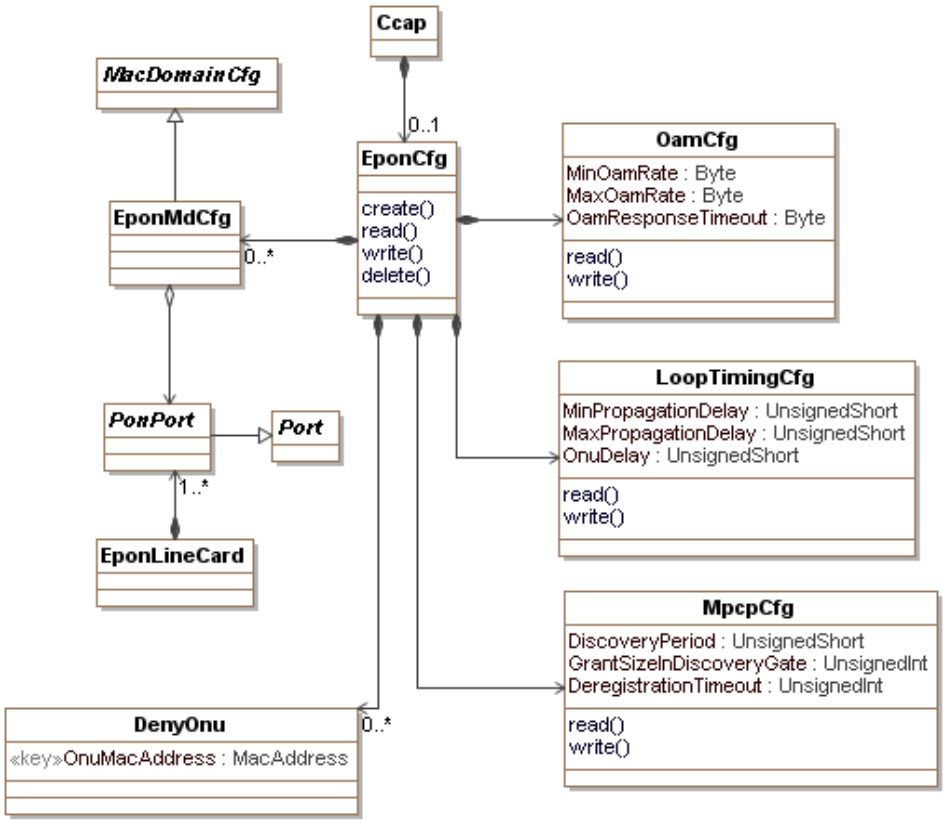


Figure 44 - EPON Configuration Information Model

6.5.10.1 Ccap

This configuration object is included in Figure 44 for reference. It is defined in Section 6.5.3.1.

6.5.10.2 EponCfg

The EponCfg object is the primary container of EPON configuration objects. It has the following associations:

Table 300 - EponCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EponMdCfg	Directed composition to EponMdCfg		0..*	
OamCfg	Directed composition to OamCfg			
LoopTimingCfg	Directed composition to LoopTimingCfg			
MpcpCfg	Directed composition to MpcpCfg			
DenyOnu	Directed composition to DenyOnu		0..*	

6.5.10.3 OamCfg

This configuration object is taken from [DPoE OSSIv1.0] and is used without modification for CCAP. This object controls the rate at which OAM messages are sent on the EPON interface.

Reference: [DPoE OSSIv1.0], EPON OAM Configuration section

6.5.10.4 LoopTimingCfg

This configuration object is taken from [DPoE OSSIv1.0] and is used with the following modifications for CCAP: the OltUpDownDelayOffset and NullGrantSize attributes have been removed.

This object configures the loop timing for EPON interfaces.

Reference: [DPoE OSSIv1.0], Loop Timing section

6.5.10.5 MpcpCfg

This configuration object is taken from [DPoE OSSIv1.0] and is used without modification for CCAP. It configures the Multi-Point Control Protocol for EPON interfaces.

Reference: [DPoE OSSIv1.0], MPCP Configuration section

6.5.10.6 EponMdCfg

This object defines a specialization of the MacDomain object for EPON interfaces.

Table 301 - EponMdCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
MacDomainConfig	Specialization of MacDomainCfg			
PonPort	Directed aggregation to PonPort			

6.5.10.7 DenyOnu

This configuration object allows an operator to create a list of ONU MAC addresses that are not allowed to register.

Table 302 - DenyOnu Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
OnuMacAddress	MacAddress	Yes (Key)			

6.5.10.7.1 OnuMacAddress

The MAC address of the ONU that will be added to the deny list. This attribute is used as a key.

6.5.10.8 MacDomainCfg

This configuration object is included in Figure 44 for reference. It is defined in Section 6.5.6.6.6.

6.5.10.9 PonPort

This configuration object is included in Figure 44 for reference. It is defined in Section 6.5.4.21.

6.5.10.10 Port

This configuration object is included in Figure 44 for reference. It is defined in Section 6.5.4.10.

6.5.10.11 EponLineCard

This configuration object is included in Figure 44 for reference. It is defined in Section 6.5.4.7.

6.5.11 Streaming Telemetry Configuration Information Model

This section defines the Information Models for DOCSIS CCAP Streaming Telemetry Configuration use cases.

6.5.11.1 Streaming Telemetry Configuration Data Type Definitions

This section defines any required data type definitions used in the Streaming Telemetry Configuration Information Model.

Table 303 - Streaming Telemetry Data Types

Data Type Name	Base Type	Permitted Values	Reference
DialDirectionType	Enum	dialOut(1), dialIn(2)	TelemetryAuthClientListCfg::DialDirection TelemetryClientConnectionStatus::DialDirection

6.5.11.1.1 DialDirectionType

This data type identifies the method by which a TCP session is established between a Telemetry Server and a Telemetry Client. Allowed values are listed and defined below:

- dialOut: The Telemetry Server originates the TCP session to a TCP server socket on the Telemetry Client
- dialIn: The Telemetry Client originates the TCP session to a TCP server socket on the Telemetry Server

6.5.11.2 Streaming Telemetry Configuration Class Diagram

Figure 45 - Streaming Telemetry Configuration Information Model defines objects for the configuration of the Streaming Telemetry Server and Streaming Telemetry Client.

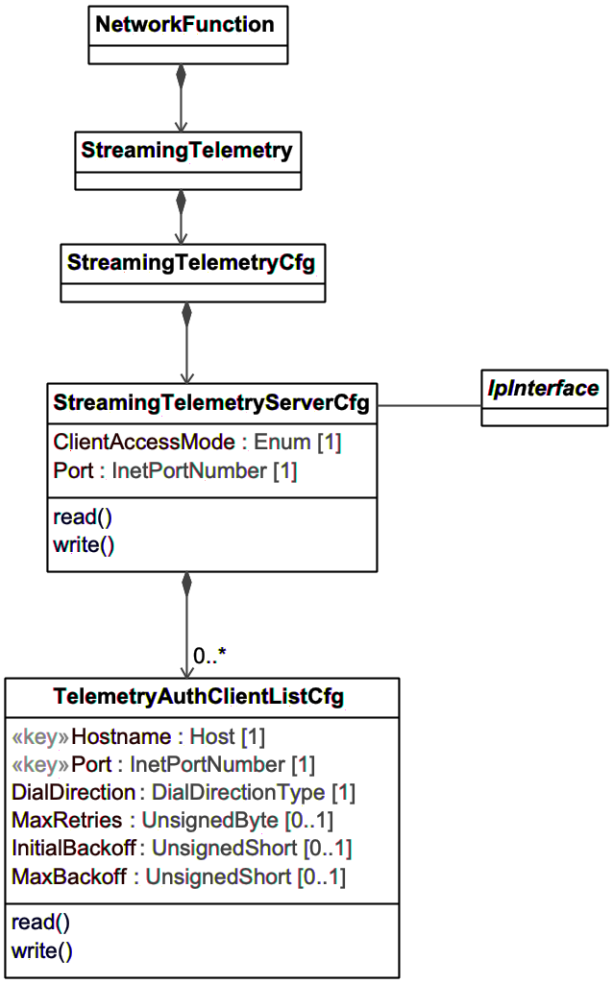


Figure 45 - Streaming Telemetry Configuration Information Model

6.5.11.3 NetworkFunction

The NetworkFunction object is the root of StreamingTelemetry objects and is included in Figure 45 for reference.

6.5.11.4 StreamingTelemetry

This object is the root of StreamingTelemetry objects.

Table 304 - StreamingTelemetry Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
StreamingTelemetryCfg	Directed composition to StreamingTelemetryCfg	1	0..1	

6.5.11.5 StreamingTelemetryCfg

This object provides the management interface for configuration of the CCAP Streaming Telemetry functionality.

Table 305 - StreamingTelemetryCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
StreamingTelemetryServerCfg	Directed composition to StreamingTelemetryServerCfg	1	0..1	

6.5.11.6 StreamingTelemetryServerCfg

This object is used by the CCAP to configure the Telemetry Server.

Table 306 - StreamingTelemetryServerCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ClientAccessMode	Enum	Yes	dialInDisabled(0), unrestricted(1), explicitlyAuthorizedOnly(2)		dialIndisabled
Port	InetPortNumber	Yes			

Table 307 - StreamingTelemetryServerCfg Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TelemetryAuthClientListCfg	Directed composition to TelemetryAuthClientListCfg	1	0..*	
IpInterface	Association with an IpInterface	1	1	

6.5.11.6.1 ClientAccessMode

This attribute allows the CCAP to control Telemetry Client access. It permits the CCAP to disable Telemetry Client access, enable access from any Telemetry Client, or restrict access to those Telemetry Clients whose IP addresses and TCP ports are configured by the TelemetryClientDialInAccessListCfg and the TelemetryClientDialOutAccessListCfg objects. The following values are defined for the Mode attribute:

- 'dialInDisabled': No Telemetry Client can dial in to the Telemetry Server.
- 'explicitlyAuthorizedOnly': The Telemetry Server allows access from only those Telemetry Clients whose IP addresses and TCP ports are configured with the TelemetryClientDialInAccessListCfg and TelemetryClientDialOutAccessListCfg objects.
- 'unrestricted: Any Telemetry Client can dial in into the Telemetry Server.

When ClientAccessMode has the value 'dialInDisabled', the CCAP MUST reject any dial-in attempt from a Telemetry Client.

When ClientAccessMode has the value 'explicitlyAuthorizedOnly', the CCAP MUST allow access only from those Telemetry Clients whose IP address and TCP port are present in the TelemetryAuthClientListCfg object.

When ClientAccessMode has the value 'explicitlyAuthorizedOnly', the CCAP MUST reject dial-in access from Telemetry Clients whose IP address and TCP port are not present in the TelemetryAuthClientListCfg object.

When the CCAP rejects a dial-in attempt from a Telemetry Client, the CCAP MUST log and event with EventId 89020001.

When ClientAccessMode has the value 'unrestricted', the CCAP MUST allow any Telemetry Client to dial-in to the CCAP using the well-known gRPC port number of 443. When ClientAccessMode has the value 'unrestricted', the CCAP is not required to listen for incoming connections on TCP ports other than port number 443.

6.5.11.6.2 Port

This attribute configures the TCP port number on the Telemetry Server that will be used for the connection with the Telemetry Client.

6.5.11.7 TelemetryAuthClientListCfg

This object is used to configure the list of Telemetry Clients that are authorized to access the Telemetry Server.

When its Telemetry Server function is attempting to establish a Dial Out connection with a Telemetry Client and is not successful on its initial attempt, the CCAP MUST follow the exponential reconnection backoff process as described below:

- Wait before subsequent reconnection attempts $2^{(n-1)} + r$ seconds, where n is the retry number and r is a uniformly randomized number in the range [-1.00 second ..+1.00 second] with a vendor specific sub-second granularity.
- If the next calculated backoff wait time would exceed the configured value for the maximum backoff time interval (MaxBackoff attribute), wait the maximum backoff time interval for all subsequent reconnection attempts.
- Continue the exponential reconnection backoff process until the connection retry is successful or until the number of connection retries has reached the configured maximum number of retry attempts (MaxRetries attribute).
- If the number of connection retries has reached the configured maximum number of retries and the connection retry is unsuccessful, stop attempting to establish the connection and log event ID 89020011.

The following example illustrates the backoff sequence (all times in second(s)):

Configured maximum backoff wait time (MaxBackoff): 300 seconds

Configured maximum number of retries (MaxRetries): 12

Table 308 - Exponential Reconnection Backoff Sequence

Retry Number (n)	**Pre-randomization Wait Time ($2^{(n-1)}$)**	**Randomization Value (*r*)** (Example)	**Next Backoff Wait Time** ($2^{(n-1)} + r$)
1	1	.46	1.46
2	2	.74	2.74
3	4	-.29	3.71
4	8	.11	8.11
5	16	.58	16.58
6	32	-.36	31.64
7	64	-.42	63.58
8	128	1.00	129
9	256	-.93	255.07
10	512	N/A	300
11	1024	N/A	300
12	2048	N/A	300

The CCAP MUST terminate a connection between the Telemetry Server and the Telemetry Client when the corresponding entry is deleted from TelemetryAuthClientListCfg.

Table 309 - TelemetryAuthClientListCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
HostName	Host	Yes (Key)			
Port	UnsignedShort	Yes (Key)			
DialDirection	DialDirectionType	Yes			
MaxRetries	UnsignedByte	No			255
InitialBackoff	UnsignedShort	No	1..300	seconds	1
MaxBackoff	UnsignedShort	No	1..3600	seconds	300

6.5.11.7.1 HostName

This key attribute contains the IP address or a fully qualified domain name (FQDN) assigned to a Telemetry Client explicitly authorized to dial in to, configure subscriptions on, and receive Streaming Telemetry data from the Telemetry Server.

The CCAP MUST support configuring an IP address for the TelemetryAuthClientListCfg HostName attribute.

The CCAP SHOULD support configuring an FQDN for the TelemetryAuthClientListCfg HostName attribute.

The CCAP SHOULD support Fully Qualified Domain Name for Dial Out connections that are resolved at the time of the dial-out attempt, including retries.

6.5.11.7.2 Port

This key attribute configures the destination TCP port on which the Telemetry Server will accept a dial-in connection.

6.5.11.7.3 DialDirection

This attribute configures the method by which a TCP session is established between the Telemetry Server and the Telemetry Client.

If the DialDirection is 'dialOut', the CCAP MUST dial-out to initiate connections to Telemetry Clients configured in TelemetryAuthClientListCfg.

6.5.11.7.4 MaxRetries

When the value of DialDirection is dialOut, this attribute configures the number of times the Telemetry Server attempts to restore a failed dial-out connection. Value 0 indicates no retries (do not retry). Value 255 indicates retry forever. The default value is 255.

When the value of DialDirection is dialIn, this attribute has no meaning and can be ignored.

The CCAP MUST generate event ID 89020011 with P1 = "first " when the value of TelemetryAuthClientListCfg::DialDirection is dialOut and The Telemetry Server is unsuccessful establishing a Dial Out connection with the Telemetry Client on the first attempt.

The CCAP MUST generate event ID 89020011 with P1 = "MaxRetries. Telemetry Server has stopped attempting to connect with Client." when the value of TelemetryAuthClientListCfg::DialDirection is dialOut and the Telemetry Server is unsuccessful restoring a failed dial-out connection after attempting the number of times equal to the value of MaxRetries.

6.5.11.7.5 InitialBackoff

When the value of DialDirection is dialOut, this attribute configures the length in seconds of the interval for which the Telemetry Server waits before the first reconnection attempt. The default value is 1 second.

When the value of DialDirection is dialIn, this attribute has no meaning and can be ignored.

The Telemetry Server rejects the configuration if the value of MaxBackoff is less than the value of InitialBackoff.

6.5.11.7.6 MaxBackoff

When the value of DialDirection is dialOut, this attribute configures the maximum length in seconds of the interval for which the Telemetry Server waits between reconnection attempts when performing the exponential backoff process. The default value is 300 seconds. The Telemetry Server rejects the configuration if the value of MaxBackoff is less than the value of InitialBackoff.

When the value of DialDirection is dialIn, this attribute has no meaning and can be ignored.

6.5.11.8 IpInterface

This configuration object is included in Figure 45 for reference. It is defined in Section 6.5.8.5.

6.6 Status Monitoring and Control Requirements

6.6.1 Status Monitoring and Control Information Models

This section defines the information models for the utilization of CCAP status and control management functions. These objects are typically not used during installation when the CCAP is brought on-line and into service. Status and control management objects are used at run time to obtain status information or command actionable control. Examples of control functions include clearing an event log or starting a packet capture on a specific MAC Domain. Examples of status functions include checking the operational state of an interface or the results of a diagnostics test. In general, configuration of these control objects would not be included in the startup-config for initial CCAP device configuration.

6.6.1.1 Fault Management Control Information Model

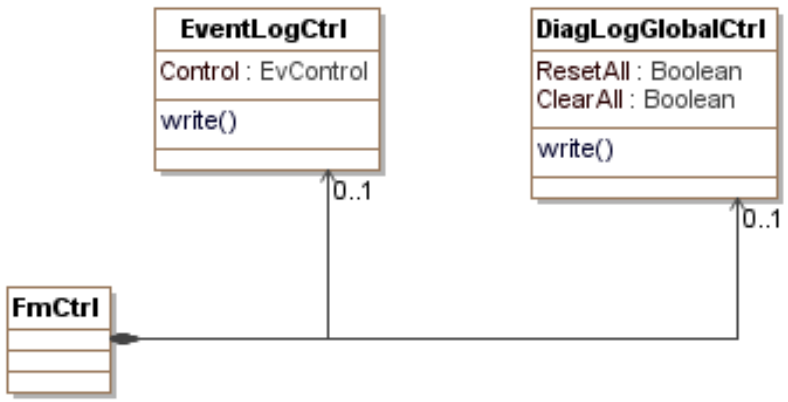


Figure 46 - Fault Management Control Information Model

6.6.1.1.1 FmCtrl

The FmCtrl object is the primary container of Fault Management Control objects. It has the following associations:

Table 310 - FmCtrl Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
EventLogCtrl	Directed composition to EventLogCtrl		0..1	
DiagLogGlobalCtrl	Directed composition to DiagLogGlobalCtrl		0..1	

6.6.1.1.1.1 EventLogCtrl

This control object is based on the docsDevEvent group defined in [RFC 4639] and contains a single actionable configuration attribute: Control. This object is used to clear the event log or to return all event priorities to their default settings.

Reference: [RFC 4639], docsDevEvControl object

6.6.1.1.1.2 DiagLogGlobalCtrl

This control object is based on the LogGlobal object defined in Annex G, Diagnostic Log (Normative) and contains the following actionable configuration attributes:

- ResetAll
- ClearAll

This object allows Log and LogDetail instances to be reset or cleared.

Reference: Annex G.2.2, LogGlobal Object

6.6.1.2 Performance Management Control and Monitoring Information Model

The objects in the Performance Management Control class diagram are taken from the following DOCSIS MIBs and are used without modification for the CCAP:

Object	MIB
CmtsSpectrumAnalysisMeas	DOCS-IF3-MIB
CmtsSignalQualityExt	DOCS-IF3-MIB
CmtsCmCtrlCmd	DOCS-IF3-MIB
CmtsDebugDsid	DOCS-QOS3-MIB
ChgOverGroup	DOCS-LOADBAL3-MIB

Reference: [OSSIv3.0], [DOCS-IF3-MIB], [DOCS-QOS3-MIB], [DOCS-LOADBAL3-MIB]

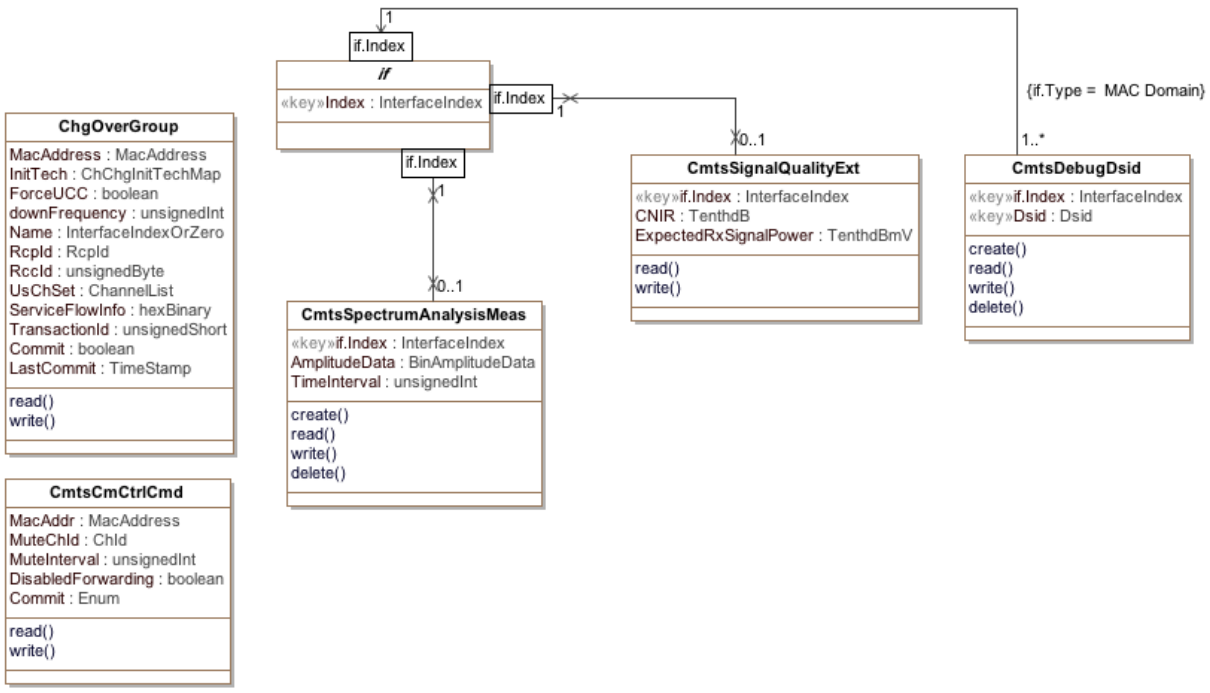


Figure 47 - Performance Management Control and Monitoring Information Model

6.6.1.2.1 CmtsSignalQualityExt

This object provides metrics and parameters associated with received carrier, noise and interference power levels in the upstream channels of the CMTS.

Table 311 - CmtsSignalQualityExt Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of logical upstream channel		
CNIR	TenthdB	read-only		dB	
ExpectedRxSignalPower	TenthdBmV	read-only		dBmV	

6.6.1.2.1.1 IfIndex

This key represents the interface index of the logical upstream of the CMTS to which this instance applies.

6.6.1.2.1.2 CNIR

This attribute provides an upstream in-channel Carrier-to-Noise plus Interference Ratio (CNIR). CNIR is defined as the ratio of the expected commanded received signal power at the CMTS input, assuming QPSK0 modulation, to the noise plus interference in the channel. This measurement occurs prior to the point at which the desired CM signal, when present, is demodulated. The measurement includes the effect of the receive matched filter but does not include the effect of any ingress filtering. Both the signal power and noise/interference power are referenced to the same point, e.g., CMTS input.

6.6.1.2.1.3 ExpectedRxSignalPower

This attribute provides the power of the expected commanded received signal in the channel, referenced to the CMTS input.

6.6.1.2.2 CmtsSpectrumAnalysisMeas

The CmtsSpectrumAnalysisMeas object was defined in previous versions of the DOCSIS OSSI specification to indicate how much desired signal, noise and interference energy exists within the channel by reporting frequency content information of energy within the channel. The CmtsSpectrumAnalysisMeas object includes interface index, amplitude of noise and a time interval indicator. The CmtsSpectrumAnalysisMeas object is deprecated and replaced with the Upstream Triggered Spectrum Capture objects defined in Section 7.3.5.6.

6.6.1.2.3 CmtsCmCtrlCmd

The CMTS CM Control Command object allows an operator to trigger the CMTS to send a CM-CTRL-REQ message to the specified CM with specific parameters.

The CMTS is not required to persist the values of the attributes of the CmtsCmCtrlCmd object across reinitializations.

References: [MULPIv4.0] Media Access Control Specification section.

Table 312 - CmtsCmCtrlCmd Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
MacAddr	MacAddress	read-write			'000000000000'H
MuteUsChId	ChId	read-write			0
MuteInterval	UnsignedInt	read-write		milliseconds	0
DisableForwarding	Boolean	read-write			false
Commit	Enum	read-write	mute(1) cmReinit(2) disableForwarding(3)		'mute'

6.6.1.2.3.1 MacAddr

This attribute represents the MAC Address of the CM which the CMTS is instructed to send the CM-CTRL-REQ message.

6.6.1.2.3.2 MuteUsChId

This attribute represents the Upstream Channel ID (UCID) to mute or unmute. A value of zero indicates all upstream channels. This attribute is only applicable when the Commit attribute is set to 'mute'.

6.6.1.2.3.3 MuteInterval

This attribute represents the length of time that the mute operation is in effect. This attribute is only applicable when the Commit attribute is set to 'mute'. A value of 0 is an indication to unmute the channel referenced by the MuteUsChId attribute while a value of 0xFFFFFFFF is used to mute the channel referenced by the MuteUsChId attribute indefinitely.

6.6.1.2.3.4 DisableForwarding

When set to 'true', this attribute disables data forwarding to the CMCI ports when the Commit attribute is set to 'disableForwarding'. When set to 'false', this attribute enables data forwarding to the CMCI ports when the Commit attribute is set to 'disableForwarding'. This attribute is only applicable when the Commit attribute is set to 'disableForwarding'.

6.6.1.2.3.5 Commit

This attribute indicates the type of command for the CMTS to trigger in the CM-CTRL-REQ message. This attribute will return the value of the last operation performed or the default if no operation has been performed.

6.6.1.2.4 ChgOverGroup

This object represents the Externally-Directed Load Balancing command interface. This object provides the controls of change-over operations for CMs. A change-over operation consists of externally-initiated requests to change the CM downstream and/or upstream channel configuration using DOCSIS MAC Message mechanism such as UCC, DCC, DBC or combinations of them. Committed change-over operations are reported in the ChgOverStatus object.

Table 313 - ChgOverGroup Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
MacAddress	MacAddress	read-write	Mandatory		'000000000000'H
InitTech	ChChgInitTechMap	read-write			'F8'H
ForceUCC	Boolean	read-write			false
DownFrequency	UnsignedInt	read-write		Hertz	0
MdIfIndex	InterfaceIndexOrZero	read-write			0
RcpId	RcpId	read-write			'0000000000'H
RccId	UnsignedByte	read-write			0
UsChSet	ChannelList	read-write			''H
ServiceFlowInfo	HexBinary	read-write	SIZE (0..128)		''H
TransactionId	UnsignedShort	read-write			0
Commit	Boolean	read-write			'false'
LastCommit	TimeStamp	read-only			0

6.6.1.2.4.1 MacAddress

This attribute represents the MAC address of the cable modem that the CMTS instructs to move to a new downstream and/or upstream channel set.

6.6.1.2.4.2 InitTech

This attribute represents the initialization technique that the cable modem is instructed to use when performing multiple-channel change-over operation. The value of this attribute applies to all upstream channels in the channel set.

6.6.1.2.4.3 ForceUCC

This attribute when set to 'true' indicates that the CMTS forces UCC messages instead of DCC messages in those scenarios that are allowed as defined in the "Upstream Channel Change Request (UCC-REQ)" section of [MULPIv4.0]. In some cases the CMTS may still use UCC commands even though this attribute value is 'false', for example in an upstream-only change-over operation directed to a CM that the CMTS is aware is only capable of UCC, but the operator is not aware of the CM capabilities. This attribute value is ignored when the target CM for the change-over operation is in MRC mode, or the UsChSet attribute is the zero-length string, or the operation includes changes for downstream channels.

6.6.1.2.4.4 DownFrequency

This attribute represents a single-downstream frequency to which the cable modem is instructed to move using a DCC request. The value zero indicates that this attribute is ignored during a commit operation.

6.6.1.2.4.5 MdIfIndex

This attribute describes the MAC Domain Interface index of the triplet: Mac Domain, RCP-ID and RCC Status Index of the RccStatus object that represents the RCC used in the change-over operation. This MAC Domain Interface Index is also used to provide context for the UsChSet and ServiceFlowInfo attributes.

6.6.1.2.4.6 RcpId

This attribute describes the RCP-ID of the triplet: Mac Domain, RCP-ID and RCC Status Index of the RccStatus object that represents the RCC used in the change-over operation. If the RCP-ID is unknown or the CM is in DOCSIS 4.0 mode, the CMTS returns a five-octet long string of zeros.

6.6.1.2.4.7 RccId

This attribute describes the RCC Status Index of the triplet: Mac Domain, RCP-ID and RCC Status Index of the RccStatus object that represents the RCC used in the change-over operation. If the RCC-ID is unknown or the CM is in DOCSIS 4.0 mode, the CMTS returns a value of zero.

6.6.1.2.4.8 UsChSet

This attribute describes the Channel list (within the context of the MAC domain identified by MdIfIndex) that represents the final TCS expected from the change-over operation.

When the operation is intended for an RCC-only, this attribute is set to zero and the attribute InitTech is ignored.

6.6.1.2.4.9 ServiceFlowInfo

This attribute provides a list of Service Flow ID-Channel Set ID pairs used to control Service Flow assignment in the change-over operation. This is intended as an override to the normal assignment based on SF attributes. This attribute is encoded as a series of 32-bit pairs as follows:

- The first four bytes correspond to the value of the Service Flow ID (attribute Id of the ServiceFlow object of the DOCSIS QoS objects.
- The last four bytes correspond to the value of the attribute ChSetId of the UsChSet or DsChSet object of the CMTS Bonding Objects.

If this attribute does not include tuples for some of the CM's Service Flows, the CMTS determines the respective channels based on SF attributes. Service Flow ID-Channel Set ID pairs matching upstream service flows are ignored if the change-over operation does not affect the TCC of the CM. Similarly, Service Flow ID-Channel Set ID pairs matching downstream service flows are ignored if the change-over operation does not affect the RCC of the CM.

6.6.1.2.4.10 TransactionId

This attribute represents an operator identifier for the change-over operation to be used to correlate logged information in the ChangeOver3 Status object. The CMTS uses this value as the Transaction ID in the DBC-REQ or DCC-REQ message transmitted in association with this operation. If this value is set to zero the CMTS defines its own MAC message Transaction ID value.

6.6.1.2.4.11 Commit

This attribute when set to 'true' triggers the change-over operation for Externally-Directed Load Balancing.

Setting this attribute to 'true' is known as a commit operation. A commit operation is considered successful if the CMTS considers that the entered information is valid, and the transaction can be initiated. It does not imply that the channel-change operation itself (i.e., UCC, DCC, DBC transaction) reports success or completion. A commit operation is considered unsuccessful if the CMTS determines that there are invalid attributes values in the ChangeOver object such that the change-over operation cannot be initiated.

Some examples for a change-over that cannot be initiated are:

- Attempt to send a DBC for MRC that does not fit the CM RCP.
- Attempt to send a DCC while a previous one is still in progress.
- Attempt to send a UCC to a channel ID that is not defined.

After system initialization all ChangeOver object parameters are set to default values.

After a successful commit operation all ChangeOver object parameters are set to default values with the exception of this attribute (commit) that is set to 'true'. An unsuccessful commit operation is rejected and this attribute reports false in subsequent value queries.

After a successful commit operation, the CMTS initiates the change-over transaction using the most appropriate technique. The potential techniques are:

- UCC - For upstream-channel-only changes on CMs not operating in MRC mode.
- DCC - For upstream and/or downstream channel changes on CMs not operating in MRC mode, as well as upstream only change for CMs operating in MRC mode but with no TCS conveyed during registration.
- DCC followed by channel assignment in REG-RSP-MP - For MAC Domain re-assignment on CMs operating in MRC mode. In this case, the change-over command might only include a downstream frequency or might include an RCC defined in the target MAC domain. The upstream channel set may or may not be provided. The only applicable Initialization Technique for this operation is 'reinitializeMAC'.
- DBC - For change in the TCS and/or RCS on CMs operating in MRC mode.

6.6.1.2.4.12 LastCommit

The value of sysUpTime when the attribute Commit was last set to true. Zero if never set.

6.6.1.2.5 CmtsDebugDsid

The CMTS Debug DSID object contains the control of DSID debug statistics reporting.

An instance in this object defines the DSID and MAC domain to which the CmtsDebugDsidStats collects statistics for the downstream channel associated with that DSID and MAC Domain. The deletion of an instance stops the reporting of statistics for the specified DSID.

This object supports instance creation and deletion.

The CMTS MUST support at least one instance of the CmtsDebugDsid object. Creation of a new instance of this object requires a valid MAC Domain and a current DSID value.

The CMTS MUST NOT persist instances created in the CmtsDebugDsid object across system reinitializations.

Table 314 - CmtsDebugDsid Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key			
Dsid	Dsid	key			

6.6.1.2.5.1 IfIndex

This attribute represents the interface index of the MAC Domain to which an instance of this object applies.

6.6.1.2.5.2 Dsid

This attribute represents the DSID value to be debugged, identified by the IfIndex attribute of this object.

6.6.1.3 IETF Status Monitoring and Control Objects

The objects in the IETF Status Monitoring and Control class diagram are taken from the following IETF MIBs and are used without modification for the CCAP:

Object	MIB
routerInterface	MGMD-MIB
routerCache	MGMD-MIB

6.6.1.3.1 Application of IETF Multicast MIB (MGMD-MIB)

DOCSIS 4.0 defines three methods for forwarding multicast traffic [MULPIv4.0]. The first method is referred to as DSID-based Multicast Forwarding. In this mode, the CCAP, not the CM, controls the forwarding of multicast traffic to CPE devices behind the CM. The second method is called GMAC Explicit Multicast Forwarding. In this mode, a DSID is used for filtering downstream packets and for some forwarding of multicast, but the CCAP also includes a GMAC address for the IP Multicast Group to allow the CM to utilize some hardware forwarding assistance. When the CM is operating in GMAC Explicit forwarding mode, the CM plays a completely passive role in the IGMP or MGMD framework and passes all membership traffic and related messages to the CCAP. The final forwarding mode is MDF Disabled. In this mode, the CM acts as it did in DOCSIS 2.0 and snoops the IGMP membership and related messages.

A CCAP that supports MGMD supports the MGMD-STD-MIB [RFC 5519]. As such, this section describes the application of the IETF [RFC 5519] to MGMD devices. The tables in the MGMD-STD- MIB [RFC 5519] have been condensed to two tables, with additional MIB objects added to match the IGMP-STD-MIB defined in [RFC 2933] The MGMD MIB will also include information about MLD (Multicast Listener Discovery) from [RFC 3019] to support IPv6.

The MGMD-STD-MIB [RFC 5519] is organized into two distinct tables: the interface and cache tables. The MGMD Interface Table contains entries for each interface that supports MGMD on a device. This includes the NSI and HFC interfaces for the CCAP. The MGMD Cache Table contains one row for each IP Multicast Group for which there are active members on a given interface. If the CCAP is implemented as a Multicast router, active multicast group membership MAY exist on both the NSI and HFC interfaces.

Support of the MGMD-STD-MIB [RFC 5519] is presented in terms of MGMD capabilities supported by the CCAP.

The CCAP MUST support the mgmdRouterInterfaceTable, mgmdRouterCacheTable, mgmdInverseRouterCacheTable and the mgmdRouterSrcListTable from the MGMD-STD-MIB [RFC 5519] within each MAC Domain where IP multicast is forwarded.

The CCAP MAY support the mgmdRouterInterfaceTable and the mgmdRouterCacheTable read-write objects as writeable (configurable via SNMP management interface).

6.6.1.4 Bulk Data Transfer Status Monitoring and Control Objects

Proactive Network Maintenance, and potentially other applications, may generate data files that need to be transferred to a server. The Bulk Data Transfer mechanism defines file storage requirements, destination address, and a mechanism to initiate a transfer. The transfer of the bulk data file may be initiated automatically on file creation or on demand. This section defines the Bulk Data Transfer capability monitoring and control requirements.

6.6.1.4.1 CCAP Bulk Data Transfer Requirements

The CCAP MUST act as a TFTP client and implement the TFTP protocol over UDP per [RFC 1350] to transfer Bulk-Data files.

The CCAP MUST initiate the TFTP connection on the standard TFTP-assigned port (69).

The CCAP MUST use the 'octet' TFTP transfer mode to perform a TFTP 'write' to the specified address.

The CCAP MUST include the TFTP Blocksize option [RFC 2348] when establishing a TFTP connection.

The CCAP MUST request a blocksize of 1448 if using TFTP over IPv4. The CCAP MUST request a blocksize of 1428 if using TFTP over IPv6.

6.6.1.4.2 Data File and Storage Requirements

The CCAP MUST retain Bulk Data files in the allocated memory unless it is commanded to delete the file, or the file is overwritten with a new file. The decision on which files to overwrite and when to overwrite is CCAP implementation-specific. The CCAP MAY retain the Bulk Data files across reboot or reset or power cycle.

6.6.1.4.3 Bulk Data Information Model (Legacy)

This section has been deprecated and has been replaced with the Bulk File Transfer Model.

This section defines objects that are used to manage the Bulk-Data files that the CCAP (referred to here as the "device") has been commanded to capture.

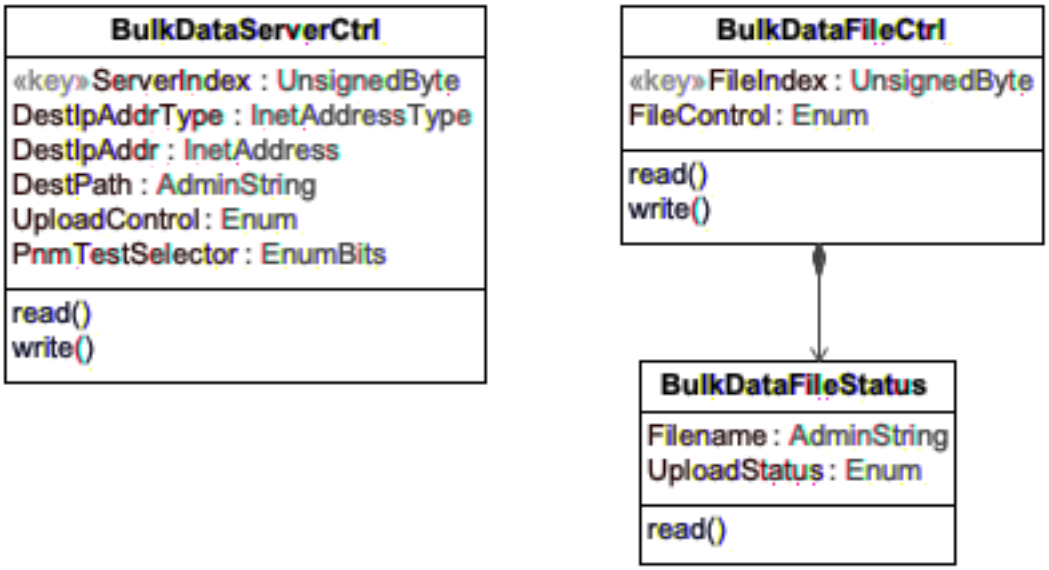


Figure 48 - Bulk Data Transfer Class Diagram

6.6.1.4.3.1 BulkDataServerCtrl

This section has been deprecated and has been replaced with the Bulk File Transfer Model.

This object provides the configuration attributes needed for the device to upload Bulk Data files to a Server.

Table 315 - BulkDataServerCtrl Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
ServerIndex	UnsignedByte	Key	1..10	N/A	
DestIpAddr	InetAddress ([RFC 4001])	R/W	N/A	N/A	"" (empty string)
DestIpAddrType	InetAddressType ([RFC 4001])	R/W	unknown(0) ipv4(1) ipv6(2)	N/A	unknown
DestPath	AdminString	R/W	N/A	N/A	"" (empty string)
UploadControl	Enum	R/W	other(1) noAutoUpload(2) autoUpload(3)	N/A	autoUpload

Attribute Name	Type	Access	Type Constraints	Units	Default
PnmTestSelector	EnumBits	R/W	other(0) dsOfdmSymbolCapture (1), dsOfdmNoisePowerRatio(2), cmtsUsOfdmaActiveAndQuietProbe(3), usImpulseNoise(4), usOfdmaRxMerPerSubcarrier(5), upstreamHistogram(6), usOfdmaRxPower(7), usTriggeredSpectrumCapture(8)	N/A	

6.6.1.4.3.1.1 ServerIndex

This attribute is the key for the table.

6.6.1.4.3.1.2 DestIpAddr

This attribute represents the IP address of the PNM server to which the bulk data file is to be sent. This attribute is further defined by the DestIpAddrType attribute.

6.6.1.4.3.1.3 DestIpAddrType

This attribute represents the IP address type of the DestIpAddr attribute. This value is of type InetAddressType which is defined by [RFC 4001].

A successful connection depends on the value of this attribute being set to an IP Family supported by the device. For example, if this value is set to IPv6 and the device is operating in IPv4-only mode, a successful upload will not be possible. In this case, the UploadStatus attribute in the BulkDataFile object would reflect the error.

6.6.1.4.3.1.4 DestPath

This attribute represents the path, excluding the filename, at the PNM server to which the bulk data file is to be sent. By default, the value of this object is an empty string. If used, this value includes all expected delimiters. The following examples, excluding the quotes, are valid values:

- "/Directory1/directory2/"
- "/pnm/"

6.6.1.4.3.1.5 UploadControl

This attribute controls the action taken by the device when a new bulk data file is generated. The possible values are defined below.

noAutoUpload - Bulk Data files are not automatically uploaded by the device. All bulk data files are available to be uploaded, on demand, by manipulating the FileControl attribute in the BulkDataFile object for that file's row instance.

autoUpload - When the autoUpload option is selected, the CCAP MUST automatically upload bulk data files as they become available. A file becomes available when a file-generation application completes the file and creates a row in the BulkDataFileTable. If this value is set, the bulk data file is automatically uploaded to the parameters defined by the DestIpAddr, DestIpAddrType, and DestPath. If the upload fails or additional uploads are desired, the file can be re-uploaded by manipulating the FileControl attribute in the BulkDataFile object for that file's row instance.

6.6.1.4.3.1.6 PnmTestSelector

This attribute permits to associate a group of PNM tests to the selected PNM server. The CCAP SHOULD reject configuration that associates more than one PNM server to the same PNM test.

6.6.1.4.3.2 BulkDataFileCtrl

This section has been deprecated and has been replaced with the Bulk File Transfer Model.

This object provides the attributes needed for the device to upload a data file to the Server. An instance is created for each file that is available, in the device, for upload. The parameters used for the upload are provided under the BulkDataServerCtrl object. The CCAP MUST create an instance of BulkDataFileCtrl for each file that is available for upload. The device could have limited resources to save captured data files. Therefore, if the number of files exceeds the minimum supported number of files requirements for the device, newly created instances can overwrite/replace existing instances as new data files become available. If a bulk data file is no longer available for upload, the CCAP MUST remove that file's instance from the BulkDataFileCtrl object.

Table 316 - BulkDataFileCtrl Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
FileIndex	UnsignedByte	Key	N/A	N/A	N/A
FileControl	Enum	R/W	other(1) tftpUpload(2) cancelUpload(3) deleteFile (4)	N/A	other

6.6.1.4.3.2.1 FileIndex

This attribute is the key for the table.

6.6.1.4.3.2.2 FileControl

This attribute controls the action taken by the device regarding the file specified by the Filename attribute. When a value is written to this attribute for a given instance, the device is required to take that action on the specified bulk data file. The possible actions are listed:

other(1) - This value is returned when the object is read. This value is not writeable.

tftpUpload(2) - The CCAP MUST initiate a TFTP-Write to the server with the parameters specified in the 'DestIpAddr', 'DestIpAddrType', and 'DestPath' attributes. This action will change the value of the UploadStatus attribute to 'uploadInProgress' while the transfer is ongoing. This object can only be set to 'tftpUpload' when the value of the 'UploadStatus' attribute is not set to a value of 'uploadInProgress' for this row OR for any row in the table. This limits the upload process to one upload at a time. This object will return 'inconsistentValue' for this case.

cancelUpload(3) - The CCAP MUST cancel a pending upload or an upload currently in progress on this bulk data file. The value of the UploadStatus attribute will be changed to 'uploadCancelled'.

deleteFile (4) - The CCAP MUST delete the file from its memory and from this table. This object cannot be set to deleteFile(4) while an upload is in progress.

6.6.1.4.3.3 BulkDataFileStatus

This section has been deprecated and has been replaced with the Bulk File Transfer Model.

This object provides the status attributes for each data file controlled via the BulkDataFileCtrl object.

Table 317 - BulkDataFileStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Filename	AdminString	R/O	N/A	N/A	N/A

Attribute Name	Type	Access	Type Constraints	Units	Default
UploadStatus	Enum	R/O	other(1) availableForUpload(2) uploadInProgress(3) uploadCompleted(4) uploadPending(5) uploadCancelled(6) error(7)		

6.6.1.4.3.3.1 Filename

This attribute contains the name of the bulk data file stored in the device, that is available to be uploaded to the server. Filenames are defined by the application that creates them.

6.6.1.4.3.3.2 UploadStatus

This attribute reflects the status of the bulk data file. The possible values are listed below.

- other(1) - Any condition not covered by the other defined values.
- availableForUpload(2) - The file is available to be uploaded.
- uploadInProgress(3) - The file is currently being uploaded.
- uploadCompleted(4) - The file was successfully uploaded.
- uploadPending(5) - The file has been selected for upload, but a condition does not allow the upload to take place. The upload will start when the condition blocking uploads has been removed. For example, another upload that is currently in progress could cause this value to be returned.
- uploadCancelled(6) - An upload was cancelled before it completed.
- error(7) - An error occurred and the file was not successfully uploaded.

6.6.1.4.4 Bulk File Transfer Information Model

This section defines the Information Models for the transfer of Telemetry data from a target device (such as a CCAP) to a back office collection system.

6.6.1.4.4.1 Bulk File Transfer Class Diagram

The following diagram defines the Telemetry Data Transfer classes.

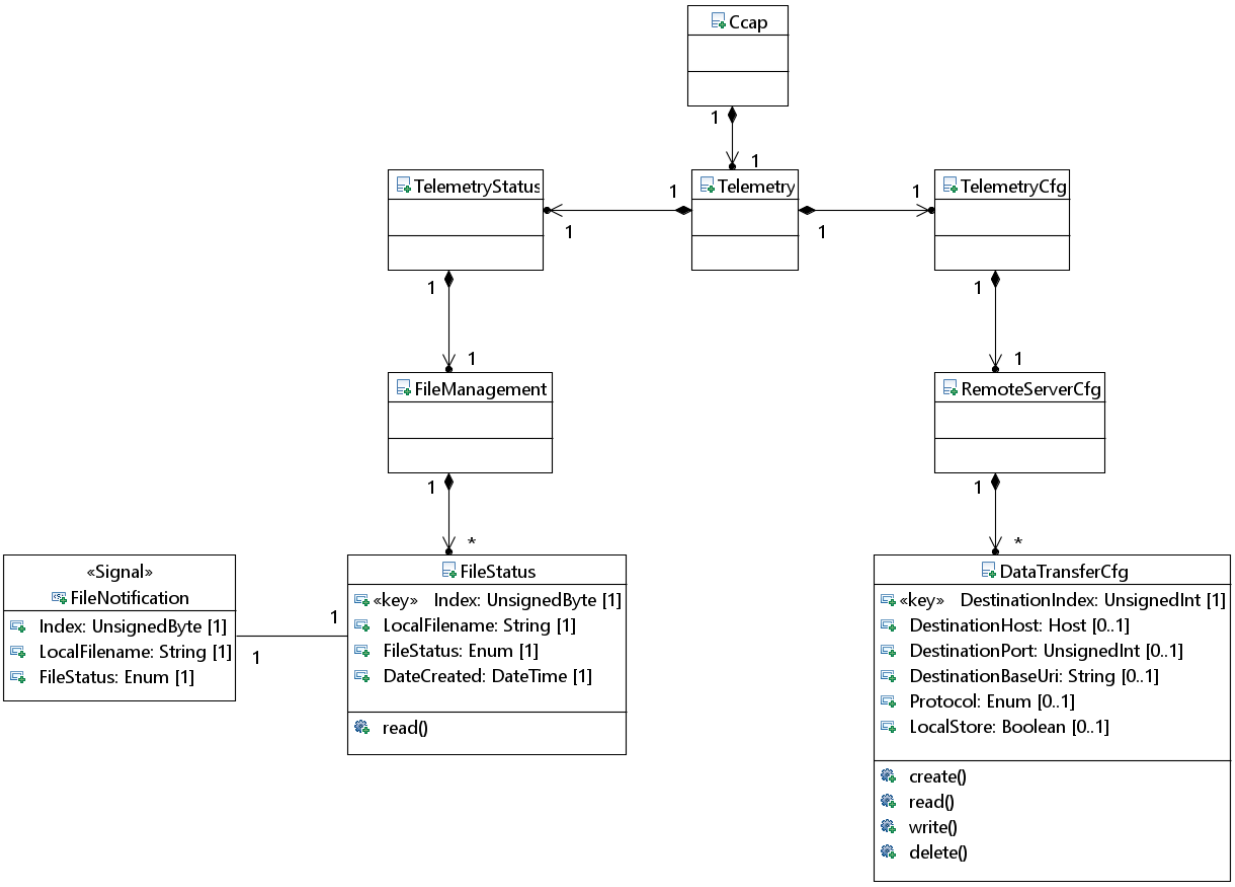


Figure 49 - Bulk File Transfer Class Diagram

6.6.1.4.4.1.1 Telemetry

The Telemetry class is the container for CCAP Telemetry information.

6.6.1.4.4.1.2 TelemetryCfg

The TelemetryCfg class is the container for CCAP Telemetry configuration information.

6.6.1.4.4.1.3 TelemetryStatus

The TelemetryStatus class is the container for CCAP Telemetry status information.

6.6.1.4.4.1.4 RemoteServerCfg

The RemoteServerCfg class is the container for remote server configuration information.

6.6.1.4.4.1.5 FileManagement

The FileManagement class is the container for file management information.

6.6.1.4.4.1.6 DataTransferCfg

The DataTransferCfg class defines the configuration of destinations for file-based Telemetry data, such as PNM test result measurements.

The CCAP MUST support creation and deletion of multiple instances of the DataTransferCfg object.

Support for HTTP and HTTPS is optional for DOCSIS 4.0 as specified in Section 6.2.6.

Table 318 - DataTransferCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
DestinationIndex	UnsignedInt	Yes (Key)	1.. 4294967295		
DestinationHost	Host	No			
DestinationPort	UnsignedInt	No			
DestinationBaseUri	String	No			
Protocol	Enum	No	tftp(1), http(2), https(3)		'tftp'
LocalStore	Boolean	No			'true'

6.6.1.4.4.1.6.1 DestinationIndex

This key attribute uniquely identifies a destination for PNM test result measurements.

6.6.1.4.4.1.6.2 DestinationHost

This attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the destination host for PNM test result measurements.

The CCAP MUST support configuring an IP address for the DataTransferCfg DestinationHost attribute.

The CCAP SHOULD support configuring an FQDN for the DataTransferCfg DestinationHost attribute.

6.6.1.4.4.1.6.3 DestinationPort

This attribute identifies a destination port number for PNM test result measurements. If the value of LocalStore is 'false', then DestinationHost, DestinationBaseUri, and Protocol are required attributes.

6.6.1.4.4.1.6.4 DestinationBaseUri

This attribute identifies a destination base Uniform Resource Identifier for PNM test result measurements. This attribute does not contain the actual filename. If the value of LocalStore is 'false', then DestinationHost, DestinationBaseUri, and Protocol are required attributes.

6.6.1.4.4.1.6.5 Protocol

This attribute identifies the data transfer protocol for the PNM test result measurements.

- tftp(1) indicates the device will use TFTP to transfer the test result measurements.
- http(2) indicates the device will use HTTP to transfer the test result measurements.
- https(3) indicates the device will use HTTPS to transfer the test result measurements.
- If HTTP or HTTPS is not supported, the CCAP MUST reject attempts to set the configuration for the attribute Protocol of the DataTransferCfg object to 'http' or 'https'.

6.6.1.4.4.1.6.6 LocalStore

This attribute identifies whether the device stores PNM test result measurements locally. If the value is set to 'true', the device will store the test result measurements locally on the device. If the value is set to 'false', the device will not store the test result measurements locally on the device, and will rely on the other attributes for where to send the measurements. If the value of LocalStore is 'false', then DestinationHost, DestinationBaseUri, and Protocol are required attributes.

6.6.1.4.4.1.7 FileStatus

The FileStatus class provides the status attributes for each Telemetry data file stored locally on the target device. An instance is created for each file that is available, in the target device, for upload. The CCAP MUST create an instance of FileStatus for each Telemetry data file that is available for upload. The device could have limited resources to save Telemetry data files. Therefore, if the number of files exceeds the minimum supported number of files requirements for the device, newly created instances can overwrite/replace existing instances as new data files become available. If a Telemetry data file is no longer available for upload, the CCAP MUST remove that file's instance from the FileStatus object.

Table 319 - FileStatus Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedByte	Yes (Key)		N/A	N/A
LocalFilename	String	Yes		N/A	
FileStatus	Enum	Yes	other(1), availableForUpload(2), uploadInProgress(3), uploadCompleted(4), uploadPending(5), uploadCancelled(6), error(7)		
DateCreated	DateTime	Yes			

6.6.1.4.4.1.7.1 Index

This key attribute is an index for the object

6.6.1.4.4.1.7.2 LocalFilename

This attribute contains the name of the Telemetry data file stored on the device, that is available to be uploaded to the File Server. Filenames are defined by the application that creates them.

6.6.1.4.4.1.7.3 FileStatus

This attribute reports the status of the Telemetry data file. The possible values are listed below.

- other(1) - Any condition not covered by the other defined values.
- availableForUpload(2) - The file is available to be uploaded.
- uploadInProgress(3) - The file is currently being uploaded.
- uploadCompleted(4) - The file was successfully uploaded.
- uploadPending(5) - The file has been selected for upload, but a condition does not allow the upload to take place. The upload will start when the condition blocking uploads has been removed. For example, another upload that is currently in progress could cause this value to be returned.
- uploadCancelled(6) - An upload was cancelled before it completed.
- error(7) - An error occurred and the file was not successfully uploaded.

6.6.1.4.4.1.7.4 DateCreated

This attribute reports the date and time of when the local file was created.

6.6.1.4.4.1.8 FileNotification

FileNotification is an asynchronous notification informing the File Server about the status of Telemetry data file. This notification is sent by the CCAP when a Telemetry data file is created and ready to upload. It can also be sent when the status of a file is updated by the CCAP (e.g., when an upload is cancelled).

When the status of a locally stored bulk data file changes, the CCAP MUST log Event ID 70000704.

Table 320 - FileNotification Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Index	UnsignedByte	Yes		N/A	N/A
LocalFilename	String	Yes		N/A	
FileStatus	Enum	Yes	other(1), availableForUpload(2), uploadInProgress(3), uploadCompleted(4), uploadPending(5), uploadCancelled(6), error(7)		

6.6.1.4.4.1.8.1 Index

This attribute is a copy of the Index attribute of the FileStatus class.

6.6.1.4.4.1.8.2 LocalFilename

This attribute is a copy of the LocalFilename attribute of the FileStatus class.

6.6.1.4.4.1.8.3 FileStatus

This attribute is a copy of the FileStatus attribute of the FileStatus class.

6.6.1.4.4.2 Telemetry Data Transfer Component Diagram

The Telemetry Data Transfer component diagram illustrates the CCAP (server) and File Server (client) components for the Telemetry Data Transfer operations specific to managing files on the target device. The CCAP server (target device) component provides an operations/methods interface that contains operations that are invoked by the File Server client to perform the actions.

6.6.1.4.4.2.1 FileManagement Component Diagram

The FileManagement component diagram illustrates the CCAP and File Server components that provide file management operations on the target device.

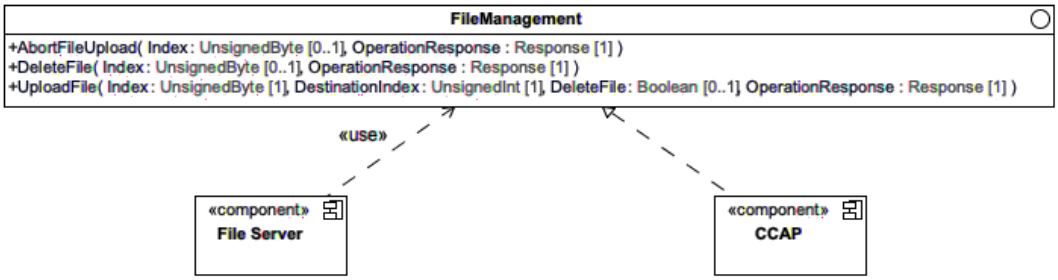


Figure 50 - FileManagement Component Diagram

6.6.1.4.4.2.1.1 AbortFileUpload Operation

The AbortFileUpload is a synchronous operation that aborts, or cancels, a pending file upload or an upload currently in progress. If the Index parameter is not provided, all pending or currently uploading files will be aborted.

A successful operation will result in the CCAP aborting a pending file upload or a file upload currently in progress. The FileStatus for the file identified by the Index will be changed to 'uploadedCancelled'.

Table 321 - AbortFileUpload Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
Index	UnsignedByte		In	0..1		
OperationResponse	Response		Out	1		

6.6.1.4.4.2.1.1.1 Parameter Definitions

- Index - This parameter is the index of the file as specified in the FileStatus class.
- OperationResponse - This parameter is the device response to the AbortFileUpload operation command. Refer to the definition of the common Response class for details.

6.6.1.4.4.2.1.1.2 Error Conditions

The following table defines the possible error conditions for the AbortFileUpload operation.

Table 322 - AbortFileUpload Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	Index does not exist on the device
Not In Valid State	File upload not in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

6.6.1.4.4.2.1.2 DeleteFile Operation

The DeleteFile is a synchronous operation that deletes a file stored locally on the target device. If the Index parameter is not provided, all files will be deleted.

A successful operation will result in the CCAP deleting a stored file from local memory. The FileStatus instance of the file identified by the Index will deleted. An unsuccessful operation will occur if a file upload is currently in progress.

Table 323 - DeleteFile Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
Index	UnsignedByte		In	0..1		
OperationResponse	Response		Out	1		

6.6.1.4.4.2.1.2.1 Parameter Definitions

- Index - This parameter is the index of the file as specified in the FileStatus class.

- OperationResponse - This parameter is the device response to the DeleteFile operation command. Refer to the definition of the common Response class for details.

6.6.1.4.4.2.1.2.2 Error Conditions

The following table defines the possible error conditions for the DeleteFile operation.

Table 324 - DeleteFile Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	Index does not exist on the device
Not In Valid State	File upload in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

6.6.1.4.4.2.1.3 UploadFile Operation

The UploadFile is a non-blocking asynchronous operation that uploads a file stored locally on the target device. The file specified by Index from the FileStatus class, with a status of 'availableForUpload', will be uploaded to the configured destination server specified by DestinationIndex of the DataTransferCfg class. If the DeleteFile parameter is not provided, the file will be retained in local storage.

A successful operation will result in the CCAP initiating a file upload using the configured file transfer method. The FileStatus instance of the file identified by the Index will be updated to 'uploadInProgress'. If the CCAP is unable to immediately initiate the file transfer due to another blocking condition, the FileStatus instance of the file identified by the Index will be updated to 'uploadPending'. The upload will be initiated when the blocking condition has been removed, for example, another upload in progress.

An unsuccessful operation will occur if the specified file, or any file upload, is currently in progress. For any unsuccessful operation, the FileStatus instance of the file identified by the Index will be updated to 'error'.

Table 325 - UploadFile Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
Index	UnsignedByte		In	1		
DestinationIndex	UnsignedInt		In	1		
DeleteFile	Boolean		In	0..1		
OperationResponse	Response		Out	1		

6.6.1.4.4.2.1.3.1 Parameter Definitions

- Index - This parameter is the index of the file as specified in the FileStatus class.
- DestinationIndex - This parameter is the index of the configured destination for the file upload.
- DeleteFile - This parameter is a Boolean flag indicating whether the target device is to retain the file in local storage. If set to ‘true’, the target device will delete the locally stored file after successful upload. If set to ‘false’, the target device will retain the locally stored file after a successful upload.
- OperationResponse - This parameter is the device response to the Upload operation command. Refer to the definition of the common Response class for details.

6.6.1.4.4.2.1.3.2 Error Conditions

The following table defines the possible error conditions for the UploadFile operation.

Table 326 - UploadFile Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	Index does not exist on the device
Not In Valid State	File upload in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

7 PERFORMANCE MANAGEMENT

7.1 Performance Management Requirements and Transport Protocols

At the CATV MAC and PHY layers, performance management focuses on the monitoring of the effectiveness of cable plant segmentation and rates of upstream traffic and collisions. Instrumentation is provided in the form of the standard interface statistics [RFC 2863] and service queue statistics (from [RFC 4546]). It is not anticipated that the CCAP upstream bandwidth allocation function will require active network management intervention and tuning.

At the LLC layer, the performance management focus is on bridge traffic management. If the CCAP implements transparent bridging, it implements the Bridge MIB [RFC 4188].

The CCAP diagnostic log capabilities, as described in Annex G, Diagnostic Log (Normative), provide early detection of CM and cable plant problems.

The DOCS-IF-MIB [RFC 4546] includes variables to track PHY state such as codeword collisions and corruption, signal-to-noise ratios, transmit and receive power levels, propagation delays, micro-reflections, in channel response, and sync loss. The DOCS-IF-MIB [RFC 4546] also includes counters to track MAC state, such as collisions and excessive retries for requests, immediate data transmits, and initial ranging requests. Section 6.6.1.2 provides enhanced signal quality monitoring and diagnostic capabilities for detecting cable plant.

A final performance concern is the ability to diagnose unidirectional loss. The CCAP implements the MIB-II [RFC 1213] Interfaces Group [RFC 2863] as specified in Annex A.

7.1.1 SNMP and MIB Requirements

Since CCAP configuration will be primarily accomplished via the NETCONF protocol and legacy CLI commands, SNMP is not used as a primary configuration interface on the CCAP. Based on this, most CCAP MIB objects will be used in a read-only mode for status and performance monitoring. Refer to Annex A for a detailed set of SNMP MIB object requirements.

The CCAP requires a very small set of read-create or read-write MIB objects used by operators for operational control, automation or testing tasks.

The CMTS and CCAP MAY augment the required MIBs with objects from other standard or vendor-specific MIBs where appropriate.

The CMTS and CCAP MUST implement the MIB requirements in accordance with this specification regardless of the value of an IETF MIB object's status (e.g., deprecated or optional).

If not required by this specification, deprecated objects are optional. If a CMTS or CCAP implements a deprecated MIB object, the CMTS or CCAP MUST implement the MIB object correctly according to the MIB definition.

If a CMTS does not implement a deprecated MIB object, the following conditions MUST be met:

- The CMTS or CCAP MUST NOT instantiate the deprecated MIB object.
- The CMTS or CCAP MUST respond with the appropriate error/exception condition, such as noSuchObject for SNMPv2c, when an attempt to access the deprecated MIB object is made.

If not required by this specification, additional objects are optional. If a CMTS or CCAP implements any additional MIB objects, the CMTS or CCAP MUST implement the MIB object correctly according to the MIB definition.

If a CMTS does not implement one or more additional objects, the following conditions MUST be met:

- The CMTS or CCAP MUST NOT instantiate the additional MIB object or objects.
- The CMTS or CCAP MUST respond with the appropriate error/exception condition, such as noSuchObject for SNMPv2c, when an attempt to access the non-existent additional MIB object is made.

If not required by this specification, obsolete objects are optional. If a CMTS or CCAP implements an obsolete MIB object, the CMTS or CCAP MUST implement the MIB object correctly according to the MIB definition.

If a CMTS or CCAP does not implement an obsolete MIB object, the following conditions MUST be met:

- The CMTS or CCAP MUST NOT instantiate the obsolete MIB object.
- The CMTS or CCAP MUST respond with the appropriate error/exception condition, such as noSuchObject for SNMPv2c, when an attempt to access the obsolete MIB object is made.

Objects which are not supported by this specification are not implemented by an agent.

- The CMTS and CCAP MUST NOT instantiate not-supported MIB objects.
- The CMTS and CCAP MUST respond with the appropriate error/exception condition, such as noSuchObject for SNMPv2c, when an attempt to access a not supported MIB object is made.

The CMTS and CCAP MUST implement the MIB access requirements defined in Annex A as follows:

- MIB objects with Not-Accessible (N-Acc) access type are implemented with not-accessible access and are typically indexes in MIB tables.
- MIB objects with Read-Create (RC) access type are implemented with read-create access.
- MIB objects with Read-Write (RW) access type are implemented with read-write access.
- MIB objects with Read-Only (RO) access type are implemented with read-only access.
- MIB objects with Read-Create (RC) access type are implemented with read-create access.
- MIB objects with Read-Create (RC) or Read-Only (RO) access types are implemented with either read-create access or read-only access as described in the object.
- MIB objects with Read-Create (RC) or Read-Write (RW) access types are implemented with either read-create access or read-write access as described in the object.
- MIB objects with Read-Write (RW) or Read-Write (RO) access types are implemented with either read-write access or read-only access as described in the object.
- MIB objects with Accessible for SNMP Notification (Acc-FN) access type are implemented as SNMP Notifications or Traps.

7.1.1.1 Protocol and Agent Requirements

The CMTS and CCAP MUST support the SNMPv1 and SNMPv2c protocol.

The CMTS and CCAP MAY support the SNMPv3 protocol.

The CCAP MUST support at least 10 SNMP Community strings with controlled access via access lists.

The IETF SNMP-related RFCs listed in Table 326 are supported by the CCAP and CMTS.

Table 327 - IETF SNMP-related RFCs

[RFC 3410]	Introduction and Applicability Statements for Internet Standard Management Framework
[RFC 3411]	An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks
[RFC 3412]	Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)
[RFC 3413]	Simple Network Management Protocol (SNMP) Applications
[RFC 3414]	User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3)
[RFC 3415]	View-based Access Control Model (VACM) for the simple Network Management Protocol (SNMP)
[RFC 3416]	Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP)
[RFC 3417]	Transport Mappings for the Simple Network Management Protocol (SNMP)
[RFC 3418]	Management Information Base for the Simple Network Management Protocol (SNMP)
[RFC 3419]	Textual Conventions for Transport Addresses
[RFC 3584]	Coexistence between Version 1, Version 2, and Version 3 of the Internet-standard Network Management Framework
[RFC 3826]	The Advanced Encryption Standard (AES) Cipher Algorithm in the SNMP User-based Security Model
[RFC 1901]	Introduction to Community-based SNMPv2 (Informational)
[RFC 1157]	A Simple Network Management Protocol

For support of SMIv2, Table 327 lists the IETF SNMP-related RFCs which are supported by the CCAP and CMTS.

Table 328 - SMIv2 IETF SNMP-related RFCs

[RFC 2578]	Structure of Management Information Version 2 (SMIv2)
[RFC 2579]	Textual Conventions for SMIv2
[RFC 2580]	Conformance Statements for SMIv2

For support of Diffie-Helman Key exchange for the User Based Security Model, Table 328 lists the IETF SNMP-related RFC which is optionally supported by the CCAP and CMTS.

Table 329 - Diffie-Helman IETF SNMP-related RFC

[RFC 2786]	Diffie-Helman USM Key Management Information Base and Textual Convention

7.1.1.1.1 CMTS and CCAP SNMP Modes of Operation

CMTS SNMP Coexistence Mode is subject to the following requirements and limitations:

- The CMTS MUST process SNMP v1/v2c Packets as described in [RFC 3411] through [RFC 3415] and [RFC 3584].
- If the CMTS supports the SNMPv3 protocol, it MUST process SNMP v3 Packets as described in [RFC 3411] through [RFC 3415] and [RFC 3584]. SNMP Access control is determined by the SNMP-COMMUNITY-MIB [RFC 3584], and SNMP-TARGET-MIB [RFC 3413], SNMP-VIEW-BASED-ACM-MIB [RFC 3415], and SNMP-User-Based-SM-MIB [RFC 3414].
- The CMTS MUST support the SNMP-COMMUNITY-MIB [RFC 3584], which controls SNMPv1/v2c packet community string associations to a security name to select entries for access control in the SNMP-VIEW-BASED-ACM-MIB [RFC 3415].
- The CMTS SHOULD support the SNMP-USER-BASED-SM-MIB [RFC 3414] and SNMP-VIEW-BASED-ACM-MIB [RFC 3415] to control SNMPv3 packets.
- The CMTS MUST support SNMP Notification destinations as specified in the SNMP-TARGET-MIB and SNMP-NOTIFICATION-MIB [RFC 3413].
- The CMTS MAY support SNMPv3 with AES encryption as defined in [RFC 3826].

7.1.1.1.2 CMTS and CCAP SNMP Access Control Configuration

The CMTS SNMP access control initial configuration is outside of the scope of this specification. If the CMTS supports SNMPv3, the CMTS MUST support the SNMPv3 key change mechanism defined in [RFC 3414].

Note that the SNMPv3 Initialization and Key Change process is based on [RFC 2786] which always configures the SNMP agent with SNMPv3 HMAC-MD5-96 as the authentication protocol and CBC-DES as the privacy protocol, both specified in [RFC 3414]. Therefore, this specification does not provide a mechanism to initialize SNMPv3 using CFB128-AES-128 for privacy key, as defined in [RFC 3826] or any other configuration defined in [RFC 3414] and are left out of scope of this specification.

[RFC 2786] provides a mechanism to kick start an SNMPv3 agent User-based Security Model [RFC 3414] and extensions to the same model for key change. [RFC 2786] does not define the mechanism to configure the initial key material for the kick start process.

7.1.1.1.3 IPv6 Transport Requirements

Several transport domains were initially defined for SNMP (see [RFC 3417]). To support IPv6, [RFC 3419] adds a new set of transport domains not only for SNMP but for any application protocol.

The CMTS and CCAP MUST support the recommendations of [RFC 3419] to support SNMP over IPv6.

7.1.1.2 CableLabs MIBs

Table 330 - CableLabs MIBs

Reference	MIB Module	Applicable Device
[DOCS-IFEXT2-MIB]	DOCSIS Interface Extension 2 MIB Module: DOCS-IFEXT2-MIB	CMTS/CCAP
[CLAB-TOPO-MIB]	CableLabs Topology MIB Module: CLAB-TOPO-MIB	CMTS/CCAP
[DOCS-DIAG-MIB]	DOCSIS Diagnostic Log MIB Module: DOCS-DIAG-MIB	CMTS/CCAP
[DOCS-IF3-MIB]	DOCSIS Interface 3 MIB Module: DOCS-IF3-MIB	CMTS/CCAP
[DOCS-IF31-MIB]	DOCSIS Interface 3.1 MIB Module: DOCS-IF31-MIB	CMTS/CCAP
[DOCS-IF40-MIB]	DOCSIS Interface 4.0 MIB Module: DOCS-IF40-MIB	CMTS/CCAP
[DOCS-MCAST-MIB]	DOCSIS Multicast MIB Module: DOCS-MCAST-MIB	CMTS/CCAP
[DOCS-MCAST-AUTH-MIB]	DOCSIS Multicast Authorization MIB Module: DOCS-MCAST-AUTH-MIB	CMTS/CCAP
[DOCS-QOS3-MIB]	DOCSIS Quality of Service 3 MIB Module: DOCS-QOS3-MIB	CMTS/CCAP
[DOCS-SEC-MIB]	DOCSIS Security MIB Module: DOCS-SEC-MIB	CMTS/CCAP
[DOCS-SUBMGT3-MIB]	DOCSIS Subscriber Management 3 MIB Module: DOCS-SUBMGT3-MIB	CMTS/CCAP
[DOCS-LOADBAL3-MIB]	DOCSIS Load Balancing 3 MIB Module: DOCS-LOADBAL3-MIB	CMTS/CCAP
[CCAP-MIB]	DOCSIS CCAP MIB Module: CCAP-MIB	CCAP
[M-OSSI], [DRFI]	DOCSIS DRF MIB Module: DOCS-DRF-MIB	CMTS/CCAP
[DOCS-PNM-MIB]	DOCSIS PNM MIB Module: DOCS-PNM-MIB	CCAP
[DOCS-FDX-MIB]	DOCSIS Full-Duplex MIB Module: DOCS-FDX-MIB	CMTS/CCAP

The CCAP MUST support read-only access for all Mandatory ("M") MIB objects that have an SNMP access type of read-only ("RO") in Sections A.1 through A.4 and Annex A of [L2VPN].

The CCAP MUST support read-only access for all Mandatory ("M") MIB objects that have an SNMP access type of read-write ("RW") or read-create ("RC") in Sections A.1 through A.3 and Annex A of [L2VPN].

The CCAP MAY support read-write access for all Mandatory ("M") MIB objects that have an SNMP access type of read-write ("RW") in Sections A.1 through A.3 and Annex A of [L2VPN].

The CCAP MAY support read-create access for all Mandatory ("M") MIB objects that have an SNMP access type of read-create ("RC") in Sections A.1 through A.3 and Annex A of [L2VPN].

The CCAP MUST support read-write access for all Mandatory ("M") MIB objects that have an SNMP access type of read-write ("RW") or of read-create ("RC") in Section A.4.

The CCAP-MIB defines the following:

- Objects which provide a link between an identifier of a CCAP interface used in the YANG model and its corresponding standard ifIndex MIB object from the ifTable and entPhysicalIndex MIB object from the Entity-MIB.
- Objects which can be used for video input program bitrate monitoring. Both the input program bitrate and input program requested bitrate can be accessed.

7.1.1.3 SCTE MIBs

The CCAP MUST support all mandatory MIB objects specified in the tables in Annex A.

For video sessions created via static configuration (e.g., via NETCONF configuration), the CCAP MUST instantiate the appropriate row entries in the SCTE-HMS-MPEG-MIB's mpegProgramMappingTable, mpegVideoSessionTable, mpegVideoSessionPtrTable, and mpegInputTSOutputSessionTable. For video sessions created via static configuration (e.g., via NETCONF configuration), the CCAP MUST set mpegVideoSessionProvMethod to tableBased (1).

For video sessions created via dynamic signaling (e.g., via ERMI), the CCAP MUST instantiate the appropriate row entries in the SCTE-HMS-MPEG-MIB's mpegProgramMappingTable, mpegVideoSessionTable, mpegVideoSessionPtrTable, and mpegInputTSOutputSessionTable. For video sessions created via dynamic signaling (e.g., via ERMI), the CCAP MUST set mpegVideoSessionProvMethod to sessionBased (2).

The CCAP MUST implement the mpegSessionsGroup table of SCTE-HMS-MPEG-MIB, which is defined as optional in [SCTE 154-4].

The CCAP SHOULD support all optional MIB objects specified in the tables in Annex A.

For an example of identifying a replication QAM via the SCTE-HMS-MPEG-MIB, see Appendix II.

7.1.1.4 IETF MIBs

Table 331 - IETF RFC MIBs

Reference	MIB Module	Applicable Device(s)
[RFC 2786]	Diffie-Helman USM Key MIB Module: SNMP-USM-DH-OBJECTS-MIB	CMTS/CCAP
[RFC 2790]	Host Resources MIB Module: HOST-RESOURCES-MIB	CMTS/CCAP
[RFC 2863]	Interfaces Group MIB Module: IF-MIB	CMTS/CCAP
[RFC 3410] [RFC 3411] [RFC 3412] [RFC 3413] [RFC 3414] [RFC 3415] [RFC 3484]	SNMPv3 MIB Modules: SNMP-FRAMEWORK-MIB, SNMP-MPD-MIB, SNMP-NOTIFICATION-MIB, SNMP-TARGET-MIB, SNMP-USER-BASED-SM-MIB, SNMP-VIEW-BASED-ACM-MIB, SNMP-COMMUNITY-MIB	CMTS/CCAP
[RFC 3418]	SNMPv2 MIB Module: SNMPv2-MIB	CMTS/CCAP
[RFC 3433]	Entity Sensor MIB Module: ENTITY-SENSOR-MIB	CMTS/CCAP
[RFC 3635]	Ethernet Interface MIB Module: EtherLike-MIB	CMTS/CCAP
[RFC 4022]	Transmission Control Protocol MIB Module: TCP-MIB	CMTS/CCAP
[RFC 4113]	User Datagram Protocol MIB Module: UDP-MIB	CMTS/CCAP
[RFC 4131]	DOCSIS Baseline Privacy Plus MIB Module: DOCS-IETF-BPI2-MIB	CMTS/CCAP

Reference	MIB Module	Applicable Device(s)
[RFC 4188]	Bridge MIB Module: BRIDGE-MIB	CMTS/CCAP
[RFC 4293]	Internet Protocol MIB Module: IP-MIB	CMTS/CCAP
[RFC 4546]	DOCSIS RF MIB Module: DOCS-IF-MIB	CMTS/CCAP
[RFC 4639]	DOCSIS Device MIB Module: DOCS-CABLE-DEVICE-MIB	CMTS/CCAP
[RFC 5132]	IP Multicast MIB Module: IPMCAST-MIB	CMTS/CCAP
[RFC 5519]	Multicast Group Membership Discovery MIB: MGMD-STD-MIB	CMTS/CCAP
[RFC 6933]	Entity MIB Module: ENTITY-MIB	CMTS/CCAP

The DOCSIS OSSI 4.0 specifications have priority over the IETF MIBs and all objects. Though deprecated or optional in the IETF MIB, the object can be required by this specification as mandatory.

7.1.1.5 Specific MIB Object Implementation Requirements

The CMTS and CCAP MUST implement the compliance and syntax of the MIB objects as specified in Annex A.

The CMTS and CCAP MUST support a minimum of 10 available SNMP table rows, unless otherwise specified by RFC or DOCSIS specification.

The CMTS and CCAP minimum number of available SNMP table rows SHOULD mean rows (per table) that are available to support device configuration.

The CMTS and CCAP used (default) SNMP table row entries MUST NOT apply to the minimum number of available SNMP table rows.

7.1.1.5.1 Treatment and Interpretation of MIB Counters

Octet and packet counters implemented as Counter32 and Counter64 MIB objects are monotonically increasing positive integers with a zero initial value and a maximum value based on the counter size that will roll-over to zero when it is exceeded. In particular, counters are defined such that the only meaningful value is the difference between counter values as seen over a sequence of counter polls. However, there are two situations that can cause this consistent monotonically increasing behavior to change: 1) resetting the counter due to a system or interface reinitialization or 2) a rollover of the counter when it reaches its maximum value of 2^{32}-1 or 2^{64}-1. In these situations, it needs to be clear what the expected behavior of the counters should be.

Case 1: The state of an interface changes resulting in an "interface counter discontinuity" as defined in [RFC 2863].

In the case where the state of an interface within the CMTS and CCAP changes resulting in an "interface counter discontinuity" [RFC 2863], the CMTS and CCAP value of the ifXTable.ifXEntry.ifCounterDiscontinuityTime for the affected interface MUST be set to the current value of sysUpTime and ALL counters for the affected interface set to ZERO. When setting the ifAdminStatus of the affected interface to down(2), the CMTS and CCAP MUST NOT consider this as an interface reset.

Case 2: SNMP Agent Reset.

An SNMP Agent Reset is defined as the reinitialization of the SNMP Agent software caused by a device reboot or device reset initiated through SNMP.

In the case of an SNMP Agent Reset within the CMTS or CCAP, the CMTS or CCAP MUST:

- set the value of sysUpTime to zero (0)
- set all interface ifCounterDiscontinuityTime values to zero (0)
- set all interface counters to zero (0)

- set all other counters maintained by the CMTS/CCAP SNMP Agent to zero (0).

Case 3: Counter Rollover.

When a counter32 object within the CMTS or CCAP reaches its maximum value of 4,294,967,295, the next value MUST be ZERO. When a counter64 object within the CMTS or CCAP reaches its maximum value of 18,446,744,073,709,551,615, the next value MUST be ZERO.

NOTE: Unless a CMTS or CCAP vendor provides a means outside of SNMP to preset a counter64 or counter32 object to an arbitrary value, it will not be possible to test any rollover scenarios for counter64 objects (and many counter32 objects as well). This is because it is not possible for these counters to rollover during the service life of the device (see discussion in section 3.1.6 of [RFC 2863]).

7.1.1.5.2 Requirements for DOCSIS Device MIB (RFC 4639)

The CMTS and CCAP MUST implement [RFC 4639].

NOTE: [RFC 4639] includes Compliance requirements for DIFFSERV-MIB [RFC 3289] to support IPv6 filtering as a replacement for the deprecated docsDevFilterIpTable. For backwards compatibility, this specification has requirements for docsDevFilterIpTable. IPv6 filtering requirements are specified in Annex A. This specification does not define requirements for [RFC 3289].

Additional requirements affecting [RFC 4639] are also found in [CM-OSSIv4.0], Protocol Filtering.

7.1.1.5.3 Requirements for DOCSIS RF MIB (RFC 4546)

The CCAP MUST implement [RFC 4546]. However, much of [RFC 4546] is not applicable to OFDM/OFDMA channels. Thus, this section defines separate requirements for handling both SC-QAM and OFDM/OFDMA channels.

The CCAP MUST instantiate a row entry for all SC-QAM and OFDM channels in the docsIfDownChannelTable. The CCAP MUST return appropriate values for all columns of the docsIfDownChannelTable for SC-QAM channels as described in the MIB itself and further specified in this section.

OFDM channels are defined and configured differently than SC-QAM channels. Thus, the docsIfDownChannelTable cannot properly represent OFDM channels. However, it is useful for the NMS to have some representation of OFDM channels in the docsIfDownChannelTable as an indication that the channel exists, and that more information can be found in other tables. Thus, rules are defined for OFDM channels to provide standard data via the docsIfDownChannelTable.

The CCAP MUST report the following values (Table 332 - docsIfDownChannelTable Requirements for OFDM Channels) for OFDM channel row entries in the docsIfDownChannelTable:

Table 332 - docsIfDownChannelTable Requirements for OFDM Channels

MIB Object	Value
docsIfDownChannelFrequency	0
docsIfDownChannelWidth	0
docsIfDownChannelModulation	other(2)
docsIfDownChannelInterleave	other(2)
docsIfDownChannelPower	0
docsIfDownChannelAnnex	other(2)
docsIfDownChannelStorageType	other(2)

For SC-QAM channels, the CCAP MUST implement the docsIfDownChannelWidth value based on the value of docsIf3MdCfgDownChannelAnnex. For SC-QAM channels, the CCAP MUST derive instances of the docsIfDownChannelAnnex from the values of docsIf3MdCfgDownChannelAnnex in a given MAC Domain.

For SC-QAM channels, the CCAP MUST report the value of docsIfDownChannelPower [RFC 4546] within 2 db of the actual power specified in dBmV as specified in [PHYv4.0].

The CCAP SHOULD NOT allow changes to the DS Channel Ids when modems are present on those channels, since any CMs that are already online will re-initialize and/or attempt to use a channel other than the one intended. The CCAP MUST ensure that an upstream or downstream channel ID is unique within a MAC Domain.

As with downstream OFDM channels and the docsIfDownChannelTable, upstream OFDMA channels cannot be represented properly in the docsIfUpChannelTable. Thus, for OFDMA channels, the CCAP MUST report the following (Table 333 - docsIfUpChannelTable Requirements for OFDMA Channels) for OFDMA channel row entries in the docsIfUpChannelTable:

Table 333 - docsIfUpChannelTable Requirements for OFDMA Channels

MIB Object	Value
docsIfUpChannelFrequency	0
docsIfUpChannelWidth	0
docsIfUpChannelModulationProfile	0
docsIfUpChannelSlotSize	0
docsIfUpChannelTxTimingOffset	0
docsIfUpChannelType	unknown(0)

Other values in the docsIfUpChannelTable for OFDMA channels are reported in an implementation-dependent manner. Operators are advised to not derive meaning from any other column in this table for rows whose columns match the values defined in Table 332.

The CCAP MUST report the docsIfCmtsModulationTable for SC-QAM channels. The maximum number of SC-QAM modulation profiles that a CCAP can support in docsIfCmtsModulationTable is vendor-specific. The CCAP MUST NOT include OFDMA Modulation Profiles in the docsIfCmtsModulationTable.

The CCAP MAY provide pre-defined SC-QAM modulation profiles (entries in the DOCS-IF-MIB docsIfCmtsModulationTable) for the purpose of being used by operators directly, or as templates to define other modulation profiles. The pre-defined SC-QAM modulation profiles provided by the CCAP MAY be read-only to prevent users from making accidental modifications. Consequently, adding or creating entries with new docsIfCmtsModIntervalUsageCode values and the same docsIfCmtsModIndex value as a pre-defined modulation profile could result in an error.

The CCAP MUST report the docsIfSignalQualityTable for SC-QAM channels. The CCAP MUST NOT include row entries for OFDMA channels in the docsIfSignalQualityTable.

As of DOCSIS 3.0, the docsIfCmtsCmStatusTable has been deprecated and replaced by the docsIf3CmtsCmRegStatusTable as the docsIfCmtsCmStatusTable doesn't properly support bonded channels.

The CCAP MUST report row entries for SC-QAM channels in the docsIfCmtsChannelUtilizationTable. The CCAP MAY provide row entries for OFDM and/or OFDMA channels in the docsIfCmtsChannelUtilizationTable; however, new utilization tables/objects are defined in the DOCS-IF31-MIB which replace these items for OFDM and OFDMA channels.

The CCAP MUST report row entries for SC-QAM channels in the docsIfCmtsDownChannelCounterTable. The CCAP MAY provide row entries for OFDM channels in the docsIfCmtsDownChannelCounterTable; however, new channel-wide and per profile counters are defined in the DOCS-IF31-MIB which replace these items for OFDM channels.

The CCAP MUST report row entries for SC-QAM channels in the docsIfCmtsUpChannelCounterTable. The CCAP MAY provide row entries for OFDMA channels in the docsIfCmtsUpChannelCounterTable; however, new channel-wide and per profile counters are defined in the DOCS-IF31-MIB which replace these items for OFDMA channels.

The CCAP MUST support the objects in the docsIfCmtsUpChannelCounterTable that are described in the DOCS-IF-MIB as being optional. However, certain impairment events on the upstream channel (e.g., burst noise) could be indistinguishable from collisions, and hence could be counted as such.

The CCAP assigns a unique numeric identifier to each individual CM that is used for per-CM reporting and management purposes. DOCSIS 3.1 defined this identifier as docsIf3CmtsCmRegStatusId. Prior to DOCSIS 3.0 this

identifier was docsIfCmtsCmStatusIndex [RFC 4546]. DOCSIS 4.0 CCAP requirements include MIB modules based on docsIfCmtsCmStatusIndex; therefore, the CCAP MUST consider docsIfCmtsCmStatusIndex to be the same identifier as docsIf3CmtsCmRegStatusId for the purpose of CM identification in MIB modules defined through SNMP conceptual row extension, and SNMP conceptual row augmentation. See section "Relation between INDEX and AUGMENTS clauses" of [RFC 2578] for details on these concepts.

The docsIfCmtsSynchInterval object applies to Primary-Capable Downstream interfaces within the MAC Domain.

The docsIfQosProfileTable has been deprecated since the DOCSIS 1.0 Class of Service (CoS) service class definition type was deprecated and is not supported in DOCSIS 4.0.

The CCAP MUST extend the DOCS-IF-MIB textual convention DocsEqualizerData SYNTAX as follows: The OCTET STRING range restriction has been removed. See below.

```
DocsEqualizerData ::= TEXTUAL-CONVENTION
         STATUS       current
         DESCRIPTION
             "This data type represents the equalizer data
              as measured at the receiver interface.
              The format of the equalizer follows the structure of the
              Transmit Equalization Adjust RNG-RSP TLV of DOCSIS RFI
              v2.0 :
              1 byte Main tap location 1..(n + m)
              1 byte Number of forward taps per symbol
              1 byte Number of forward taps: n
              1 byte Number of reverse taps: m

              Following are the equalizer coefficients:
              First, forward taps coefficients:
              2 bytes F1 (real),  2 bytes  F1 (imag)
              ...
              2 bytes Fn (real),  2 bytes  Fn (imag)

              Then, reverse taps coefficients:
              2 bytes D1 (real),  2 bytes  D1 (imag)
              ...

              2 bytes Dm (real),  2 bytes  Dm (imag)

              The equalizer coefficients are considered signed 16-bit
              integers in the range from -32768 (0x8000) to 32767
              (0x7FFF).

              DOCSIS specifications require up to a maximum of
              64 equalizer taps (n + m); therefore, this object size
               can get up 260 bytes (4 + 4x64).
              The minimum object size (other than zero) for a t-spaced
              tap with a minimum of 8 symbols will be 36 (4 + 4x8)."
         REFERENCE
            "Data-Over-Cable Service Interface Specifications: Radio
             Frequency Interface Specification SP-RFIv2.0-I10-051209,
             Figure 8-23."
         SYNTAX       OCTET STRING
```

7.1.1.5.4 Requirements for SNMPv2 MIB (RFC 3418)

7.1.1.5.4.1 SNMPv2-MIB System Group Requirements

The CMTS and CCAP MUST implement the System Group of [RFC 3418].

The CCAP MUST use the value of the Name attribute of the Ccap object when reporting sysName via the SNMPv2-MIB. The CCAP MUST use the value of the Location attribute of the Ccap configuration object when reporting the sysLocation via the SNMPv2-MIB.

The CMTS and CCAP MUST implement the sysDescr object. For the CMTS and CCAP, the format and content of the information in sysDescr is vendor-dependent.

7.1.1.5.4.2 SNMPv2-MIB SNMP Group Requirements

This group provides SNMP protocol statistics and protocol errors counters.

The CMTS and CCAP MUST implement The SNMP Group from [RFC 3418].

7.1.1.5.5 Requirements for Interfaces Group MIB (RFC 2863)

The CCAP MUST implement the interface MIB [RFC 2863].

The ifType object associated with a DOCSIS interface can have the following enumerated values:

- CATV MAC interface: docsCableMacLayer (127)
- CATV downstream channel: docsCableDownstream (128)
- CATV M-CMTS downstream channel: docsCableMCmtsDownstream (229) (See [M-OSSI])
- CATV Downstream OFDM interface: docsOfdmDownstream (277)
- CATV upstream interface: docsCableUpStream (129)
- CATV Upstream OFDMA interface: docsOfdmaUpstream (278)
- CATV logical upstream channel: docsCableUpstreamChannel (205)
- CATV upstream RF port: docsCableUpstreamRfPort (256)
- CATV downstream RF port: cableDownstreamRfPort (257)

The following statements define the CCAP interface-numbering scheme requirements:

The CCAP MUST implement an instance of ifEntry for each CATV-MAC interface, downstream channel, upstream interface, logical upstream channel, and any other interface type that exists in the CMTS.

The CCAP MUST populate the ifStackTable with the associations of CATV-MAC interfaces to upstream and downstream channels as defined in the MdChCfg configuration object (refer to Section 7.2.1.1.7).

The CCAP MUST implement a row entry in the ifTable for each Downstream RF Port in the CCAP chassis. A Downstream RF Port is typically associated with a single F-connector or single MCX-75 connector on a DLC.

The CCAP MUST implement an ifType value of 257 in the ifTable row entry for each Downstream RF Port.

When an instance of VideoDownChannel is created on a given Downstream RF Port, the CCAP MUST create an ifTable entry with an ifType value of 214 (mpegTransport). For replicated QAMs, an ifTable entry will be created for every instance of a QAM on a given Downstream RF Port, regardless of whether the QAM has been replicated.

When an instance of DocsisDownChannel is created on a given Downstream RF Port, the CCAP MUST create an ifTable entry with an ifType value of 128 (docsCableDownstream).

When an instance of DOCSIS OFDMDownstreamChannel is created on a given Downstream RF Port, the CCAP MUST create an ifTable entry with an ifType value of 278 (docsOfdmDownstream).

In the absence of user configuration, the CCAP MAY automatically instantiate ifTable entries for VideoDownChannel objects and/or DocsisDownChannel objects.

The CCAP MUST implement a row entry in the ifTable for each Upstream RF Port in the CCAP chassis. An Upstream RF Port is typically associated with a single F-connector or a single MCX-75 connector on a ULC.

The CCAP MUST implement an ifType value of 256 in the ifTable row entry for each Upstream RF Port.

When an instance of DOCSIS UpstreamPhysicalChannel is created on a given Upstream RF Port, the CCAP MUST automatically create one or more corresponding instances of an UpstreamLogicalChannel.

When an instance of DOCSIS UpstreamPhysicalChannel is created on a given Upstream RF Port, the CCAP MUST create an ifTable entry with an ifType value of 129 (docsCableUpstream).

When an instance of DOCSIS OFDMAUpstreamChannel is created on a given Upstream RF Port, the CCAP MUST create an ifTable entry with an ifType value of 278 (docsOfdmaUpstream).

When an instance of DOCSIS UpstreamLogicalChannel is created, the CCAP MUST create an ifTable entry with an ifType value of 205 (docsCableUpstreamChannel).

In the absence of user configuration, the CCAP MAY automatically instantiate DOCSIS UpstreamPhysicalChannels of ifType 129 for each physical Upstream RF port on a ULC.

When an instance of DOCSIS MAC Domain is created, the CCAP MUST create an ifTable entry with an ifType value of 127 (docsCableMaclayer).

For each loopback interface that is defined in the system, the CCAP MUST represent that interface with an ifTable entry with an ifType value of 24, per [RFC 2863].

For each row entry created in the ifTable, the CCAP MUST create a corresponding row entry in the ifXTable.

The CCAP SHOULD maintain the same ifIndex value for configured interfaces across reboots if there have been no configuration changes. The interfaces to be persisted across reboots include those interfaces specified in the CCAP configuration UML information model.

7.1.1.5.5.1 ifAdminStatus

The CCAP MUST NOT accept or forward any traffic over an interface whose ifAdminStatus is 'down', (traffic includes data and MAC management traffic where applicable).

When the CCAP initializes, all Ethernet interfaces start with ifAdminStatus in the up(1) state. As a result of either explicit management or configuration information saved via other non-SNMP method (i.e., CLI commands) retained by the managed system, ifAdminStatus is then changed to either the down(2) or testing(3) states (or remains in the up(1) state). When the CCAP initializes, all DOCSIS interfaces start with ifAdminStatus in the down(2) state. As a result of either explicit management or configuration information saved via other non-SNMP method (i.e., CLI commands) retained by the managed system, ifAdminStatus is then changed to either the up(1) or testing(3) states (or remains in the down(2) state).

7.1.1.5.5.2 SNMP Notification Control Requirements

If a multi-layer interface model is present in the device, each sub-layer for which there is an entry in the ifTable can generate linkUp/Down traps. Since interface state changes would tend to propagate through the interface stack (from top to bottom, or bottom to top), it is likely that several traps would be generated for each linkUp/Down occurrence. The ifLinkUpDownTrapEnable object allows managers to control SNMP notification generation and configure only the interface sub-layers of interest.

The CCAP MUST implement the MIB object ifLinkUpDownTrapEnable specified in [RFC 2863].

For linkUp/Down events on CCAP DOCSIS interfaces, the CCAP SHOULD generate an SNMP notification for each CCAP interface. Therefore, the CCAP MUST have its default setting of ifLinkUpDownTrapEnable for each CCAP interface (MAC, RF-Downstream(s), RF-Upstream(s)) set to 'enabled'.

7.1.1.5.5.3 ifTable and ifXTable Counters

Application of the [RFC 2863] ifTable and ifXTable MIB counter objects are done on a per-interface basis and are detailed in Table 333. This table defines specific SNMP Access and MIB requirements for each of the interface counters defined in [RFC 2863]. The CCAP MUST count octets on the downstream and upstream interfaces (logical and physical). The CCAP MAY implement the packet counters from [RFC 2863], but when implemented on these interfaces, the counter object will return a value of zero. The CCAP MUST count packets and octets on ethernet and MAC interfaces. Per the requirements in [RFC 2863] Counter Size section, a given interface may support only 32-bit or 64-bit (High Capacity), or both sets of counters based on interface speed.

The following table describes the rules for counting packets and octets on RF and MAC domain interfaces.

Table 334 - IF-MIB Counter Rules

MIB Counter Objects	MAC Domain Interfaces	Upstream/Downstream RF Interfaces
ifInOctets ifHCInOctets	The total number of data octets (data in transit, data targeted to the managed device) received on this interface from the RF interface and before application of protocol filters.	This includes MAC packets as well as data packets, and includes the length of the MAC header, this does not include any PHY overhead.
ifInUcastPkts ifHCInUcastPkts	The total number of Unicast data packets (data in transit, data targeted to the managed device) received on this interface from the RF interface before application of protocol filters.	The total number of Unicast data packets (data in transit, data targeted to the managed device) received on this interface from the RF interface before application of protocol filters.
ifOutOctets ifHCOutOctets	The total number of data octets (data in transit, data generated by the managed device) transmitted on this interface to the RF interface after application of protocol filters.	This includes MAC packets as well as data packets, and includes the length of the MAC header, this does not include any PHY overhead.
ifOutUcastPkts ifHCOutUcastPkts	The total number of Unicast data packets (data in transit, data generated by the managed device) transmitted on this interface to the RF interface after application of protocol filters.	The total number of Unicast data packets (data in transit, data generated by the managed device) transmitted on this interface after application of protocol filters.
ifInMulticastPkts ifHCInMulticastPkts	The total number of Multicast data packets (data in transit, data targeted to the managed device) received on this interface from the RF interface before application of protocol filters.	The total number of Multicast data packets (data in transit, data targeted to the managed device) received on this interface before application of protocol filters.
ifInBroadcastPkts ifHCInBroadcastPkts	The total number of Broadcast data packets (data in transit, data targeted to the managed device) received on this interface from the RF interface before application of protocol filters.	The total number of Broadcast data packets (data in transit, data targeted to the managed device) received on this interface before application of protocol filters.
ifOutMulticastPkts ifHCOutMulticastPkts	The total number of Multicast data packets (data in transit, data generated by the managed device) transmitted on this interface to the RF interface after application of protocol filters	The total number of Broadcast data packets (data in transit, data targeted to the managed device) received on this interface before application of protocol filters.
ifOutBroadcastPkts ifHCOutBroadcastPkts	The total number of Broadcast data packets (data in transit, data generated by the managed device) transmitted on this interface to the RF interface after application of protocol filters	The total number of Broadcast data packets (data in transit, data generated by the managed device) transmitted on this interface after application of protocol filters

The CCAP MUST implement the ifTable and ifXTable [RFC 2863] Counter32 and Counter64 MIB objects as defined for each interface in Table 334 - IF-MIB Counter Rules.

7.1.1.5.5.4 ifSpeed and ifHighSpeed

For SC-QAM downstream channels (VideoDownChannels and DocsisDownChannels), the ifSpeed is the symbol rate multiplied by the number of bits per symbol. For SC-QAM upstream channels, the ifSpeed is the raw bandwidth in bps of this interface, regarding the highest speed modulation profile that is defined. This is the symbol rate multiplied with the number of bits per symbol for this modulation profile.

For OFDM downstream channels, the CCAP MUST calculate the ifSpeed per the following algorithm:

```
numCountedSubcarriers = 0;
totalBitLoading = 0;

for (i - 0; i < numActiveSubcarriers; ++i)
{
if subcarrier is not PLC and not continuous pilot then
{
totalBitLoading += modulationOrder(i); //in bits per symbol
numCountedSubcarriers += 1
}
}
averageBitLoading = (totalBitLoading / numCountedSubcarriers)
```

```
ifSpeed = numCountedSubcarriers * averageBitLoading * subcarrierSpacingHz *
          [numSymPeriods/(numSymPeriods + (cyclicPrefixSamples/204.8))] * (127/128)
```

The number of symbols in a minislot for a given OFDMA channel is a factor of the number of symbols in a frame and the number of subcarriers per minislot. The minislot capacity depends on the minislot bit loading and pilot pattern, which are variable per minislot based on IUC, the minislot location in the frame and the burst profile being used. Another factor is whether a minislot is classified as a body minislot or as an edge minislot.

For the purpose of calculating ifSpeed, the CCAP uses an OFDMA Data IUC with the highest capacity assuming that all minislots are body minislots. The minislot capacity is calculated by multiplying the number of data symbols in a minislot by modulation order (in bits per symbol) and adding to the number of complementary pilot symbols in a minislot multiplied by the complementary data pilot modulation order. The upstream channel capacity is calculated by adding the capacity of all minislots in a frame and multiplying that number by the frame rate.

For upstream OFDMA channels, the CCAP MUST calculate the ifSpeed per the following algorithm:

```
frameCapacity = 0
for (i = 0; i < numMinislotsPerFrame; ++i)
{
   minislotCapacity(i) = numDataSymbols(i) * modulationOrder(i) +
                         numComplementaryPilotSymbols(i) *
                         compPilotSymbolModulationOrder(i);
   frameCapacity += minislotCapacity(i);
}
```

$$numFramesPerSecond = \frac{idftSize}{(idftSize + cyclicPrefix)(numSymbolsPerOfdmaFrameK)(fftDuration)}$$

```
ifSpeed = numFramesPerSecond * frameCapacity;
```

7.1.1.5.5.5 CCAP ifStack Table

Shown below is an example of how the ifStack table might look for downstream interfaces on the CCAP. The values used for the ifIndexes are for example purposes only. The ifStack table for the CCAP has been modified from previous versions of DOCSIS and CableLabs specifications. The rationale for this change is related to the multiservice nature of the CCAP and the desire to include the physical port in the ifStack. On the downstream side of the ifStack, the table remains consistent with the way Downstream Interfaces were modeled in the DOCSIS and Modular Headend Architectures, with the exception being the addition of the Downstream RF Port being placed at the bottom of the ifStack. The diagram in Figure 51 shows both the VideoDownChannel objects and the DocsisDownChannel objects being sent over the same DS RF Port.

On the upstream side, similar constructs have been used; however, the upstream model has inverted the relationship between Upstream Logical and Upstream Physical channels to more accurately reflect the nature of the relationships between burst receivers and the channels they are configured to receive. In the CCAP model, the lowest tier of the ifStack starts with the Upstream RF Port, then moves to the Upstream Physical Channel, and then progresses to the Upstream Logical Channels, and finally the DOCSIS MAC Domain.

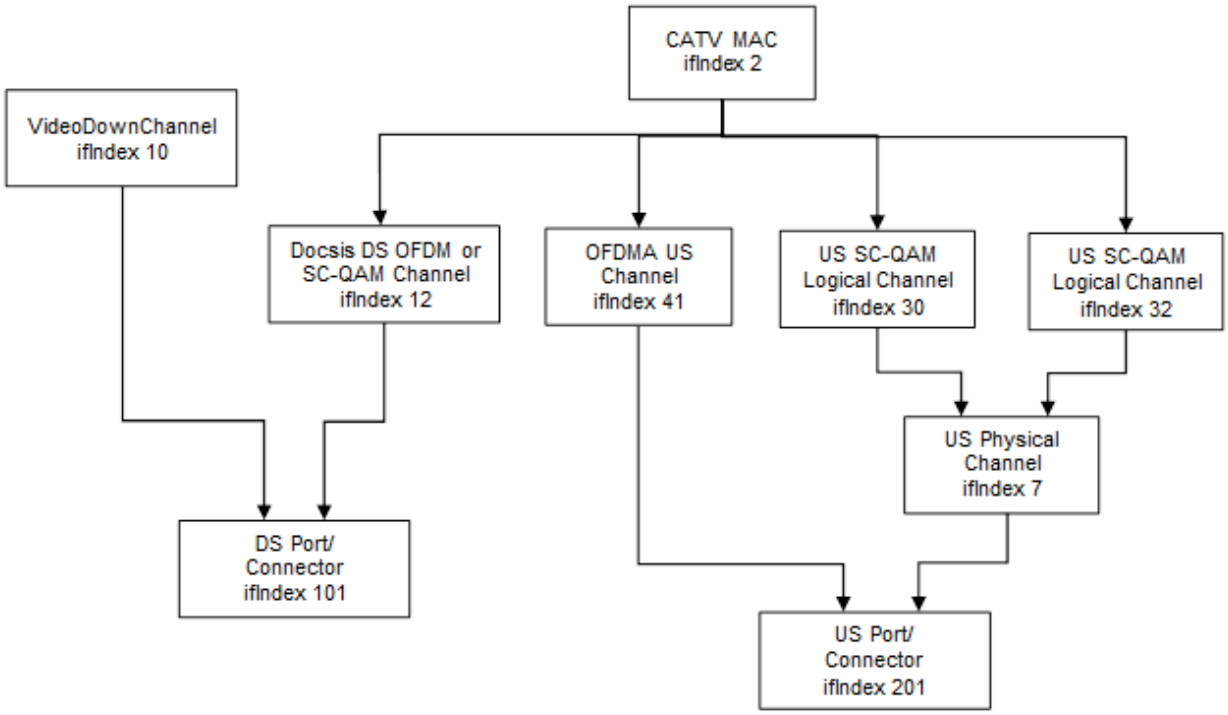


Figure 51 - ifStack Table for CCAP RF Interfaces

Table 335 - CCAP ifStack Table Representation

ifStackHigherLayer	ifStackLowerLayer
0	2
0	10
2	12
2	30
2	32
2	41
7	201
10	101
12	101
30	7
32	7
41	201
101	0
201	0

Table 336 - IfTable/IfXTable Details for Ethernet Interfaces

MIB Objects	CCAP-Ethernet	DTI
IfTable		
ifIndex	(n)	(n)
ifDescr		

MIB Objects	CCAP-Ethernet	DTI
ifType	6	other(1)
ifMtu	1500	256
ifSpeed (bps) Note: Interfaces higher than 10Gbps are not shown in this MIB Object. These interface speeds are recorded in the ifXTable ifHighSpeed MIB Object.	100,000 1000,000,000, 10,000,000,000,	5
ifPhysAddress	MAC Address of this interface	Empty-String
ifAdminStatus Refer to Section 7.1.1.5.5.1	up(1), down(2), testing(3)	up(1), down(2), testing(3)
ifOperStatus	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)
ifLastChange		
ifXTable		
ifName		
ifLinkUpDownTrapEnable		
ifHighSpeed (mbps)	100, 1000, 10,000, 40,000, 100,000	5
ifPromiscuousMode	true(1), false(2)	true(1), false(2)
ifConnectorPresent		
ifAlias		
ifCounterDiscontinuityTime		

Table 337 - IfTable/IfXTable for RF and DOCSIS Interfaces

MIB Objects	CCAP-MAC	CCAP VideoDownChannel	CCAP DocsisDownChannel	CCAP-Upstream Physical Channel	CCAP-Upstream Logical Channel	CCAP DsRfPort	CCAP UsRfPort	CCAP DsOfdm Channel	CCAP UsOfdmaChannel
IfTable									
ifIndex	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)
ifDescr									
ifType	127	214*	128	129	205	257	256	277	278
ifMtu For RF Upstream/Downstream; the value includes the length of the MAC header. Note: When a DOCSIS 4.0 CCAP enables extended MAC frame length for a CM, the CCAP-MAC MTU should reflect a value configured by the CCAP up to a maximum value of 2000. Refer to [MULPIv4.0] Extended MAC Frame Length.	2000	188	2030	2030	2030	0	0	2030	2030
ifSpeed Refer to Section 7.1.1.5.5.4	0	DVB-C ~QAM64= 41,712,000 ~QAM256= 55,616,000 J.83 Annex B ~QAM64= 30,341,646 ~QAM256= 42,884,296	DVB-C ~QAM64= 41,712,000 ~QAM256= 55,616,000 J.83 Annex B ~QAM64= 30,341,646 ~QAM256= 42,884,296	(n)	(n)	0	0	Refer to Section 7.1.1.5.5.4	Refer to Section 7.1.1.5.5.4
ifPhysAddress	MAC Address of interface	Empty-String	Empty-String	Empty-String	Empty-String	Empty-String	Empty-String	Empty-String	Empty-String
ifAdminStatus:	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)	up(1), down(2), testing(3)

MIB Objects	CCAP-MAC	CCAP VideoDownChannel	CCAP DocsisDownChannel	CCAP-Upstream Physical Channel	CCAP-Upstream Logical Channel	CCAP DsRfPort	CCAP UsRfPort	CCAP DsOfdm Channel	CCAP UsOfdmaChannel
ifOperStatus	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)	up(1), down(2), testing(3), dormant(5), notPresent(6)
ifLastChange									
ifXTable									
ifName									
ifLinkUpDownTrapEnable									
ifHighSpeed Refer to Section 7.1.1.5.5.4	0	DVB-C ~QAM64=41, ~QAM256=55 J.83 Annex B ~QAM64=30, ~QAM256=42	DVB-C ~QAM64=41, ~QAM256=55 J.83 Annex B ~QAM64=30, ~QAM256=42	(n)*	(n)**	0	0	Refer to Section 7.1.1.5.5.4	Refer to Section 7.1.1.5.5.4
ifPromiscuousMode	True(1), False(2)		False(2)	True(1), False(2)	True(1)	False(2)	False(2)	False(2)	False(2)
ifConnectorPresent									
ifAlias									
ifCounterDiscontinuityTime									
Table Note: *Also considered 226-QAM, but selected MPEG transport because the interface represents the logical content rather than the physical transmission.									

Table 338 - CCAP ifCounters Information

MIB Counter Objects	Access	CCAP-MAC	CCAP-Video Down Channel	CCAP-Docsis Down Channel	CCAP-Upstream Physical Channel	CCAP-Upstream Logical Channel	CCAP-Ds RfPort	CCAP-Us RfPort	CCAP DsOfdmChannel	CCAP UsOfdmaChannel
ifTable										
ifInOctets	RO	Mandatory	Mandatory	NA	Mandatory	Mandatory	NA	NA	Mandatory	Mandatory
ifInUcastPkts	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifInDiscards	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory

MIB Counter Objects	Access	CCAP-MAC	CCAP-Video Down Channel	CCAP-Docsis Down Channel	CCAP-Upstream Physical Channel	CCAP-Upstream Logical Channel	CCAP-Ds RfPort	CCAP-Us RfPort	CCAP DsOfdmChannel	CCAP UsOfdmaChannel
ifInErrors	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifInUnknownProtos	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Optional
ifOutOctets	RO	Mandatory	Mandatory	M	NA	NA	NA	NA	Mandatory	NA
ifOutUcastPkts	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
ifOutDiscards	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
ifOutErrors	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
ifXTable										
ifInMulticastPkts	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifInBroadcastPkts	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifOutMulticastPkts	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
ifOutBroadcastPkts	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
IfHCInOctets	RO	Mandatory	Mandatory	NA	Mandatory	Mandatory	NA	NA	NA	Mandatory
ifHCInUcastPkts	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifHCInMulticastPkts	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifHCInBroadcastPkts	RO	Mandatory	NA	NA	Optional	Optional	NA	NA	NA	Mandatory
ifHCOutOctets	RO	Mandatory	Mandatory	M	NA	NA	NA	NA	Mandatory	NA
ifHCOutUcastPkts	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
ifHCOutMulticastPkts	RO	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA
ifHCOutBroadcastPkts	RW	Mandatory	NA	O	NA	NA	NA	NA	Mandatory	NA

7.1.1.5.5.6 Interfaces YANG Module Mapping

Starting with the development and specification of DOCSIS 1.0, CCAP managed objects have been modeled as network interfaces. Basic DOCSIS constructs such as RF ports, RF channels, MAC domains as well as various components of the CCAP are represented as interfaces where they can be managed via SNMP ifTable and its extensions. The SNMP ifTable was introduced in RFC 1156 as part of the MIB Interfaces group and has been in use since it's publication. The ifTable relies on an ifIndex as the index to the ifTable. This ifIndex is a 32-bit unique identifier for each interface modeled in the ifTable. Numerous DOCSIS OSSI models frequently reference cable network interfaces in management models developed for subscriber management and proactive network maintenance, among others.

The transition from SNMP MIBs to YANG for the management of the CCAP provides many benefits, as network management protocols have evolved since the early days of SNMP management of network devices. To bridge the gap from SNMP management to new protocols which support YANG data models, the IETF has developed a YANG data model for interface management [RFC 8343].

RFC 8343 was developed to provide the generic interfaces data model, equivalent to the SNMP Interfaces group widely adopted as part of the original MIB-II [RFC 1213] and currently defined in the IF-MIB [RFC 2863]. Unlike the ifIndex used in SNMP, RFC 8343 relies on human readable interface name (name YANG node) to uniquely identify each managed interface (it is the key to the RFC 8343 interfaces list). This can be mapped from the IF-MIB ifName for devices which supported ifName within the ifTable. In addition, RFC 8343 provides a mapping into the ifTable ifIndex through the if-index YANG node.

The table below illustrates the MIB-to-YANG model mapping.

Table 339 - MIB-to-YANG Model Interface Identification Mapping

IF-MIB [RFC 2863]	**ietf-interfaces YANG Module** [RFC 8343]
ifTable	interface list
ifIndex (table index)	if-index
ifName (included in ifXTable)	name (key)

7.1.1.5.6 Requirements for Entity-MIB (Annex A)

The CCAP MUST implement the ENTITY-MIB [RFC 6933] as described in the following subsections and Annex A.

7.1.1.5.6.1 Entity-MIB CCAP Requirements for entPhysicalTable

The CCAP implements a row entry in the entPhysicalTable for the system chassis and each Field Replaceable Unit (FRU) installed in the CCAP chassis.

The CCAP MUST report an entry in the entPhysicalTable for the chassis component with Physical Class 'chassis'.

The CCAP MUST report entries in the entPhysicalTable of Physical Class 'container' (such as slots) that contains physical Field Removable Units (FRU) normally modeled as elements of Physical Class 'module'.

The CCAP MUST provide as much information as possible about entPhysicalTable listed in Table 340 - entPhysicalTable Requirements for major components such as CCAP chassis, backplanes and containers or modules in the form or cards and/or field replaceable units (FRUs) when possible. Modules within modules (or cards) or other contained physical components need not be detailed.

The CCAP MUST provide the unique component serial number, via the entPhysicalSerialNum object, contained within the row entry in the entPhysicalTable for the system chassis and each FRU that has a serial number in the system. Example FRUs with serial numbers include, but are not limited to, fabric cards, DTI cards, SREs, DLCs, ULCs, combined Upstream & Downstream line cards, Ethernet cards, and PON line cards.

The CCAP SHOULD provide the unique component serial number, via the entPhysicalSerialNum object, contained within the row entry in the entPhysicalTable for each FRU that is a pluggable optical module such as an SFP, SFP+, QSFP, XFP, CXP.

Example FRUs that might not have serial numbers, yet are expected to be represented in the entPhysicalTable, include flash cards, fan modules, and power supply modules.

The CCAP SHOULD implement row entries in the entPhysicalTable for temperature sensors in the system with an entPhysicalClass value of "sensor".

The CCAP MAY report temperature sensors in the form of instances in the entPhysicalTable for elements of Physical Class 'sensor' with the corresponding entPhySensorType 'celsius' value in the corresponding entPhySensorTable instance of the ENTITY-SENSOR-MIB [RFC 3433].

The CCAP SHOULD provide the unique component serial number, via the entPhysicalSerialNum object, contained within the row entry in the entPhysicalTable for every FRU that is capable of causing and/or generating an event, message, log, or alarm.

The [DRFI] specification defines a multi-channel RF port capability. The set of downstream channels within the same RF port is also known as a "Channel Block" (see [DRFI]).

The [MULPIv4.0] specification does not have a concrete definition of multiple upstream interfaces being part of the same RF spigot as [DRFI] does for downstream channels, but in several diagrams (e.g., [MULPIv4.0] Downstream Convergence Layer Block Diagram) those options are discussed. For the upstream interfaces, only the physical upstream interfaces are modeled in the Entity MIB. The logical upstream interfaces are defined in the CCAP ifStackTable.

A Channel Block is defined as the set of downstream interfaces (Physical Class 'port') that share the same immediate physical component of Physical Class 'module' in the containment tree (entPhysicalContainsTable).

The Entity MIB entries below the 'chassis' container will at a minimum consist of the downstream and upstream interfaces and optionally the logical MAC Domain groupings. The goal in this reporting structure is to catalog and report those interfaces that can be combined to logically form MAC Domains.

The CCAP MUST report RF ports as Physical Class 'module' elements in the entPhysicalTable. The CCAP MUST include the text "RF port" within the description of the SNMP object entPhysicalDescr for RF ports modeled in the entPhysicalTable.

The CCAP MAY report MAC Domain interfaces (ifType = 127) as Physical Class 'module' in the entPhysicalTable.

The CCAP MUST report downstream interfaces (ifType = 128 and ifType = 277), as Physical Class 'port' in the entPhysicalTable.

The CCAP MUST report upstream interfaces (ifType = 129 and ifType = 278) as Physical Class 'port' in the entPhysicalTable. Upstream logical channels are not represented in the entPhysicalTable as those are subinterfaces illustrated in the ifStackTable [RFC 2863].

The CCAP MAY represent interfaces other than the defined above as part of the entPhysicalTable.

7.1.1.5.6.2 CCAP Guidelines for the implementation of the Entity MIB

The Entity MIB [RFC 6933] provides a physical component layer applicable to managed objects defined for DOCSIS devices. In particular for the entPhysicalTable MIB objects, not all the physical components listed need to instantiate all the object's attributes in entPhysicalTable (the Maximum Access is as defined in [RFC 6933]).

Table 339 represents high level constraints for any instance of entPhysicalTable.

Table 340 - entPhysicalTable Requirements

MIB object	Value
entPhysicalIndex	n
entPhysicalDescr	Text Description
entPhysicalVendorType	Enterprise-specific OID or zeroDotZero
entPhysicalContainedIn	0..n
entPhysicalClass	Physical Class per [RFC 6933]

MIB object	Value
entPhysicalParentRelPos	-1..n per [RFC 6933]
entPhysicalName	Physical element name In case of a component mapped to an interface Index ifName can be reported, otherwise zero-length string
entPhysicalHardwareRev	Hardware revision or zero-length string
entPhysicalFirmwareRev	Firmware revision or zero-length string
entPhysicalSoftwareRev	Software revision or zero-length string
entPhysicalSerialNum	Serial Number or zero-length string
entPhysicalMfgName	Manufacturer Name or zero-length string
entPhysicalModelName	Model Name or zero-length string
entPhysicalAlias	Physical element operator defined alias In case of a component mapped to an interface Index ifAlias can be reported and implemented as read-only, otherwise zero-length string
entPhysicalAssetID	User defined Asset ID or zero-length string
entPhysicalIsFRU	'true' or 'false'
entPhysicalMfgDate	Manufacturer data or all zeros '0000000000000000'H
entPhysicalUris	URI or zero-length string

The following sections detail requirements for the CCAP on specific topics where the DOCSIS 4.0 requirements interact with the Entity MIB have been set.

7.1.1.5.6.3 Entity-MIB CCAP Requirements for entLogicalTable, entLPMappingTable and entConfigChange Notification

The CCAP is not required to support multiple naming scopes. Therefore, this specification has no CCAP requirements for entLogicalTable and entLPMappingTable and is left for vendor-specific implementation.

In addition, this specification has no CCAP requirements for the entConfigChange Notification and is left for vendor-specific implementation.

7.1.1.5.6.4 Entity-MIB CCAP Requirements for entPhysicalContainsTable

The purpose of the entPhysicalContainsTable in the CCAP is to represent the association of multiple downstream and upstream interfaces within the physical construction of the CCAP. These associations are already modeled in the entPhysicalTable (entPhysicalContainedIn and entPhysicalParentRelPos). The entPhysicalContainsTable provide a more direct relationship of those parent-child associations. Additionally, it may provide mechanisms to indicate other associations like restrictions and configurability of downstream and upstream interfaces within a particular MAC Domain as defined below.

For the purpose of identifying downstream and upstream interfaces within an RF port as well as Channel Blocks, the CCAP MAY report in the entPhysicalContainsTable the physical component of Physical Class 'module' as the entPhysicalIndex value for each of the downstream or upstream interface Physical Indexes as the values for entPhysicalChildIndex.

For the purpose of modeling which upstream and downstream interfaces can physically and logically be configured within a MAC Domain, the CCAP MAY define logical components of Physical Class 'backplane' (in entPhysicalTable) to include (in entPhysicalContainsTable) all the MAC Domain interface resources and downstream/upstream interfaces that could potentially be added in a particular MAC Domain.

If supported, the CCAP MAY apply the following rules to indicate containment models for MAC Domain and downstream/upstream associations:

- The 'backplane' physical component entries in entPhysicalTable have a valid Physical Index for entPhysicalContainedIn (e.g., the CCAP 'chassis' or another 'backplane' Physical Class component).

- The 'backplane' physical components are not referenced by other physical components in entPhysicalTable as their entPhysicalContainedIn value.
- Physical components 'backplane' are the parent index in entPhysicalContainsTable for children indexes representing MAC Domain interfaces, downstream/upstream interfaces, and/or physical components 'modules' that represent RF ports or Channel Blocks. When this set of parent-child entries contains 'modules' (e.g., Channel Blocks) instead of individual US/DS interfaces, it indicates that the complete 'module' is configurable within a single MAC Domain, while the existence of individual 'backplane' - downstream/upstream interfaces parent-children entries in entPhysicalContainsTable indicates that individual channels (even within a Channel Block) can be associated with specific MAC Domains).

The CCAP does not need to report in the entPhysicalContainsTable the MAC Domain downstream/upstream channel hierarchy normally represented in the ifStackTable.

7.1.1.5.6.5 Entity-MIB CCAP Requirements for entAliasMappingTable

The entAliasMappingTable is used in this specification to associate the physical elements modeled in the Entity MIB with the logical components of the CCAP management model.

For each row entry created in the SNMPv2-MIB ifTable that can be mapped to an entity represented in the Entity-MIB, the CCAP MUST create a corresponding row entry in the entAliasMappingTable.

The CCAP MUST implement a row entry in the entAliasMappingTable for each UsRfPort and each DsRfPort in the chassis.

The CCAP MAY represent the mapping of MAC Domain to downstream and upstream interfaces in the entAliasMappingTable.

The CCAP MAY represent the mapping of other logical components with physical components in the entAliasMappingTable.

7.1.1.5.7 Requirements for Entity Sensor MIB (RFC 3433)

The CMTS MAY implement the Entity Sensor MIB [RFC 3433].

For ENTITY-MIB [RFC 6933] entPhysicalTable instances with entPhysicalClass of 'sensor', the CMTS and CCAP MAY implement the entPhySensorTable with the same entPhysicalIndex used in the entPhysicalTable and the entPhySensorType of 'celsius'.

7.1.1.5.8 Requirements for Host Resources MIB (RFC 2790)

The CMTS and CCAP MAY implement the HOST-RESOURCES-MIB [RFC 2790].

7.1.1.5.9 Requirements for Ethernet Interface MIB (RFC 3635)

The CMTS and CCAP MUST implement [RFC 3635] for each of its Ethernet interfaces.

7.1.1.5.10 Requirements for Bridge MIB (RFC 4188)

If a CMTS is a Bridging CMTS, the CMTS MUST implement the Bridge MIB [RFC 4188] to manage the bridging process and represent state information about the CMTS Forwarders using link-layer (bridging) semantics.

If STP is enabled for the CMTS, then the CMTS implements the dot1dStp scalar group [RFC 4188] and optionally the dot1dStpPortTable [RFC 4188] as specified in Annex A.

7.1.1.5.11 Requirements for Internet Protocol MIB (RFC 4293)

The CMTS and CCAP requirements for [RFC 4293] are defined in the following sections.

7.1.1.5.11.1 The IP Group

The CMTS MUST implement the ipv4GeneralGroup.

The CMTS MUST implement the ipv6GeneralGroup2.

The CMTS MUST implement the ipv4InterfaceTable.

The CMTS MUST populate the ipv4InterfaceTable with each Ethernet interface with an assigned IPv4 address. The CMTS MAY record other interfaces in the ipv4InterfaceTable which have assigned IPv4 addresses.

The CMTS MUST populate the ipv6InterfaceTable with each Ethernet interface with an assigned IPv6 address. The CMTS MAY record other interfaces in the ipv6InterfaceTable which have assigned IPv6 addresses.

The CMTS MAY implement the ipSystemStatsTable.

The Routing CMTS MUST implement the ipIfStatsTable that includes both the CATV MAC interface and any NSI interfaces. The Bridging CMTS MAY implement the ipIfStatsTable.

The Routing CMTS MUST implement the ipAddressPrefixTable. The Bridging CMTS MAY implement the ipAddressPrefixTable.

The Routing CMTS MUST implement the ipAddressTable as Read-Only. The Bridging CMTS MAY implement the ipAddressTable.

The Routing CMTS MUST implement the ipNetToPhysicalTable. The Bridging CMTS MAY implement the ipNetToPhysicalTable.

The Routing CMTS MUST implement the ipDefaultRouterTable. The Bridging CMTS MAY implement the ipDefaultRouterTable.

If the CMTS has been configured for a default route, the Routing CMTS MUST populate the default router in the ipDefaultRouterTable.

The CMTS can populate the ipDefaultRouterTable with an IPv4 and/or IPv6 statically configured default router or a default router learned through a dynamic update mechanism such as a routing protocol update or IPv6 router advertisement message.

The Routing CMTS MUST implement the ipv6RouterAdvertTable. The Bridging CMTS MUST NOT implement the ipv6RouterAdvertTable.

7.1.1.5.11.2 The ICMP Group

The CMTS MUST implement the icmpStatsTable.

The CMTS MUST implement the icmpMsgStatsTable.

7.1.1.5.12 Requirements for User Datagram Protocol (UDP) MIB (RFC 4113)

The CMTS and CCAP SHOULD implement the UDP-MIB [RFC 4113].

7.1.1.5.13 Requirements for Transmission Control Protocol (TCP) MIB (RFC 4022)

The CMTS and CCAP SHOULD implement the TCP group in [RFC 4022].

7.1.1.5.14 Requirements for Multicast Group Membership Discovery (MGMD) MIB (RFC 5519)

The CMTS MUST implement [RFC 5519].

Refer to Section 6.5.8.21 for DOCSIS 4.0 MGMD CMTS and CCAP configuration implementation details.

7.1.1.5.15 Requirements for DOCSIS Baseline Privacy Plus MIB (RFC 4131)

The CMTS MUST implement [RFC 4131].

The CMTS MUST implement the CMTS extensions to [RFC 4131] listed in Section 6.5.6.2.

The CMTS MUST report values for the MIB object docsBpi2CmtsCACertTrust of either 'trusted', 'untrusted', or 'root'. The CMTS MAY persist entries with a docsBpi2CmtsCACertTrust value of 'chained' across reboots. The CMTS MUST be capable of removing entries in the docsBpi2CmtsCACertTable via SNMP by setting the row status

to 'destroy'. The CMTS MUST NOT allow new entries to be created for certificates that already exist in the docsBpi2CmtsCACertTable.

The CMTS MUST persist the entries in docsBpi2CmtsProvisionedCmCertTable across reboots. The CMTS MUST be capable of removing entries in docsBpi2CmtsProvisionedCmCertTable via SNMP by setting the row status to 'destroy'. The CMTS MUST NOT allow new entries to be created for certificates that already exist in the docsBpi2CmtsProvisionedCmCertTable.

The CMTS MUST extend the MIB object docsBpi2CmtsAuthBpkmCmCertValid enumerations as follows:

```
   docsBpi2CmtsAuthBpkmCmCertValid         OBJECT-TYPE
        SYNTAX    INTEGER {
                          unknown (0),
                          validCmChained (1),
                          validCmTrusted (2),
                          invalidCmUntrusted (3),
                          invalidCAUntrusted (4),
                          invalidCmOther (5),
                          invalidCAOther (6),
                          invalidCmRevoked(7),
                          invalidCARevoked(8)
                          }
        MAX-ACCESS     read-only
        STATUS    current
        DESCRIPTION
             "Contains the reason why a CM's certificate is deemed
        valid or invalid.
        Return unknown(0) if the CM is running BPI mode.
        ValidCmChained(1) means the certificate is valid
           because it chains to a valid certificate.
        ValidCmTrusted(2) means the certificate is valid
           because it has been provisioned (in the
           docsBpi2CmtsProvisionedCmCert table) to be trusted.
        InvalidCmUntrusted(3) means the certificate is invalid
           because it has been provisioned (in the
           docsBpi2CmtsProvisionedCmCert table) to be untrusted.
        InvalidCAUntrusted(4) means the certificate is invalid
           because it chains to an untrusted certificate.
        InvalidCmOther(5) and InvalidCAOther(6) refer to
           errors in parsing, validity periods, etc., which are
           attributable to the CM certificate or its chain,
           respectively; additional information may be found
           in docsBpi2AuthRejectErrorString for these types
           of errors.
        invalidCmRevoked(7) means the certificate is
          invalid as it was marked as revoked.
        invalidCARevoked(8) means the CA certificate is
          invalid as it was marked as revoked.
"        REFERENCE
             "DOCSIS Security Specification CM-SP-SECv3.0-I08-080522,
              Certificate Revocation section."
        ::= { docsBpi2CmtsAuthEntry 19 }
```

A DOCSIS 3.0 CMTS uses the value of MdifIndex as the ifIndex key in the following tables:

- docsBpi2CmtsBaseTable
- docsBpi2CmtsAuthTable
- docsBpi2CmtsTEKTable
- docsBpi2CmtsIpMulticastMapTable

Entries in the docsBpi2CmtsIpMulticastMapTable are only populated when an authorized joiner for a specific multicast group, which has been configured in the CmtsGrpCfg object for encryption (i.e., a CmtsGrpEncrypt object

instance exists and is referenced by a CmtsGrpCfg instance), has successfully joined a session. Thus, entries in this table are only created when active sessions have been initiated to authorized clients.

The CCAP MUST support the docsBpi2CmtsProvisionedCmCertDeviceType object as an addition to docsBpi2CmtsProvisionedCmCertTable.

```
docsBpi2CmtsProvisionedCmCertDeviceType OBJECT-TYPE
     SYNTAX         INTEGER {
                                        cm(1),
                                        rpd(2)
     MAX-ACCESS     read-create
     STATUS         current
     DESCRIPTION
          "This object indicates the device type for the provisioned
           certificate."
     REFERENCE
          "DOCSIS CCAP OSS Interface Specification,
           Requirements for DOCSIS Baseline Privacy Plus
           MIB (RFC 4131) section."
     ::= { docsBpi2CmtsProvisionedCmCertEntry 6 }
```

7.1.1.5.16 Requirements for Diffie-Helman USM Key MIB (RFC 2786)

The CMTS and CCAP MAY implement [RFC 2786].

7.1.1.5.17 Requirements for SNMPv3 MIB Modules

If the CMTS or CCAP supports the SNMPv3 protocol, the CMTS and CCAP MUST implement the MIBs defined in [RFC 3411] through [RFC 3415] and [RFC 3584].

The CMTS and CCAP SHOULD support a minimum of 30 available rows in the vacmViewTreeFamilyTable object.

7.1.1.5.18 Requirements for DOCSIS Interface Extension 2 MIB

The CMTS and CCAP MUST implement DOCS-IFEXT2-MIB, as specified in Annex A.

7.1.1.5.19 Requirements for CableLabs Topology MIB

The CMTS and CCAP MUST implement CLAB-TOPO-MIB, as specified in Annex A.

7.1.1.5.20 Requirements for DOCSIS Diagnostic Log MIB

The CMTS and CCAP MUST implement DOCS-DIAG-MIB, as specified in Annex A.

7.1.1.5.21 Requirements for DOCSIS Interface 3 MIB

The CMTS and CCAP MUST implement the DOCS-IF3-MIB, as specified in Annex A.

7.1.1.5.22 Requirements for DOCSIS Multicast MIB

The CMTS and CCAP MUST implement the DOCS-MCAST-MIB, as specified in Annex A.

7.1.1.5.23 Requirements for DOCSIS Multicast Authorization MIB

The CMTS and CCAP MUST implement the DOCS-MCAST-AUTH-MIB, as specified in Annex A.

7.1.1.5.24 Requirements for DOCSIS Quality of Service 3 MIB

The CMTS and CCAP MUST implement the DOCS-QOS3-MIB, as specified in Annex A.

A DOCSIS 4.0 CMTS and CCAP populates entries in the docsQosUpstreamStatsTable with information for Pre-3.0 DOCSIS devices. Devices operating in Multiple Transmit Channel mode will not be recorded in the docsQosUpstreamStatsTable and will instead be recorded in the docsQosServiceFlowCcfStatsTable.

7.1.1.5.25 Requirements for DOCSIS Security MIB

The CMTS and CCAP MUST implement the DOCS-SEC-MIB, as specified in Annex A.

7.1.1.5.26 Requirements for DOCSIS Subscriber Management 3 MIB

The CMTS and CCAP MUST implement the DOCS-SUBMGT3-MIB, as specified in Annex A.

7.1.1.5.27 Requirements for DOCSIS Load Balancing 3 MIB

The CMTS and CCAP MUST implement the DOCS-LOADBAL3-MIB, as specified in Annex A.

7.1.1.5.28 Requirements for DOCSIS DRF MIB (DRFI)

The CMTS MUST implement the managed objects from DOCS-DRF-MIB [DRFI] specified in Annex A for all the Downstream Channel interfaces that are integrated (ifType = 'docsCableDownstream').

7.1.1.5.29 Requirements for IP Multicast MIB (RFC 5132)

The CCAP MUST implement [RFC 5132].

If the CCAP has any one of the following multicast protocols enabled, PIM [RFC 4601], MLD [RFC 2710] [RFC 3810], or IGMP [RFC 1112] [RFC 2236] [RFC 3376], the CCAP MUST report a value of 'true' for ipMcastEnabled. When all three multicast protocols, PIM, MLD and IGMP are disabled in the CCAP, the value of 'false' is reported for ipMcastEnabled.

7.1.1.5.30 Requirements for DOCSIS Full-Duplex MIB

The CMTS and CCAP MUST implement the managed objects from DOCS-FDX-MIB [DOCS-FDX-MIB] specified in Annex A.

7.1.1.5.31 Requirements for DOCSIS Frequency-Division-Duplex MIB

The CMTS and CCAP MUST implement the managed objects from DOCS-FDD-MIB [DOCS-FDD-MIB] specified in Annex A, Detailed MIB Requirements (Normative).

7.1.1.5.32 Requirements for DOCSIS Interface 40 MIB

The CMTS and CCAP MUST implement the managed objects from DOCS-IF40-MIB [DOCS-IF40-MIB] specified in Annex A, Detailed MIB Requirements (Normative).

7.2 Performance Management Information Models

The Performance Management Information Model has been divided into the following categories:

- State Data: These objects are used to gather state information from the CCAP.
- Statistical Data: These objects are used to gather statistical information from the CCAP.

Those models are shown in the following sections.

7.2.1 State Data Information Models

7.2.1.1 CMTS Bonding Performance Management Information Model

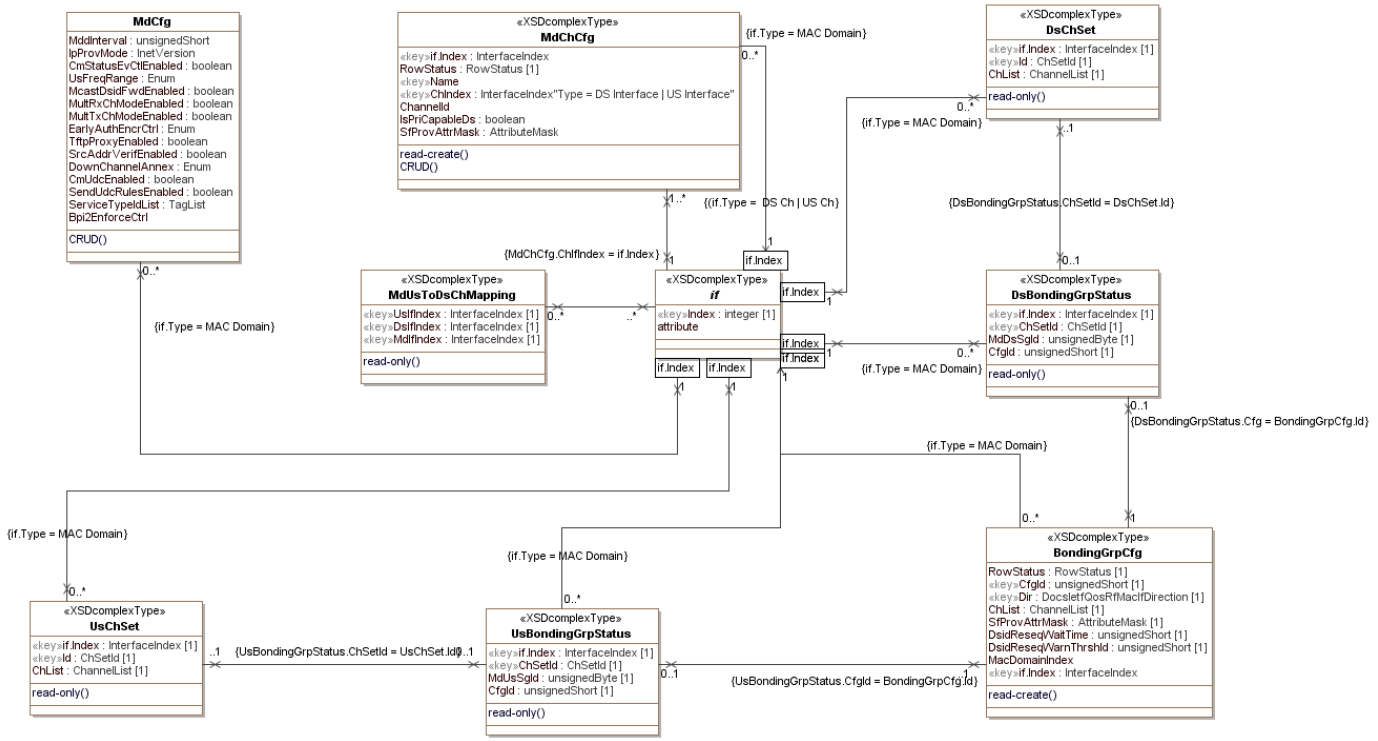


Figure 52 - CMTS Bonding Performance Management Information Model

7.2.1.1.1 MdUsToDsChMapping

This object returns the set of downstream channels that carry UCDs and MAPs for a particular upstream channel in a MAC Domain.

Table 341 - MdUsToDsChMapping Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
UsIfIndex	InterfaceIndex	key	Interface Index of a logical upstream channel	N/A	N/A
DsIfIIndex	InterfaceIndex	key		N/A	N/A
MdIfIndex	InterfaceIndex	read-only		N/A	N/A

7.2.1.1.1.1 UsIfIndex

This key represents the interface index of the logical upstream channel (ifType docsCableUpstreamChannel(205)) to which this instance applies.

7.2.1.1.1.2 DsIfIndex

This key represents the interface index of a downstream channel (ifTypes docsCableDownstream(128) and docsCableMCmtsDownstream(229)) carrying in UCD and MAP messages associated with the upstream channel defined by this instance.

7.2.1.1.1.3 MdIfIndex

This attribute represents the MAC domain of the upstream and downstream channels of this instance.

7.2.1.1.2 DsChSet

This object defines a set of downstream channels. These channel sets may be associated with channel bonding groups, MD-DS-SGs, MD-CM-SGs, or any other channel set that the CMTS may derive from other CMTS processes.

References: [MULPIv4.0] Partial Service Encoding section and Cable Modem Attribute Masks section in the Encodings for Configuration and MAC-Layer Messaging Annex.

Table 342 - DsChSet Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	InterfaceIndex of the MAC Domain interface	N/A	N/A
Id	ChSetId	key		N/A	N/A
ChList	ChannelList	read-only	SIZE (0|2..255)	N/A	N/A

7.2.1.1.2.1 IfIndex

This key represents the MAC Domain interface index where the downstream channel set is defined.

7.2.1.1.2.2 Id

This key defines a reference identifier for the downstream channel set within the MAC Domain.

7.2.1.1.2.3 ChList

This attribute defines the ordered list of channels that comprise the upstream channel set.

7.2.1.1.3 UsChSet

This object defines a set of upstream channels. These channel sets may be associated with channel bonding groups, MD-US-SGs, MD-CM-SGs, or any other channel set that the CMTS may derive from other CMTS processes.

References: [MULPIv4.0] Partial Service Encoding section and Cable Modem Attribute Masks section in the Encodings for Configuration and MAC-Layer Messaging Annex.

Table 343 - UsChSet Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	InterfaceIndex of the MAC Domain interface	N/A	N/A
Id	ChSetId	key		N/A	N/A
ChList	ChannelList	read-only	SIZE (0|2..255)	N/A	N/A

7.2.1.1.3.1 IfIndex

This key represents the MAC Domain interface index where the upstream channel set is defined.

7.2.1.1.3.2 Id

This key defines a reference identifier for the upstream channel set within the MAC Domain.

7.2.1.1.3.3 ChList

This attribute defines the ordered list of channels that comprise the upstream channel set.

7.2.1.1.4 DsBondingGrpStatus

This object returns administratively-configured and CMTS defined downstream bonding groups.

Table 344 - DsBondingGrpStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	N/A
ChSetId	ChSetId	key		N/A
MdDsSgId	UnsignedByte	read-only		N/A
CfgId	UnsignedShort	read-only		N/A

7.2.1.1.4.1 IfIndex

This key represents the interface index of the MAC Domain of the bonding group of this instance.

7.2.1.1.4.2 ChSetId

This key represents the identifier for the Downstream Bonding Group or the single-downstream channel of this instance.

7.2.1.1.4.3 MdDsSgId

This attribute corresponds to the MD-DS-SG-ID that includes all the downstream channels of the Downstream Bonding Group. The value zero indicates that the bonding group does not contain channels from a single MD-DS-SG and therefore the bonding group is not valid and usable.

7.2.1.1.4.4 CfgId

This attribute provides the BondingGrpCfgId for the downstream bonding group if it was configured. Otherwise, the zero value indicates that the CMTS will define the bonding group.

7.2.1.1.5 UsBondingGrpStatus

This object returns administratively-configured and CMTS-defined upstream bonding groups.

Table 345 - UsBondingGrpStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	N/A
ChSetId	ChSetId	key		N/A
MdUsSgId	UnsignedByte	read-only		N/A
CfgId	UnsignedShort	read-only		N/A

7.2.1.1.5.1 IfIndex

This key represents the interface index of the MAC Domain of the bonding group of this instance.

7.2.1.1.5.2 ChSetId

This key represents the identifier for the Upstream Bonding Group or the single-upstream channel of this instance.

7.2.1.1.5.3 MdUsSgId

This attribute corresponds to the MD-US-SG-ID that includes all the upstream channels of the Upstream Bonding Group. The value zero indicates that the bonding group does not contain channels from a single MD-US-SG and therefore the bonding group is not valid and usable.

7.2.1.1.5.4 CfgId

This attribute provides the BondingGrpCfgId for the upstream bonding group if it was configured. Otherwise, the zero value indicates that the CMTS defines the bonding group.

7.2.1.1.6 BondingGrpCfg

This object defines statically configured Downstream Bonding Groups and Upstream Bonding Groups on the CMTS.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the ChList attribute to be set.

The CMTS MUST persist all instances of BondingGrpCfg across reinitializations.

Table 346 - BondingGrpCfg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	InterfaceIndex of Mac Domain interface	N/A	N/A
Dir	IfDirection	key		N/A	N/A
Id	UnsignedShort	key	1..65535	N/A	N/A
ChList	ChannelList	read-create	SIZE (2..255)	N/A	N/A
SfProvAttrMask	AttributeMask	read-create		N/A	'80000000'H
DsidReseqWaitTime	UnsignedByte	read-create	0 | 1..180 | 255	hundredMicroseconds	255
DsidReseqWarnThrshld	UnsignedByte	read-create	0..179 | 255	hundredMicroseconds	255

7.2.1.1.6.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies.

7.2.1.1.6.2 Dir

This key represents whether this bonding group is an Upstream Bonding Group or a Downstream Bonding Group.

7.2.1.1.6.3 CfgId

This key represents the configured bonding group identifier in the indicated direction for the MAC Domain. This attribute is used for the sole purpose of tracking bonding groups defined by management systems.

7.2.1.1.6.4 ChList

This attribute contains the list of channels of the bonding group.

7.2.1.1.6.5 SfProvAttrMask

This attribute represents the Provisioned Attribute Mask encoding for the bonding group.

References: [MULPIv4.0] Service Flow Assignment section.

7.2.1.1.6.6 DsidReseqWaitTime

For a Downstream Bonding Group, this attribute provides the DSID Resequencing Wait Time that is to be used for all DSIDs associated with this Downstream Bonding Group. The value of 255 indicates that the DSID Resequencing Wait Time is determined by the CMTS. The value zero in not supported for downstream bonding groups.

For an Upstream Bonding Group, this attribute has no meaning and returns the value 0.

7.2.1.1.6.7 DsidReseqWarnThrshld

For a Downstream Bonding Group, this attribute provides the DSID Resequencing Warning Threshold that is to be used for all DSIDs associated with this Downstream Bonding Group. The value of 255 indicates that the DSID Resequencing Warning Threshold is determined by the CMTS. The value of 0 indicates that the threshold warnings are disabled. When the value of DsidReseqWaitTime is not equal to 0 or 255, the CMTS MUST ensure that the value of this object is either 255 or less than the value of DsidReseqWaitTime.

For an Upstream Bonding Group, this attribute has no meaning and returns the value 0.

7.2.1.1.7 MdChCfg

This object configures the association of downstream and upstream channels to a particular MAC Domain (MD) on a CMTS. The creation of channels and MAC domain object interface instances is vendor-specific. In particular, the assignment of the channel interface index is normally vendor-specific. Therefore, this object is intended only for associating channels to a MAC Domain and assumes that those channels were previously configured.

The CMTS MAY have restrictions on which channels can be configured in the same MAC Domain. For example, it could require the upstream channels to be from the same line card.

This object supports the creation and deletion of multiple instances.

Creation of a new instance of this object requires the ChId attribute to be set.

The CMTS MUST persist all instances of MdChCfg across reinitializations.

Table 347 - MdChCfg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	N/A	N/A
ChIfIndex	InterfaceIndex	key	InterfaceIndex of downstream or upstream channel	N/A	N/A
IsPriCapableDs	Boolean	read-create		N/A	
ChId	ChId	read-create	1..255	N/A	N/A
SfProvAttrMask	AttributeMask	read-create		N/A	'00000000'H

7.2.1.1.7.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies. The CMTS MAY restrict the value chosen for the IfIndex attribute of the MdChCfg object.

7.2.1.1.7.2 ChIfIndex

This key represents the interface index of an existing OFDMA upstream (ifType docsOfdmaUpstreamChannel(278)) or OFDM downstream (ifType docsOfdmDownstreamChannel(277)) or existing logical upstream (ifType docsCableUpstreamChannel(205)) or downstream (ifTypes docsCableDownstream(128) and docsCableMCmtsDownstream(229)) channel that is configured to be part of the MAC Domain.

The CMTS could require that all upstream logical channels under the same physical upstream interface be assigned to one MAC Domain.

7.2.1.1.7.3 IsPriCapableDs

If set to 'true', this attribute configures the downstream channel as Primary-Capable. The default value for a downstream channel is 'true'. This attribute is not relevant for upstream interfaces; therefore, it reports the value 'false' for such interfaces. A CMTS MAY restrict the permitted value of this attribute based upon physical channel capabilities. OFDM channels are all Primary-Capable.

7.2.1.1.7.4 ChId

This attribute contains the 8-bit Downstream Channel ID (DCID) or Upstream Channel ID (UCID) configured for the channel in the MAC Domain.

7.2.1.1.7.5 SfProvAttrMask

This attribute contains Provisioned Attribute Mask of non-bonded service flow assignment to this channel.

7.2.1.2 Receive Channel Performance Management Information Model

This section defines the CCAP Receive Channel Configuration (RCC) Status objects.

The RccCfg object is taken from the CCAP Configuration UML model, described in Section 6.5.6.6.14.

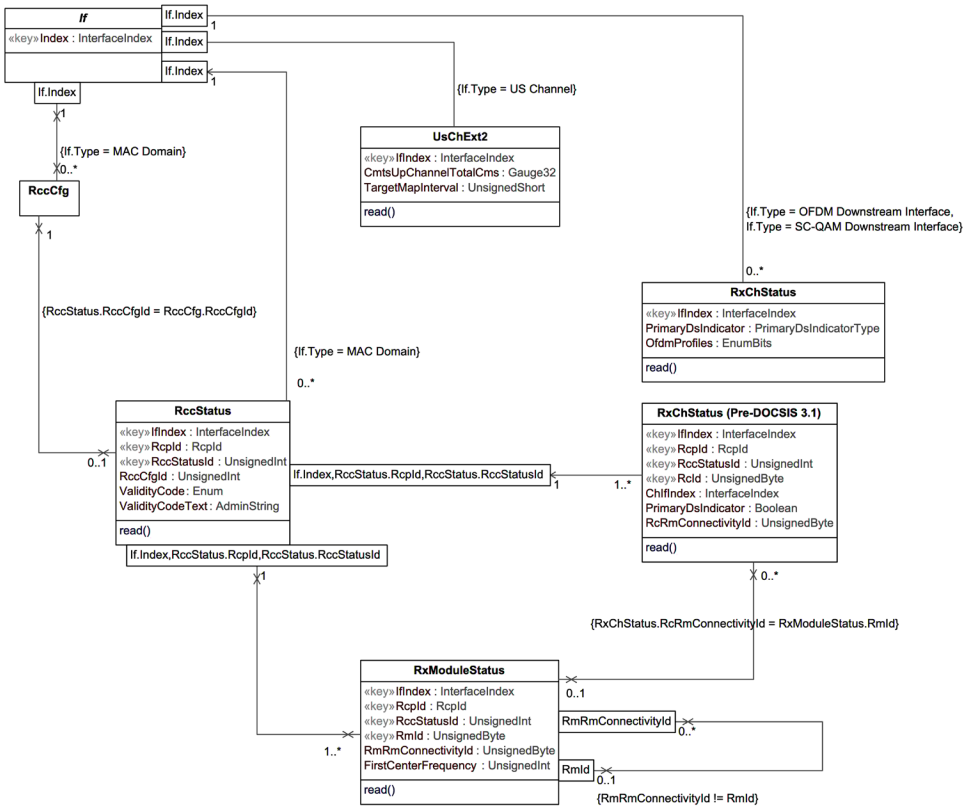


Figure 53 - Receive Channel Performance Management Information Model

7.2.1.2.1 RccStatus

The RCC Status object provides a read-only view of the statically-configured (from the RccCfg object) and dynamically-created RCCs.

The CMTS creates an RCC Status instance for each unique MAC Domain Cable Modem Service Group (MD-CM-SG) to which it signals an RCC to the CM.

Table 348 - RccStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	
RcpId	RcpId	key		
RccStatusId	UnsignedInt	key	1..4294967295	
RccCfgId	UnsignedInt	read-only		

Attribute Name	Type	Access	Type Constraints	Units
ValidityCode	Enum	read-only	other(1) valid(2) invalid(3) wrongPrimaryDs(4) missingPrimaryDs(5) multiplePrimaryDs(6) duplicateDs(7) wrongFrequencyRange(8) wrongConnectivity(9)	
ValidityCodeText	AdminString	read-only		

7.2.1.2.1.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies.

7.2.1.2.1.2 RcpId

This key represents the RCP-ID to which this instance applies.

7.2.1.2.1.3 RccStatusId

This key represents an RCC combination for a particular RcpId either from an RCC configuration object or a CMTS-determined RCC and is unique per combination of MAC Domain IfIndex and RcpId.

7.2.1.2.1.4 RccCfgId

This attribute identifies an RCC-Configured combination from which this instance was defined. If nonzero, it corresponds to the RccCfg instance from which the RCC was created. Zero means that the RCC was dynamically created by the CMTS.

7.2.1.2.1.5 ValidityCode

This attribute indicates whether the RCC instance of this object is valid or not. An RCC Status instance from a configured or a dynamic RCC could become invalid, for example, due to changes in the topology.

7.2.1.2.1.6 ValidityCodeText

This attribute contains the CMTS vendor-specific log information from the Receive Channel Configuration Status encoding.

7.2.1.2.2 RxModuleStatus

The Receive Module Status object provides a read-only view of the statically configured and dynamically created Receive Modules within an RCC. When this object is defined on the CM, the value of RccStatusId is always 1.

Table 349 - RxModuleStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	
RcpId	RcpId	key		
RccStatusId	UnsignedInt	key	1..4294967295	
RmId	UnsignedByte	key	1..255	
RmRmConnectivityId	UnsignedByte	read-only		
FirstCenterFrequency	UnsignedInt	read-only		Hz

7.2.1.2.2.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies.

7.2.1.2.2.2 RcpId

This key represents the RCP-ID to which this instance applies.

7.2.1.2.2.3 RccStatusId

This key represents an RCC combination for a particular RcpId either from an RCC configuration object or a CMTS determined RCC and is unique per combination of MAC Domain interface index and RcpId. Note that when this attribute is instantiated at the CM, its value will always be 1.

7.2.1.2.2.4 RmId

This key represents an identifier of a Receive Module instance within the Receive Channel Profile.

References: [MULPIv4.0] Receive Module Index section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.2.2.5 RmRmConnectivityId

This attribute represents the Receive Module to which this Receive Module connects. Requirements for module connectivity are detailed in the RmRmConnectivityId of the RccCfg object.

7.2.1.2.2.6 FirstCenterFrequency

This attribute represents the low frequency channel of the Receive Module, or 0 if not applicable to the Receive Module.

7.2.1.2.3 Pre-DOCSIS 3.1 RxChStatus

The Receive Channel Status object reports the status of the statically-configured and dynamically-created Receive Channels within an RCC. When this object is defined on the CM, the value of RccStatusId is always 1.

This object provides the ability for the CCAP to report a DOCSIS 3.0 CM receive channel configuration and is applicable for cases where a DOCSIS 3.0 CM registers with a DOCSIS 3.1 or later CCAP.

Table 350 - Pre-DOCSIS 3.1 RxChStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	
RcpId	RcpId	key		
RccStatusId	UnsignedInt	key	1..4294967295	
RcId	UnsignedByte	key	1..255	
ChIfIndex	InterfaceIndex	read-only	InterfaceIndex of Downstream Channel assigned to the Receive Channel	
PrimaryDsIndicator	Boolean	read-only		
RcRmConnectivityId	UnsignedByte	read-only		

7.2.1.2.3.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies.

7.2.1.2.3.2 RcpId

This key represents the RCP-ID to which this instance applies.

7.2.1.2.3.3 RccStatusId

This key represents an RCC combination for a particular RcpId either from an RCC configuration object or a CMTS determined RCC. It is unique per combination of MAC Domain interface index and RcpId. Note that when this attribute is instantiated at the CM, its value will always be 1.

7.2.1.2.3.4 RcId

This key represents an identifier for the parameters of the Receive Channel instance within the Receive Channel Profile.

7.2.1.2.3.5 ChIfIndex

This attribute contains the interface index of the Downstream Channel that this Receive Channel Instance defines.

7.2.1.2.3.6 PrimaryDsIndicator

If set to 'true', this attribute indicates the Receive Channel is to be the primary-capable downstream channel for the CM receiving this RCC. Otherwise, the downstream channel is to be a non-primary-capable channel.

7.2.1.2.3.7 RcRmConnectivityId

This attribute identifies the Receive Module to which this Receive Channel connects. A value of zero indicates that the Receive Channel Connectivity TLV is omitted from the RCC.

7.2.1.2.4 RxChStatus

The Receive Channel Status object reports the status of the statically-configured and dynamically-created Receive Channels within an RCC.

This object provides the ability for the CCAP to report a DOCSIS CM OFDM receive channel configuration.

Table 351 - RxChStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	SC-QAM or OFDM Index		
PrimaryDsIndicator	PrimaryDsIndicatorType	read-only			
OfdmProfiles	EnumBits	read-only	profile0(0), profile1(1), profile2(2), profile3(3), profile4(4), profile5(5), profile6(6), profile7(7), profile8(8), profile9(9), profile10(10), profile11(11), profile12(12), profile13(13), profile14(14), profile15(15)		

7.2.1.2.4.1 IfIndex

This key represents the SC-QAM or OFDM interface index to which this instance applies.

7.2.1.2.4.2 PrimaryDsIndicator

This attribute is used to identify the downstream channel as primary, backup primary, or non-primary.

7.2.1.2.4.3 OfdmProfiles

A CCAP supports as many as 16 downstream profiles on an OFDM channel as defined in [MULPIv3.1] Downstream Profiles section. This attribute identifies which downstream channel profiles are provisioned on the CM. Examples of EnumBits follow. Each bit of this attribute corresponds to one of the sixteen profiles, with bit 0 corresponding to profile 0 and bit 15 corresponding to profile 15. Value '1' returned for a bit indicates the corresponding profile is provisioned on the cable modem. Value '0' returned for a bit indicates the corresponding profile is not provisioned on the cable modem.

When reporting for an SC-QAM channel, this attribute returns value '0' for all bits.

Example 1: A Cable Modem configured with OFDM Profile 5 would return a query response as follows. EnumBits: 0000010000000000 or 0x0400.

Example 2: A Cable Modem configured with an SC_QAM Channel would return a query response as follows. EnumBits: 000000000000000 or 0x0.

7.2.1.2.5 UsChExt2

The UsChExt2 object is optional and defines management extensions for upstream local channels.

Reference: docsIfExt2CmtsUpChannelTable [DOCS-IFEXT2-MIB]

Table 352 - UsChExt2 Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of a logical upstream channel.	N/A
CmtsUpChannelTotalCms	Gauge32	read-only		N/A
TargetMapInterval	UnsignedShort	read-only		microseconds

7.2.1.2.5.1 IfIndex

This key represents the interface index of the logical upstream channel to which this instance applies.

7.2.1.2.5.2 CmtsUpChannelTotalCms

This attribute reports the total number of CMs with channels in the CM Transmit Channel Set (TCS) and where each CM's CmtsCmRegStatus::Value has reached a state of 'registrationComplete', 'operational', 'bpiInit', or 'forwardingDisabled'.

7.2.1.2.5.3 TargetMapInterval

This attribute reports the target MAP interval for the selected channel.

7.2.1.3 DOCS-L2VPN-MIB State Information Model

The objects in the DOCS-L2VPN-MIB: State Objects are taken from the DOCS-L2VPN-MIB specified in Annex A of [L2VPN] and are used without modification for the CCAP.

Reference: [L2VPN], DOCS-L2VPN-MIB

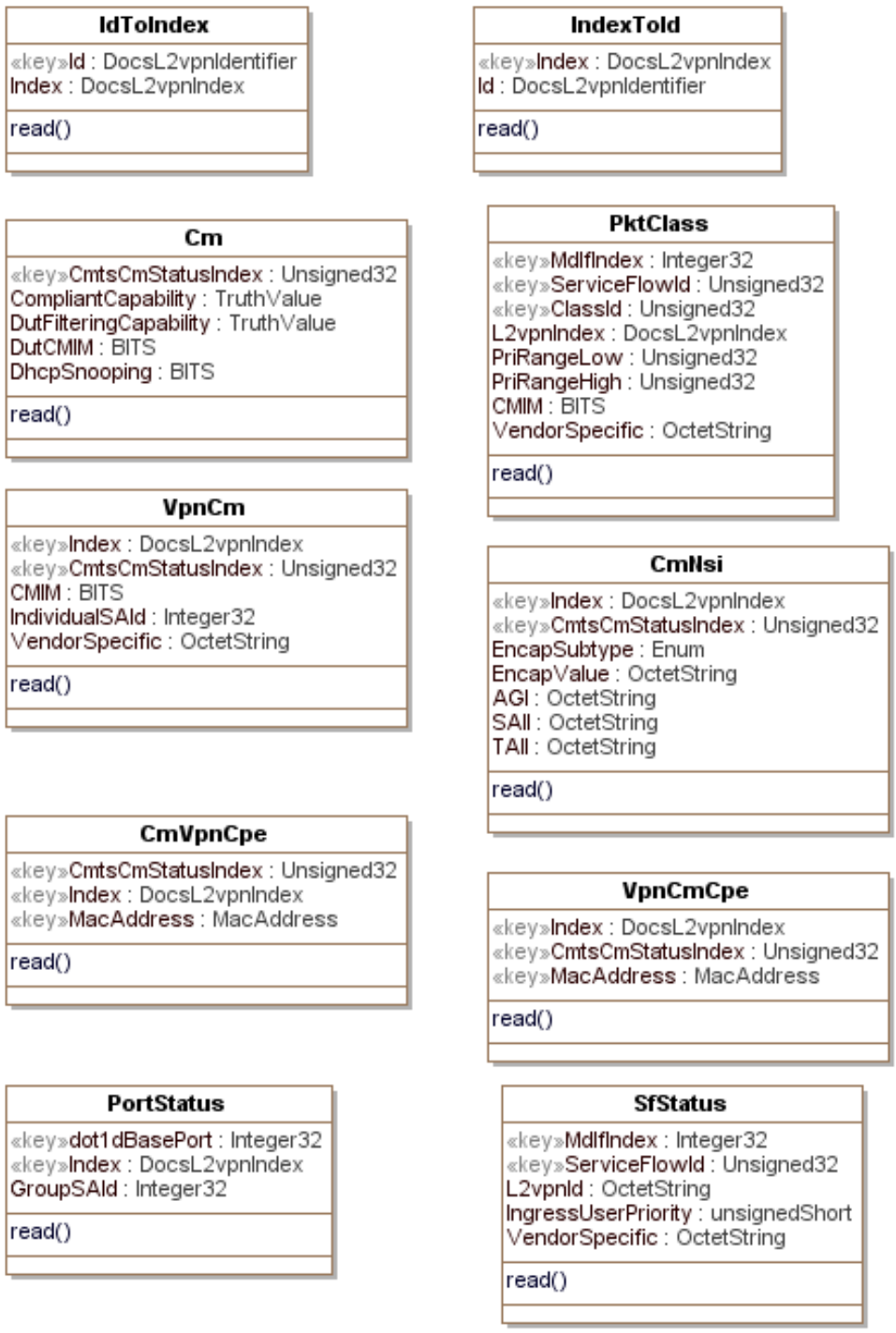


Figure 54 - DOCS-L2VPN-MIB State Information Model

7.2.1.4 DOCS-LOADBAL3-MIB State Information Model

The objects in the DOCS-LOADBAL3-MIB are taken from the DOCS-LOADBAL3-MIB specified Annex Q of [OSSIv3.0] and used without modification for the CCAP.

The following attributes of the CmtsCmParams object are writeable:

- ProvGrpId
- ProvServiceTypeId
- PolicyId
- Priority

Reference: [OSSIv3.0], DOCS-LOADBAL3-MIB

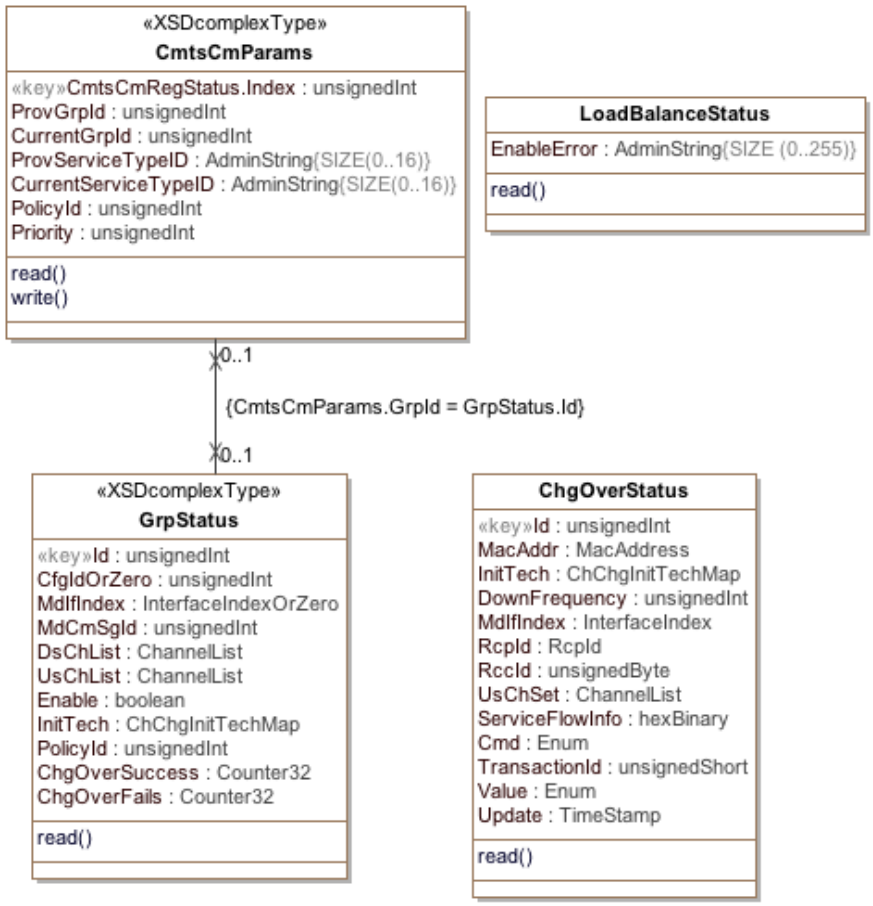


Figure 55 - DOCSIS Load Balance State Information Model

7.2.1.4.1 CmtsCmParams

This object represents the autonomous load balancing parameters provisioned for cable modem. The CMTS selects the cable modem Load Balancing Group (GrpId attribute of this object) from multiple sources by following the rules and sequence described below:

The CMTS selects the assignment of the CM to a Load Balancing Group by determining first if the CM is in a Restricted Load Balancing Group or in its absence to the General Load Balancing group that corresponds to the MD-CM-SG of the CM. The selection of the Restricted Load Balancing group is achieved by first matching the CM in the RestrictCmCfg Object and if no match is found, by selecting the best match within the ResGrpCfg object.

The best match within the ResGrpCfg follows the MULPI requirements on precedence of the CM signaled TLVs: ServiceType ID and Load Balancing Group ID (for backward compatibility of provisioned Group IDs).

References: [MULPIv4.0], Channel Assignment During Registration section.

Table 353 - CmtsCmParams Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	read-only		N/A	N/A
ProvGrpId	UnsignedInt	read-only		N/A	N/A
CurrentGrpId	UnsignedInt	read-only		N/A	N/A
ProvServiceTypeID	String	read-only	SIZE (0..16)	N/A	N/A
CurrentServiceTypeID	String	read-only	SIZE (0..16)	N/A	N/A
PolicyId	UnsignedInt	read-only		N/A	N/A
Priority	UnsignedInt	read-only		N/A	N/A

7.2.1.4.1.1 CmtsCmRegStatusId

This key is the CMTS generated unique identifier of a CM for status report purposes.

7.2.1.4.1.2 ProvGrpId

This attribute indicates the provisioned Load Balancing Group ID TLV the CM signaled to the CMTS during registration, or zero if not provisioned in the CM.

7.2.1.4.1.3 CurrentGrpId

This attribute references the Load Balancing Group Identifier (Id attribute from the GrpStatus object) associated with the cable modem after the CMTS validates the CM Load Balancing Group ID TLV, Service Type ID TLV and Restricted CM list. The value zero indicates that the Load Balancing Group is invalid, or the General Load Balancing Group is invalid due ambiguous topology resolution.

7.2.1.4.1.4 ProvServiceTypeID

This attribute indicates the provisioned Service Type ID TLV the CM signaled to the CMTS during registration, or the zero-length string if not provisioned in the CM.

7.2.1.4.1.5 CurrentServiceTypeID

This attribute represents the Service Type ID the CMTS picked from the Restricted Group of Restricted CM list, or the Service Type Id TLV the CM signaled to the CMTS during registration, or the zero-length string if none was used.

7.2.1.4.1.6 PolicyId

This attribute references the Load Balancing Policy ID associated to the cable modem either from the configuration file or from the general or Restricted Load Balancing Groups CMTS configuration.

7.2.1.4.1.7 Priority

This attribute references the Load Balancing Priority associated to the cable modem either from the configuration file or from the General or Restricted Load Balancing Groups CMTS configuration.

7.2.1.4.2 GrpStatus

This object represents the status of all General and Restricted Load Balancing Groups in this CMTS. This object summarizes the load balancing parameters that applies to CMTS system wide Load Balancing Groups. The Load Balancing Groups defined in this object include the configured Restricted Load Balancing Groups and the General Load Balancing Groups derived from the GeneralGrpCfg object.

Table 354 - GrpStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Id	UnsignedInt	read-only		N/A	N/A
CfgIdOrZero	UnsignedInt	read-only		N/A	N/A
MdIfIndex	InterfaceIndexOrZero	read-only	Interface Index of the MAC interface	N/A	N/A
MdCmSgId	UnsignedInt	read-only		N/A	N/A
DsChList	ChannelList	read-only		N/A	N/A
UsChList	ChannelList	read-only		N/A	N/A
Enable	Boolean	read-only		N/A	N/A
InitTech	ChChgInitTechMap	read-only		N/A	N/A
PolicyId	UnsignedInt	read-only		N/A	N/A
ChgOverSuccess	Counter32	read-only		N/A	N/A
ChgOverFails	Counter32	read-only		N/A	N/A

7.2.1.4.2.1 Id

This key represents a unique identifier of a Load Balancing Group in the CMTS.

7.2.1.4.2.2 CfgIdOrZero

This attribute references the Id attribute of the instance of the ResGrpCfg this instance corresponds to. The value zero indicates that the instance corresponds to a General Load Balancing Group.

7.2.1.4.2.3 MdIfIndex

This attribute represents the MAC domain where the Load Balancing Group applies. The value zero is allowed to indicate that vendor-specific mechanisms are used in load balancing operations. For example, to provide Load Balancing Groups across MAC domains.

7.2.1.4.2.4 MdCmSgId

This attribute corresponds to the MD-CM-SG-ID that includes all the upstream and downstream channels of the Load Balancing Group. The value zero indicates that this instance corresponds to a Restricted Load Balancing Group. If there are vendor-specific Load Balancing Groups configuration (e.g., MdIfIndex set to zero), this attribute value might not be meaningful.

7.2.1.4.2.5 DsChList

This attribute contains the list of downstream channels of the Load Balancing Group. If there are vendor-specific Load Balancing Groups configuration (e.g., MdIfIndex set to zero), this attribute value might not be meaningful.

7.2.1.4.2.6 UsChList

This attribute contains the list of the upstream channels of the Load Balancing Group. If there are vendor-specific Load Balancing Groups configuration (e.g., MdIfIndex set to zero), this attribute value might not be meaningful.

7.2.1.4.2.7 Enable

This attribute when set to 'true' indicates that load balancing is enabled on this group or disabled if set to 'false'.

7.2.1.4.2.8 InitTech

This attribute indicates the initialization techniques that the CMTS can use when load balancing cable modems that are associated with the Load Balancing Group.

7.2.1.4.2.9 PolicyId

This attribute indicates the Policy that the CMTS can use when load balancing cable modems that are associated with the Load Balancing Group.

7.2.1.4.2.10 ChgOverSuccess

This attribute counts the number of successful Autonomous Load Balancing operations associated with this Load Balancing Group.

7.2.1.4.2.11 ChgOverFails

This attribute counts the number of failed Autonomous load balancing operations associated with this Load Balancing Group.

7.2.1.4.3 ChgOverStatus

This object reports the status of cable modems instructed to move to a new downstream and/or upstream channel or channel sets when commanded either by an operation in the ChgOver object. An instance in this object is created for each change-over operation committed successfully. If the instance value attribute is not final (the change-over operation is still pending completion), this instance is expected to be updated at some point later to reflect the final state of the change-over operation.

Table 355 - ChgOverStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Id	UnsignedInt	key			
MacAddr	MacAddress	read-only			
InitTech	ChChgInitTechMap	read-only			
DownFrequency	UnsignedInt	read-only			
MdIfIndex	InterfaceIndexOrZero	read-only	Interface Index of the MAC interface		
RcpId	RcpId	read-only			
RccId	UnsignedByte	read-only			
UsChSet	ChannelList	read-only			
ServiceFlowInfo	HexBinary	read-only			
Cmd	Enum	read-only	ucc(1) dcc(2) dbc(3) crossMD(4)		
TransactionId	UnsignedShort	read-only			
Value	Enum	read-only	messageSent(1) noOpNeeded(2) modemDeparting(3) waitToSendMessage(4) cmOperationRejected(5) cmtsOperationRejected(6) timeOutT13(7) timeOutT15(8) rejectinit(9) success(10) dbcTimeout(11)		
Update	TimeStamp	read-only			

7.2.1.4.3.1 Id

This key represents a monotonically increasing value for the record that stores the status of the change-over operation. When the ChOverStatus object exceeds the size limit of this object the lowest Id value instances are removed so that the total number of entries no longer exceeds the size limit allowing the CMTS to maintain the most current entries.

7.2.1.4.3.2 MacAddr

This attribute represents the Mac address set in the ChgOver object commit operation.

7.2.1.4.3.3 InitTech

The initialization technique set in change-over operation.

7.2.1.4.3.4 DownFrequency

This attribute represents the Downstream frequency set in the ChgOver object commit operation, or zero

7.2.1.4.3.5 MdIfIndex

This attribute represents the MAC Domain Interface index set in the ChgOver object commit operation, or zero.

7.2.1.4.3.6 RcpId

This attribute represents the RCP-ID set in the MultipleChChgOver object commit operation, or all zeros RCP-ID value.

7.2.1.4.3.7 RccId

This attribute represents the RCC Status Index set in the ChgOver object commit operation, or zero.

7.2.1.4.3.8 UsChSet

This attribute represents the Upstream Channel Set in the ChgOver object commit operation, or zero.

7.2.1.4.3.9 ServiceFlowInfo

This attribute represents the list of Service Flow-Channel Set ID pairs set in the ChgOver object commit operation, or zero-length string.

7.2.1.4.3.10 Cmd

The load balancing MAC Management Message exchange type used by the CMTS for the change-over operation in the ChgOver object commit operation.

- 'ucc' indicates the usage of Upstream Channel Change (UCC) messages exchange.
- 'dcc' indicates the usage of Dynamic Channel Change (DCC) messages exchange.
- 'dbc' indicates the usage of Dynamic Bonding Change (DBC) messages exchange
- 'crossMD' although this term does not correspond to a MAC Management Message type, it indicates the movement of a CM to a different MAC Domain that includes a sequence of different MAC Management Messages types (i.e., DCC to move the CM to the correct MAC Domain, followed by channel assignment in REG-RSP-MP).

7.2.1.4.3.11 TransactionId

This attribute represents the transaction Id value used in the change-over operation.

7.2.1.4.3.12 Value

This attribute represents the status of the specified change-over operation. The enumerations are:

Change-over using DCC message exchange:

- 'modemDeparting'
  The cable modem has responded with a change-over response of either a DCC-RSP with a confirmation code of depart(180) or a UCC-RSP.
- 'timeOutT13'
  Failure due to no DCC-RSP with confirmation code depart(180) received prior to expiration of the T13 timer.
- 'timeOutT15'
  T15 timer timed out prior to the arrival of a bandwidth request, RNG-REQ message, or DCC-RSP message with confirmation code of arrive(181) from the cable modem.

Change-over using DBC message exchange:

- 'dbcTimeout'
  The number of DBC-REQ retries was exceeded and no DBC-RSP was received

Change-over CMTS verifications:

- 'messageSent'
  The CMTS has sent a DOCSIS MAC message request to instruct the CM to do the change-over operation.
- 'noOpNeed'
  A change-over operation was requested in which neither the DS and US channels where the CM is operational changed.
- 'waitToSendMessage'
  The specified operation is active and CMTS is waiting to send the channel change message with channel info to the cable modem.
- 'cmOperationRejected'
  Channel Change operation was rejected by the cable modem.
- 'cmtsOperationRejected'
  Channel Change operation was rejected by the Cable Modem Termination System.
- 'rejectInit'
  Operation rejected due to unsupported initialization tech requested.
- 'success'
  CMTS received an indication that the CM successfully completed the change-over operation. e.g., If an initialization technique of re-initialize the MAC is used, success in indicated by the receipt of a DCC-RSP message with a confirmation code of depart(180) or DBC confirmation code ok/success. In all other DCC cases, success is indicated by: (1) the CMTS received a DCC-RSP message with confirmation code of arrive(181) or (2) the CMTS internally confirms the presence of the CM on the new channel(s).

7.2.1.4.3.13 Update

The value of sysUpTime when the attribute Value of this instance was last updated.

7.2.1.4.4 LoadBalanceStatus

This object represents the control and status of Autonomous Load Balancing Operations.

Table 356 - LoadBalanceStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
EnableError	AdminString	read-only	SIZE(0..255)		"H

7.2.1.4.4.1 EnableError

This attribute represents a text message that describes a failure to enable load balancing due configuration errors, or other considerations. The zero-length string indicates no errors occurred during the last Autonomous Load Balancing activation.

7.2.1.5 DOCS-MCAST-AUTH-MIB Performance Management Information Model

The objects in the DOCS-MCAST-AUTH-MIB are taken from the DOCS-MCAST-AUTH-MIB specified in Annex Q of [OSSIv3.0] and used without modification for the CCAP.

Reference: [OSSIv3.0], DOCS-MCAST-AUTH-MIB

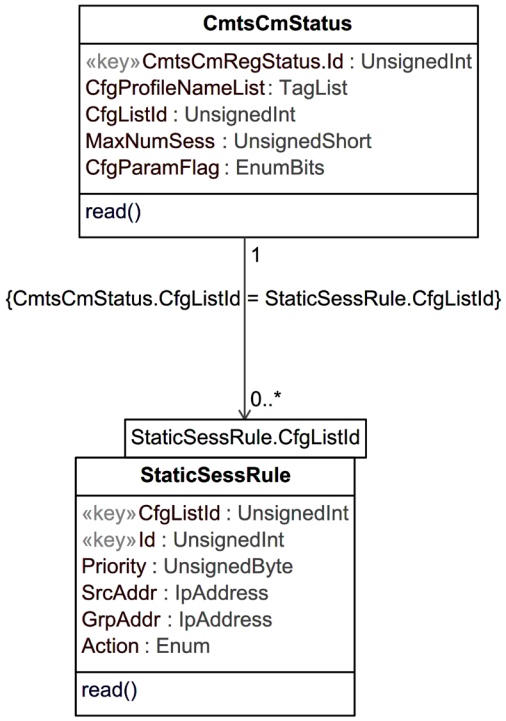


Figure 56 - Multicast Authorization Performance Management Information Model

7.2.1.5.1 CmtsCmStatus

This object maintains per-CM status of Multicast Authorization policies to be applied to this CM. The CM acquires these policy parameters through the CM registration process, or in the absence of some or all of those parameters, from the Ctrl Object.

This object is meaningful when the Ctrl Enable attribute is set to 'enable'.

In the process of authorizing a CM client's session request, the CMTS MUST check rules defined in StaticSessRule object and then rules defined in ProfileSessRule object. In the case of multiple multicast session matches, the rule priority attribute defines the final selected session rule. The selection of a session rules when multiple matches have the same priority is vendor specific.

The CMTS MAY report in the CmtsCmStatus object CMs that do not signal any IP Multicast Authorization Encodings in the registration process.

Table 357 - CmtsCmStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	key	1..4294967295	N/A	N/A
CfgProfileNameList	TagList	read-only		N/A	N/A
CfgListId	UnsignedInt	read-only		N/A	N/A
MaxNumSess	UnsignedShort	read-only		sessions	N/A
CfgParamFlag	EnumBits	read-only	profile(0) staticMulticast(1) maxNumSessions(2)	N/A	N/A

7.2.1.5.1.1 CmtsCmRegStatusId

This attribute is a key which uniquely identifies the CM. This attribute matches an index value of the CMTS CM Registration Status object.

References: Section 7.2.2.2.1, CmtsCmRegStatus.

7.2.1.5.1.2 CfgProfileNameList

This attribute indicates the set of Profile Names associated with the CM.

This attribute indicates the CM signaled 'IP Multicast Authorization Profile Name' encodings during the CM registration process, or in the absence of instances of that config file parameter, the DefProfileNameList attribute from the Ctrl object.

References: [MULPIv4.0] IP Multicast Profile Name Subtype sections.

7.2.1.5.1.3 CfgListId

This attribute identifies the reference to a CMTS created Session Rule List based on the CM signaled 'IP Multicast Authorization Static Session Rule' encodings. The CMTS may reuse this attribute value to reference more than one CM that have signaled the same list of Session Rules to the CMTS.

The value zero indicates that the CM did not signal Multicast Session Rules to the CMTS or the CMTS does not support the StaticSessRule, in which case, the CMTS ignores any CM signaled Session Rule encodings during registration.

References: [MULPIv4.0] IP Multicast Join Authorization Static Session Rule Subtype section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.5.1.4 MaxNumSess

This attribute indicates the CM signaled value in Maximum Multicast Sessions Encoding during the CM registration process. If this value is missing the DefMaxNumSess attribute of the Ctrl object is used to determine the maximum number of multicast sessions this client may forward. The value 0 indicates that no dynamic joins are permitted. The value 65535 (the largest valid value) indicates that the CMTS permits any number of sessions to be joined by clients reached through the CM.

References: [MULPIv4.0] Maximum Multicast Sessions Encoding section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.5.1.5 CfgParamFlag

This attribute represents the functions that are activated through the registration process.

The bit 'profile' indicates whether the CM signaled 'IP Multicast Authorization Profile Name Subtype' encodings.

The bit 'staticMulticast' indicates whether the CM signaled 'IP Multicast Authorization Static Session Rule Subtype' encodings.

The bit 'maxNumSessions' indicates whether the CM signaled the 'Maximum Multicast Sessions' encoding.

7.2.1.5.2 StaticSessRule

This object defines the Session authorization Rules based on the CM or group of CMs signaled in IP Multicast Join Authorization Static Session Subtype encoding This object reflects the Static Session rules that were included in the CM registration request message.

The CMTS MAY persist all instances of the StaticSessRule object across reinitializations.

References: [MULPIv4.0] IP Multicast Join Authorization Static Session Rule Subtype section in the Encodings for Configuration and MAC-Layer Messaging Annex.

Table 358 - StaticSessRule Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CfgListId	UnsignedInt	key	1..4294967295	N/A	N/A
Id	UnsignedInt	key	1..4294967295	N/A	N/A
Priority	UnsignedByte	read-only		N/A	N/A
SrcAddr	IpAddress	read-only		N/A	N/A
GrpAddr	IpAddress	read-only		N/A	N/A
Action	Enum	read-only	permit(1) deny(2)	N/A	N/A

7.2.1.5.2.1 CfgListId

This attribute contains a CMTS-derived value for a set of multicast static session rules associated to one or more CMs.

7.2.1.5.2.2 Id

This attribute provides an identifier for each Multicast Authorization Static Session rule in the IP Multicast Join Authorization Static Session SubType communicated by a CM or group of CMs during registration.

7.2.1.5.2.3 Priority

This attribute defines the rule priority for the static session rule. Higher values indicate a higher priority. If more than one session rule matches a joined session, the session rule with the highest rule priority determines the authorization action.

7.2.1.5.2.4 SrcAddr

This attribute identifies a specific Multicast Source Address defined for this rule. A Source Address that is all zeros is defined as 'all source addresses (*, G)'. Source addresses are unicast host addresses.

References: [RFC 3306] sections 6 and 7.

7.2.1.5.2.5 GrpAddr

This attribute is the IP address corresponding to an IP multicast group.

7.2.1.5.2.6 Action

This attribute specifies the authorization action for a session join attempt that matches the session rule.

The value 'accept' indicates that the rule permits a matching multicast join request is allowed. The value 'deny' indicates that a matching multicast join request is denied.

7.2.1.6 DOCSIS QoS State Information Model

This section defines state performance management objects from the DOCS-QOS3-MIB.

Reference: [DOCS-QOS3-MIB]

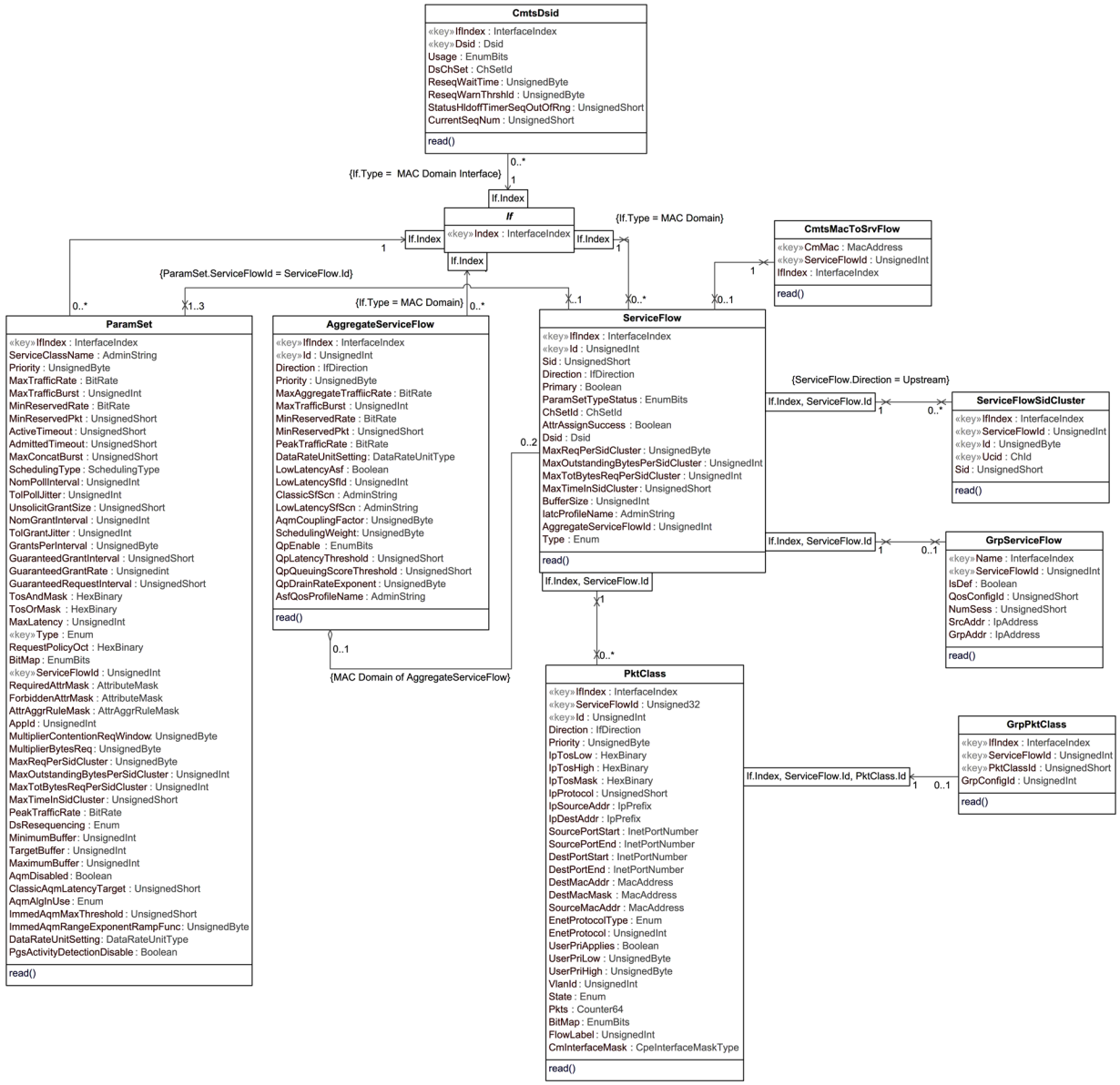


Figure 57 - DOCSIS QoS State Performance Management Information Model

7.2.1.6.1 PktClass

This object describes the packet classification configured on the CM or CMTS. The model is that a packet either received as input from an interface or transmitted for output on an interface may be compared against an ordered list of rules pertaining to the packet contents. Each rule is an instance of this object. A matching rule provides a Service Flow ID to which the packet is classified. All rules need to match for a packet to match a classifier. The attributes in this row correspond to a set of Classifier Encoding parameters in a DOCSIS MAC management message. The BitMap attribute indicates which particular parameters were present in the classifier as signaled in the DOCSIS

message. If the referenced parameter was not present in the signaled Classifier, the corresponding attribute in this instance reports a value as specified by that attribute description.

References: [MULPIv4.0] Service Flows and Classifiers section.

Table 359 - PktClass Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	Interface Index of MAC Domain interface	N/A	N/A
ServiceFlowId	Unsigned32	Key	1..4294967295	N/A	N/A
Id	UnsignedInt	Key	1..65535	N/A	N/A
Direction	IfDirection	read-only		N/A	N/A
Priority	UnsignedByte	read-only		N/A	N/A
IpTosLow	HexBinary	read-only	SIZE (1)	N/A	N/A
IpTosHigh	HexBinary	read-only	SIZE (1)	N/A	N/A
IpTosMask	HexBinary	read-only	SIZE (1)	N/A	N/A
IpProtocol	UnsignedShort	read-only	0..258	N/A	N/A
IpSourceAddr	IpPrefix	read-only		N/A	N/A
IpDestAddr	IpPrefix	read-only		N/A	N/A
SourcePortStart	InetPortNumber	read-only		N/A	N/A
SourcePortEnd	InetPortNumber	read-only		N/A	N/A
DestPortStart	InetPortNumber	read-only		N/A	N/A
DestPortEnd	InetPortNumber	read-only		N/A	N/A
IcmpTypeLow	UnsignedByte	read-only		N/A	N/A
IcmpTypeHigh	UnsignedByte	read-only		N/A	N/A
DestMacAddr	MacAddress	read-only		N/A	N/A
DestMacMask	MacAddress	read-only		N/A	N/A
SourceMacAddr	MacAddress	read-only		N/A	N/A
EnetProtocolType	Enum	read-only		N/A	N/A
EnetProtocol	UnsignedShort	read-only	0..65535	N/A	N/A
UserPriLow	UnsignedByte	read-only	0..7	N/A	N/A
UserPriHigh	UnsignedByte	read-only	0..7	N/A	N/A
VlanId	UnsignedShort	read-only	0 | 1..4094	N/A	N/A
State	Enum	read-only	active(1) inactive(2)	N/A	N/A
Pkts	Counter64	read-only		packets	

Attribute Name	Type	Access	Type Constraints	Units	Default
BitMap	EnumBits	read-only	rulePriority(0), activationState(1), ipTos(2), ipProtocol(3), ipSourceAddr(4), ipSourceMask(5), ipDestAddr(6), ipDestMask(7), sourcePortStart(8), sourcePortEnd(9), destPortStart(10), destPortEnd(11), destMac(12), sourceMac(13), ethertype(14), userPri(15), vlanId(16), flowLabel(17), cmInterfaceMask(18), icmpTypeLow(19), icmpTypeHigh(20)	N/A	N/A
FlowLabel	UnsignedInt	read-only	0..1048575	N/A	N/A
CmInterfaceMask	CpeInterfaceMaskType	read-only		N/A	N/A

Table 360 - PktClass Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
GrpPktClass	Directed association to GrpPktClass	1	0..1	

7.2.1.6.1.1 IfIndex

This key represents the interface index of the MAC Domain of the Service Flow.

7.2.1.6.1.2 ServiceFlowId

This key represents an identifier assigned to a Service Flow by CMTS within a MAC Domain. The value 0 is used only for the purpose of reporting instances pertaining UDCs and not used for association of QoS classifiers to service flows.

7.2.1.6.1.3 Id

This key indicates the assigned identifier to the packet classifier instance by the CMTS, which is unique per Service Flow. For UDCs this corresponds to the Service Flow Reference of the classifier.

References: [MULPIv4.0] Classifier Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.4 Direction

This attribute indicates the direction to which the classifier is applied.

7.2.1.6.1.5 Priority

This attribute specifies the order of evaluation of the classifiers. The higher the value, the higher the priority. The value of 0 is used as default in provisioned Service Flows Classifiers. The default value of 64 is used for dynamic Service Flow Classifiers. If the referenced parameter is not present in a classifier, this attribute reports the default value as defined above.

References: [MULPIv4.0] Rule Priority section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.6 IpTosLow

This attribute indicates the low value of a range of ToS byte values. If the referenced parameter is not present in a classifier, this attribute reports the value of 0. The IP ToS octet as originally defined in [RFC 791] has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). This object is defined as an 8-bit octet as defined by the DOCSIS Specification for packet classification.

References: [MULPIv4.0] IPv4 Type of Service Range and Mask and IPv6 Traffic Class Range and Mask sections in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.7 IpTosHigh

This attribute indicates the 8-bit high value of a range of ToS byte values. If the referenced parameter is not present in a classifier, this attribute reports the value of 0. The IP ToS octet as originally defined in [RFC 791] has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). This object is defined as an 8-bit octet as defined by the DOCSIS Specification for packet classification.

References: [MULPIv4.0] IPv4 Type of Service Range and Mask and IPv6 Traffic Class Range and Mask sections in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.8 IpTosMask

This attribute indicates the mask value is bitwise ANDed with ToS byte in an IP packet, and this value is used for range checking of TosLow and TosHigh. If the referenced parameter is not present in a classifier, this attribute reports the value of 0. The IP ToS octet as originally defined in [RFC 791] has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). This object is defined as an 8-bit octet per the DOCSIS Specification for packet classification.

References: [MULPIv4.0] IPv4 Type of Service Range and Mask and IPv6 Traffic Class Range and Mask sections in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.9 IpProtocol

This attribute indicates the value of the IP Protocol field required for IP packets to match this rule. The value 256 matches traffic with any IP Protocol value. The value 257 by convention matches both TCP and UDP. If the referenced parameter is not present in a classifier, this attribute reports the value of 258.

References: [MULPIv4.0] IP Protocol and IPv6 Next Header Type sections in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.10 IpSourceAddr

This attribute specifies the value of the IP Source Address and mask required for packets to match this rule. An IP packet matches the rule when the packet IP Source Address bitwise ANDed with the IpSourceMask value equals the IpSourceAddr value. If the referenced parameter is not present in a classifier, this object reports the value of '00000000'H.

References: [MULPIv4.0] IPv4 Source Address and IPv6 Source Address sections in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.11 IpDestAddr

This attribute specifies the value of the IP Destination Address and mask required for packets to match this rule. An IP packet matches the rule when the packet IP Destination Address bitwise ANDed with the IpDestMask value equals the IpDestAddr value. If the referenced parameter is not present in a classifier, this attribute reports the value of '00000000'H.

References: [MULPIv4.0] IPv4 Destination Address and IPv6 Destination Address sections in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.12 SourcePortStart

This attribute specifies the low-end inclusive range of TCP/UDP source port numbers to which a packet is compared. This attribute is irrelevant for non-TCP/UDP IP packets. If the referenced parameter is not present in a classifier, this attribute reports the value of 0.

References: [MULPIv4.0] TCP/UDP Source Port Start section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.13 SourcePortEnd

This attribute specifies the high-end inclusive range of TCP/UDP source port numbers to which a packet is compared. This attribute is irrelevant for non-TCP/UDP IP packets. If the referenced parameter is not present in a classifier, this attribute reports the value of 65535.

References: [MULPIv4.0] TCP/UDP Source Port End section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.14 DestPortStart

This attribute specifies the low-end inclusive range of TCP/UDP destination port numbers to which a packet is compared. If the referenced parameter is not present in a classifier, this attribute reports the value of 0.

References: [MULPIv4.0] TCP/UDP Destination Port Start section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.15 DestPortEnd

This attribute specifies the high-end inclusive range of TCP/UDP destination port numbers to which a packet is compared. If the referenced parameter is not present in a classifier, this attribute reports the value of 65535.

References: [MULPIv4.0] TCP/UDP Destination Port End section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.16 IcmpTypeLow

This attribute specifies the low-end inclusive range of the ICMP type numbers to which a packet is compared. If the referenced parameter is not present in a classifier, this attribute reports the value of 0.

References: [MULPIv4.0] TypeLow encodings section of the Common Radio Frequency Interface Annex.

7.2.1.6.1.17 IcmpTypeHigh

This attribute specifies the high-end inclusive range of the ICMP type numbers to which a packet is compared. If the referenced parameter is not present in a classifier, this attribute reports the value of 255.

References: [MULPIv4.0] TypeHigh encodings section of the Common Radio Frequency Interface Annex.

7.2.1.6.1.18 DestMacAddr

An Ethernet packet matches an entry when its destination MAC address bitwise ANDed with DestMacMask equals the value of DestMacAddr. If the referenced parameter is not present in a classifier, this attribute reports the value of '000000000000'H.

References: [MULPIv4.0] Destination MAC Address section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.19 DestMacMask

An Ethernet packet matches an entry when its destination MAC address bitwise ANDed with DestMacMask equals the value of DestMacAddr. If the referenced parameter is not present in a classifier, this attribute reports the value of '000000000000'H.

References: [MULPIv4.0] Destination MAC Address section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.20 SourceMacAddr

An Ethernet packet matches this entry when its source MAC address equals the value of this attribute. If the referenced parameter is not present in a classifier, this attribute reports the value of 'FFFFFFFFFFFF'.

References: [MULPIv4.0] Source MAC Address section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.21 EnetProtocolType

This attribute indicates the format of the layer 3 protocol ID in the Ethernet packet. A value of 'none' means that the rule does not use the layer 3 protocol type as a matching criteria. A value of 'ethertype' means that the rule applies only to frames that contain an EtherType value. Ethertype values are contained in packets using the Dec-Intel-Xerox (DIX) encapsulation or the RFC1042 Sub-Network Access Protocol (SNAP) encapsulation formats. A value of 'dsap' means that the rule applies only to frames using the IEEE802.3 encapsulation format with a Destination Service Access Point (DSAP) other than 0xAA (which is reserved for SNAP). A value of 'mac' means that the rule applies only to MAC management messages for MAC management messages. A value of 'all' means that the rule matches all Ethernet packets. If the Ethernet frame contains an 802.1P/Q Tag header (i.e., EtherType 0x8100), this attribute applies to the embedded EtherType field within the 802.1P/Q header. If the referenced parameter is not present in a classifier, this attribute reports the value of 0.

References: [MULPIv4.0] Ethertype/DSAP/MacType section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.22 EnetProtocol

If EnetProtocolType is 'none', this attribute is ignored when considering whether a packet matches the current rule. If EnetProtocolType is 'ethertype', this attribute gives the 16-bit value of the EtherType that the packet needs to match in order to match the rule. If EnetProtocolType is 'dsap', the lower 8 bits of this attribute's value needs to match the DSAP byte of the packet in order to match the rule. If EnetProtocolType is 'mac', the lower 8 bits of this attribute's value represent a lower bound (inclusive) of MAC management message type codes matched, and the upper 8 bits represent the upper bound (inclusive) of matched MAC message type codes. Certain message type codes are excluded from matching, as specified in the reference. If the Ethernet frame contains an 802.1P/Q Tag header (i.e., EtherType 0x8100), this attribute applies to the embedded EtherType field within the 802.1P/Q header. If the referenced parameter is not present in the classifier, the value of this attribute is reported as 0.

References: [MULPIv4.0] Ethertype/DSAP/MacType section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.23 UserPriLow

This attribute applies only to Ethernet frames using the 802.1P/Q tag header (indicated with EtherType 0x8100). Such frames include a 16-bit Tag that contains a 3-bit Priority field and a 12-bit VLAN number. Tagged Ethernet packets need to have a 3-bit Priority field within the range of PriLow to PriHigh in order to match this rule. If the referenced parameter is not present in the classifier, the value of this attribute is reported as 0.

References: [MULPIv4.0] IEEE 802.1P User_Priority section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.24 UserPriHigh

This attribute applies only to Ethernet frames using the 802.1P/Qtag header (indicated with EtherType 0x8100). Such frames include a 16-bit Tag that contains a 3-bit Priority field and a 12-bit VLAN number. Tagged Ethernet packets need to have a 3-bit Priority field within the range of PriLow to PriHigh in order to match this rule. If the referenced parameter is not present in the classifier, the value of this attribute is reported as 7.

References: [MULPIv4.0] IEEE 802.1P User_Priority section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.25 VlanId

This attribute applies only to Ethernet frames using the 802.1P/Q tag header. Tagged packets need to have a VLAN Identifier that matches the value in order to match the rule. If the referenced parameter is not present in the classifier, the value of this attribute is reported as 0.

References: [MULPIv4.0] IEEE 802.1Q VLAN_ID section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.26 State

This attribute indicates whether or not the classifier is enabled to classify packets to a Service Flow. If the referenced parameter is not present in the classifier, the value of this attribute is reported as inactive(2).

References: [MULPIv4.0] Classifier Activation State section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.27 Pkts

This attribute counts the number of packets that have been classified using this entry. This includes all packets delivered to a Service Flow maximum rate policing function, whether or not that function drops the packets. This counter's last discontinuity is the ifCounterDiscontinuityTime for the same ifIndex that indexes this attribute.

7.2.1.6.1.28 BitMap

This attribute indicates which parameter encodings were actually present in the DOCSIS packet classifier encoding signaled in the DOCSIS message that created or modified the classifier. Note that Dynamic Service Change messages have replace semantics, so that all non-default parameters need to be present whether the classifier is being created or changed. A bit of this attribute is set to 1 if the parameter indicated by the comment was present in the classifier encoding, and to 0 otherwise. Note that BITS are encoded most significant bit first, so that if, for example, bits 6 and 7 are set, this attribute is encoded as the octet string '030000'H.

7.2.1.6.1.29 IpAddrType

This attribute indicates the type of the Internet address for IpSourceAddr, IpSourceMask, IpDestAddr, and IpDestMask. If the referenced parameter is not present in a classifier, this object reports the value of 'ipv4'.

7.2.1.6.1.30 FlowLabel

This attribute represents the Flow Label field in the IPv6 header to be matched by the classifier. The value zero indicates that the Flow Label is not specified as part of the classifier and is not matched against the packets.

References: [MULPIv4.0] IPv6 Flow Label section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.1.31 CmInterfaceMask

This attribute represents a bit-mask of the CM in-bound interfaces to which this classifier applies. This attribute only applies to QoS upstream Classifiers and upstream Drop Classifiers. For QoS downstream classifiers this object reports the zero-length string.

References: [MULPIv4.0] CM Interface Mask (CMIM) Encoding section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2 ParamSet

This object describes the set of QoS parameters defined in a managed device. DOCSIS 1.0 COS service profiles are not represented in this object. Each row corresponds to a DOCSIS QoS Parameter Set as signaled via DOCSIS MAC management messages. Each attribute of an instance of this object corresponds to one or part of one Service Flow Encoding. The BitMap attribute indicates which particular parameters were signaled in the original registration or dynamic service request message that created the QoS Parameter Set. In many cases, even if a QoS Parameter Set parameter was not signaled, the DOCSIS specification calls for a default value to be used. That default value is reported as the value of the corresponding attribute in this object instance. Many attributes are not applicable, depending on the Service Flow direction, upstream scheduling type or Service Flow bonding configuration. The attribute value reported in this case is specified by those attributes' descriptions.

CCAP reporting of admitted and provisioned service flow parameter sets was mandatory in earlier versions of DOCSIS but is now optional, to reduce the volume of information reported by the CCAP.

The CCAP MUST report the active service flow parameter set values. The CCAP MAY report the admitted and provisioned service flow parameter sets.

References: [MULPIv4.0] Service Flow Encodings section in the Encodings for Configuration and MAC-Layer Messaging Annex.

Table 361 - ParamSet Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default (See attribute Description)
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	N/A
ServiceClassName	AdminString	read-only	SIZE (0..15)	N/A	N/A
Priority	UnsignedByte	read-only	0..7	N/A	N/A
MaxTrafficRate	BitRate	read-only			N/A
MaxTrafficBurst	UnsignedInt	read-only		bytes	N/A
MinReservedRate	BitRate	read-only			N/A
MinReservedPkt	UnsignedShort	read-only		bytes	N/A
ActiveTimeout	UnsignedShort	read-only		seconds	N/A
AdmittedTimeout	UnsignedShort	read-only		seconds	N/A
MaxConcatBurst	UnsignedShort	read-only		bytes	N/A
SchedulingType	SchedulingType	read-only		N/A	N/A
NomPollInterval	UnsignedInt	read-only		microseconds	N/A
TolPollJitter	UnsignedInt	read-only		microseconds	N/A
UnsolicitGrantSize	UnsignedShort	read-only		bytes	N/A
NomGrantInterval	UnsignedInt	read-only		microseconds	N/A
TolGrantJitter	UnsignedInt	read-only		microseconds	N/A
GrantsPerInterval	UnsignedByte	read-only	0..127	dataGrants	N/A
GuaranteedGrantInterval	UnsignedShort	read-only		microseconds	N/A
GuaranteedGrantRate	BitRate	read-only			N/A
GuaranteedRequestInterval	UnsignedShort	read-only		microseconds	N/A
TosAndMask	HexBinary	read-only	SIZE (1)	N/A	N/A
TosOrMask	HexBinary	read-only	SIZE (1)	N/A	N/A

Attribute Name	Type	Access	Type Constraints	Units	Default (See attribute Description)
MaxLatency	UnsignedInt	read-only		microseconds	N/A
Type	Enum	key	active (1) admitted (2) provisioned (3)	N/A	N/A
RequestPolicyOct	HexBinary	read-only	SIZE (4)	N/A	N/A
BitMap	EnumBits	read-only	trafficPriority(0), maxTrafficRate(1), maxTrafficBurst(2), minReservedRate(3), minReservedPkt(4), activeTimeout(5), admittedTimeout(6), maxConcatBurst(7), schedulingType(8), requestPolicy(9), nomPollInterval(10), tolPollJitter(11), unsolicitGrantSize(12), nomGrantInterval(13), tolGrantJitter(14), grantsPerInterval(15), tosOverwrite(16), maxLatency(17), requiredAttrMask(18), forbiddenAttrMask(19), attrAggrMask(20), applicationId(21), multipCntnReqWindow(22), multipBytesReq(23), maxReqPerSidCluster(24), maxOutstandingBytesPerSidCluster(25), maxTotalBytesReqPerSidCluster(26), maximumTimeInSidCluster(27), peakTrafficRate(28), dsResequencing(29), minimumBuffer(30), targetBuffer(31), maximumBuffer(32), aqmDisabled(33), aqmLatencyTarget(34), dataRateUnit(35), aqmAlgInUse(36), guaranteedGrantInterval(37), guaranteedGrantRate(38), guaranteedGrantRequestInterval(39), immedAqmMaxThrshld(40), immedAqmRngExpRampFunc(41), pgsActivityDetectionDisable(42)		N/A
ServiceFlowId	UnsignedInt	key	1.. 4294967295		N/A
RequiredAttrMask	AttributeMask	read-only			N/A
ForbiddenAttrMask	AttributeMask	read-only			N/A
AttrAggrRuleMask	AttrAggrRuleMask	read-only	SIZE (0 | 4)		N/A

Attribute Name	Type	Access	Type Constraints	Units	Default (See attribute Description)
AppId	UnsignedInt	read-only			N/A
MultiplierContentionReqWindow	UnsignedByte	read-only	0 | 4..12	eighths	N/A
MultiplierBytesReq	UnsignedByte	read-only	1 | 2 | 4 | 8 | 16	requests	N/A
MaxReqPerSidCluster	UnsignedByte	read-only		bytes	N/A
MaxOutstandingBytesPerSidCluster	UnsignedInt	read-only		bytes	N/A
MaxTotBytesReqPerSidCluster	UnsignedInt	read-only		bytes	N/A
MaxTimeInSidCluster	UnsignedShort	read-only		milliseconds	N/A
PeakTrafficRate	BitRate	read-only			N/A
DsResequencing	Enum	read-only	resequencingDsidIfBonded(0) noResequencingDsid(1) notApplicable(2)	N/A	N/A
MinimumBuffer	UnsignedInt	read-only		bytes	N/A
TargetBuffer	UnsignedInt	read-only		bytes	N/A
MaximumBuffer	UnsignedInt	read-only		bytes	N/A
AqmDisabled	Boolean	read-only			
ClassicAqmLatencyTarget	UnsignedShort	read-only	0..256	milliseconds	
AqmAlgInUse	Enum	read-only	unknown(1) other(2) docsisPIE(3) immediateAqm(4)	N/A	
ImmedAqmMaxThreshold	UnsignedShort	read-only		microseconds	1000
ImmedAqmRangeExponentRampFunc	UnsignedByte	read-only		$\log_2$(nanoseconds)	
DataRateUnitSetting	DataRateUnitType	read-only		N/A	'bps'
PgsActivityDetectionDisable	Boolean	read-only		N/A	false

7.2.1.6.2.1 IfIndex

This key represents the interface index of the MAC Domain of the Service Flow.

7.2.1.6.2.2 ServiceClassName

This attribute represents the Service Class Name from which the parameter set values were derived. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns the zero-length string.

References: [MULPIv4.0] Service Class Name section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.3 Priority

This attribute represents the relative priority of a Service Flow. Higher numbers indicate higher priority. This priority should only be used to differentiate Service Flow from identical parameter sets. This attribute returns 0 if the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set or if the parameter is not applicable.

References: [MULPIv4.0] Traffic Priority section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.4 MaxTrafficRate

This attribute represents the 4-byte value of the maximum sustained traffic rate allowed for this Service Flow. It represents all MAC frame data PDUs from the bytes following the MAC header HCS to the end of the CRC. The number of bytes forwarded is limited during any time interval. The value 0 means no maximum traffic rate is enforced. The value of the DataRateUnitSetting attribute defines the units of MaxTrafficRate. This attribute applies to both upstream and downstream Service Flows. This attribute returns 0 if the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, or if the parameter is not applicable.

References: [MULPIv4.0] Maximum Sustained Traffic Rate section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.5 MaxTrafficBurst

This attribute specifies the token bucket size in bytes for this parameter set. The value is calculated from the byte following the MAC header HCS to the end of the CRC. This object is applied in conjunction with MaxTrafficRate to calculate maximum sustained traffic rate. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns 3044 for scheduling types 'bestEffort', 'nonRealTimePollingService' and 'realTimePollingService'. If this parameter is not applicable, it is reported as 0.

References: [MULPIv4.0] Maximum Traffic Burst section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.6 MinReservedRate

This attribute represents the 4-byte value of the guaranteed minimum rate allowed for this Service Flow. The value is calculated from the byte following the MAC header HCS to the end of the CRC. The value of 0 indicates that no bandwidth is reserved. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns 0. If the parameter is not applicable, it is reported as 0. The value of the DataRateUnitSetting attribute defines the units of MinReservedRate.

References: [MULPIv4.0] Minimum Reserved Traffic Rate section of the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.7 MinReservedPkt

This attribute specifies an assumed minimum packet size in bytes for which the MinReservedRate will be provided. The value is calculated from the byte following the MAC header HCS to the end of the CRC. If the referenced parameter is omitted from a DOCSIS QoS parameter set, the used and reported value is CMTS implementation and the CM reports a value of 0. If the referenced parameter is not applicable to the direction or scheduling type of the Service Flow, both CMTS and CM report the value 0.

References: [MULPIv4.0] Assumed Minimum Reserved Rate Packet Size, in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.8 ActiveTimeout

This attribute specifies the maximum duration in seconds that resources remain unused on an active service flow before the CMTS signals that both the active and admitted parameter sets are null. The value 0 signifies an infinite amount of time. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns 0.

References: [MULPIv4.0] Timeout for Active QoS Parameters section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.9 AdmittedTimeout

This attribute specifies the maximum duration in seconds that resources remain in admitted state before resources need to be released. The value of 0 signifies an infinite amount of time. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns 200.

References: [MULPIv4.0] Timeout for Admitted QoS Parameters section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.10 MaxConcatBurst

This attribute specifies the maximum concatenated burst in bytes that an upstream Service Flow is allowed. The value is calculated from the FC byte of the Concatenation MAC Header to the last CRC byte of the last concatenated MAC frame, inclusive. The value of 0 specifies no maximum burst. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns the value of 1522 for scheduling types 'bestEffort', 'nonRealTimePollingService', and 'realTimePollingService'. If the parameter is not applicable, it is reported as 0.

MaxConcatBurst only applies to pre-DOCSIS 3.1 devices.

References: [MULPIv4.0] Maximum Concatenated Burst section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.11 SchedulingType

This attribute specifies the upstream scheduling service used for upstream Service Flow. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set of an upstream Service Flow, this attribute returns the value of 'bestEffort'. For QoS parameter sets of downstream Service Flows, this attribute's value is reported as 'undefined'.

References: [MULPIv4.0] Service Flow Scheduling Type section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.12 NomPollInterval

This attribute specifies the nominal interval in microseconds between successive unicast request opportunities on an upstream Service Flow. This attribute applies only to upstream Service Flows with SchedulingType of value 'nonRealTimePollingService', 'realTimePollingService', and 'unsolictedGrantServiceWithAD'. The parameter is mandatory for 'realTimePollingService'. If the parameter is omitted with 'nonRealTimePollingService', the CMTS uses an implementation-dependent value. If the parameter is omitted with 'unsolictedGrantServiceWithAD(5)' the CMTS uses the value of the Nominal Grant Interval parameter. In all cases, the CMTS reports the value it is using when the parameter is applicable. The CM reports the signaled parameter value if it was signaled. Otherwise, it returns 0. If the referenced parameter is not applicable to the direction or scheduling type of the corresponding DOCSIS QoS Parameter Set, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Polling Interval section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.13 TolPollJitter

This attribute specifies the maximum amount of time in microseconds that the unicast request interval may be delayed from the nominal periodic schedule on an upstream Service Flow. This parameter is applicable only to upstream Service Flows with a SchedulingType of 'realTimePollingService' or 'unsolictedGrantServiceWithAD'. If the referenced parameter is applicable but not present in the corresponding DOCSIS QoS Parameter Set, the CMTS uses an implementation-dependent value and reports the value it is using. The CM reports a value of 0 in this case. If the parameter is not applicable to the direction or upstream scheduling type of the Service Flow, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Tolerated Poll Jitter section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.14 UnsolicitGrantSize

This attribute specifies the unsolicited grant size in bytes. The grant size includes the entire MAC frame data PDU from the Frame Control byte to the end of the MAC frame. The referenced parameter is applicable only for upstream flows with a SchedulingType of 'unsolicitedGrantServicewithAD' or 'unsolicitedGrantService', and it is mandatory when applicable. Both CMTS and CM report the signaled value of the parameter in this case. If the referenced parameter is not applicable to the direction or scheduling type of the corresponding DOCSIS QoS Parameter Set, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Unsolicited Grant Size section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.15 NomGrantInterval

This attribute specifies the nominal interval in microseconds between successive data grant opportunities on an upstream Service Flow. The referenced parameter is applicable only for upstream flows with a SchedulingType of 'unsolicitedGrantServicewithAD' or 'unsolicitedGrantService(6)', and it is mandatory when applicable. Both CMTS and CM report the signaled value of the parameter in this case. If the referenced parameter is not applicable to the direction or scheduling type of the corresponding DOCSIS QoS Parameter Set, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Nominal Grant Interval section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.16 TolGrantJitter

This attribute specifies the maximum amount of time in microseconds that the transmission opportunities may be delayed from the nominal periodic schedule. The referenced parameter is applicable only for upstream flows with a SchedulingType of 'unsolicitedGrantServicewithAD' or 'unsolicitedGrantService(6)', and it is mandatory when applicable. Both CMTS and CM report the signaled value of the parameter in this case. If the referenced parameter is not applicable to the direction or scheduling type of the corresponding DOCSIS QoS Parameter Set, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Tolerated Grant Jitter section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.17 GrantsPerInterval

This attribute specifies the number of data grants per Nominal Grant Interval (NomGrantInterval). The referenced parameter is applicable only for upstream flows with a SchedulingType of 'unsolicitedGrantServicewithAD' or 'unsolicitedGrantService', and it is mandatory when applicable. Both CMTS and CM report the signaled value of the parameter in this case. If the referenced parameter is not applicable to the direction or scheduling type of the corresponding DOCSIS QoS Parameter Set, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Grants per Interval section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.18 GuaranteedGrantInterval

This attribute specifies the maximum interval between successive data transmission opportunities for a PGS Service Flow. The valid range of this parameter is specific to the CMTS. If the referenced parameter is not applicable to the direction or scheduling type of the corresponding DOCSIS QoS Parameter Set, both CMTS and CM report this attribute's value as 0.

References: [MULPIv4.0] Guaranteed Grant Interval section of Annex C.

7.2.1.6.2.19 GuaranteedGrantRate

The value of this parameter specifies the minimum granting rate for an upstream PGS service flow. The valid range of this parameter is specific to the CMTS. The value of the DataRateUnitSetting attribute defines the units of GuaranteedGrantRate.

References: [MULPIv4.0] Guaranteed Grant Rate section of Annex C.

7.2.1.6.2.20 GuaranteedRequestInterval

This attribute specifies the maximum interval (in units of microseconds) between successive request opportunities (including unicast request opportunities and piggyback request opportunities) for an upstream PGS service flow.

References: [MULPIv4.0] Guaranteed Request Interval of Annex C.

7.2.1.6.2.21 TosAndMask

This attribute specifies the AND mask for the IP ToS byte for overwriting an IPv4 packet's ToS value or IPv6 packet's Traffic Class value. The IP packet ToS byte is bitwise ANDed with TosAndMask, then the result is bitwise ORed with TosORMask and the result is written to the IP packet ToS byte. A value of 'FF'H for TosAndMask and a value of '00'H for TosOrMask means that the IP Packet ToS byte is not overwritten. This combination is reported if the referenced parameter is not present in a QoS Parameter Set. The IP ToS octet as originally defined in [RFC 791] has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). The IPv6 Traffic Class octet [RFC 2460] is consistent with that new definition. Network operators should avoid specifying values of TosAndMask and TosORMask that would result in the modification of the ECN bits. In particular, operators should not use values of TosAndMask that have either of the least-significant two bits set to 0. Similarly, operators should not use values of TosORMask that have either of the least-significant two bits set to 1. Even though this attribute is only enforced by the CMTS, the CM reports the value as signaled in the referenced parameter.

References: [MULPIv4.0] IP Type Of Service (DSCP) Overwrite section in the Encodings for Configuration and MAC-Layer Messaging Annex; [RFC 3168]; [RFC 3260]; [RFC 2460]; [RFC 791].

7.2.1.6.2.22 TosOrMask

This attribute specifies the OR mask for the IPv4 ToS value or IPv6 Traffic Class value. See the description of TosAndMask for further details. The IP ToS octet, as originally defined in [RFC 791] has been superseded by the 6-bit Differentiated Services Field (DSField, [RFC 3260]) and the 2-bit Explicit Congestion Notification Field (ECN field, [RFC 3168]). The IPv6 Traffic Class octet [RFC 2460] is consistent with that new definition. Network operators should avoid specifying values of TosAndMask and TosORMask that would result in the modification of the ECN bits.

References: [MULPIv4.0] IP Type Of Service (DSCP) Overwrite section in the Encodings for Configuration and MAC-Layer Messaging Annex; [RFC 3168]; [RFC 3260]; [RFC 2460]; [RFC 791].

7.2.1.6.2.23 MaxLatency

This attribute specifies the maximum latency between the reception of a packet by the CMTS on its NSI and the forwarding of the packet to the RF interface. A value of 0 signifies no maximum latency is enforced. This attribute only applies to downstream Service Flows. If the referenced parameter is not present in the corresponding downstream DOCSIS QoS Parameter Set, this attribute returns 0. This parameter is not applicable to upstream DOCSIS QoS Parameter Sets, so its value is reported as 0 in that case.

References: [MULPIv4.0] Maximum Downstream Latency section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.24 Type

This key represents the QoS Parameter Set Type of the Service Flow. The following values are defined: 'active' Indicates the Active QoS parameter set, describing the service currently being provided by the DOCSIS MAC domain to the service flow. 'admitted' Indicates the Admitted QoS Parameter Set, describing services reserved by the DOCSIS MAC domain for use by the service flow. 'provisioned' Indicates the QoS Parameter Set defined in the DOCSIS CM Configuration file for the service flow.

Only the ‘active’ service flow parameter set is required to be reported. The ‘admitted’ and ‘provisioned’ sets are not required to be reported.

References: [MULPIv4.0] Service Flow Scheduling Type section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.25 RequestPolicyOct

This attribute specifies which transmit interval opportunities the CM omits for upstream transmission requests and packet transmissions. This object takes its default value for downstream Service Flows. Unless otherwise indicated, a bit value of 1 means that a CM is not to use that opportunity for upstream transmission. The format of this string enumerated the bits from 0 to 31 from left to right, for example bit 0 corresponds to the left most bit of the fourth octet. (octets numbered from right to left). The bit positions are defined as follows:

- 'broadcastReqOpp' - all CMs broadcast request opportunities
- 'priorityReqMulticastReq' - priority request multicast request opportunities
- 'reqDataForReq' - request/data opportunities for requests
- 'reqDataForData' - request/data opportunities for data
- 'piggybackReqWithData' - piggyback requests with data
- 'concatenateData' - concatenate data
- 'fragmentData' - fragment data
- 'suppressPayloadHeaders' - suppress payload headers
- 'dropPktsExceedUGSize' - A value of 1 means that the service flow will drop packets that do not fit in the Unsolicited Grant size. If the referenced parameter is not present in a QoS Parameter Set, the value of this object is reported as '00000000'H.

References: [MULPIv4.0] Request/ Transmission Policy section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.26 BitMap

This attribute indicates the set of QoS Parameter Set parameters actually signaled in the DOCSIS registration or dynamic service request message that created or modified the QoS Parameter Set. Possible QoS Parameter Set parameters are listed below with the corresponding TLV Type. A bit is set to 1 when the associated parameter is present in the original request as follows:

- 'trafficPriority' Traffic Priority (24/25.7)
- 'maxTrafficRate' Maximum Sustained Traffic Rate (24/25.8)
- 'maxTrafficBurst' Maximum Traffic Burst (24/25.9)
- 'minReservedRate' Minimum Reserved Traffic Rate (24/25.10)
- 'minReservedPkt' Assumed Minimum Reserved Rate Packet Size (24/25.11)
- 'activeTimeout' Timeout for Active QoS Parameters (24/25.12)
- 'admittedTimeout' Timeout for Admitted QoS Parameters (24/25.13)
- 'maxConcatBurst' Maximum Concatenated Burst (24.14)
- 'schedulingType' Service Flow Scheduling Type (24.15)
- 'requestPolicy' Request/Transmission Policy (24.16)
- 'nomPollInterval' Nominal Polling Interval (24.17)
- 'tolPollJitter' Tolerated Poll Jitter (24.18)
- 'unsolicitGrantSize' Unsolicited Grant Size (24.19)
- 'nomGrantInterval' Nominal Grant Interval (24.20)
- 'tolGrantJitter' Tolerated Grant Jitter (24.21)
- 'grantsPerInterval' Grants per Interval (24.22)
- 'tosOverwrite' IP Type of Service (DSCP) Overwrite (24.23)

- 'maxLatency' Maximum Downstream Latency (25.14)
- 'requiredAttrMask' Service Flow Required Attribute Mask (24/25.31)
- 'forbiddenAttrMask Service Flow Forbidden Attribute Mask (24/25.32)
- 'attrAggrMask' Service Flow Attribute Aggregation Mask (24/25.33)
- 'applicationId' Application Identifier (24/25.34)
- 'multipCntnReqWindow' Multiplier to Contention Request Backoff Window (24.25)
- 'multipBytesReq' Multiplier to Number of Bytes Requested (24.26)
- 'maxReqPerSidCluster' Maximum Requests per SID Cluster (47/89.3.1)
- 'maxOutstandingBytesPerSidCluster' Maximum Outstanding Bytes per SID Cluster (47/89.3.2)
- 'maxTotalBytesReqPerSidCluster' Maximum Total Bytes Requested per SID Cluster (47/89.3.3)
- 'maximumTimeInSidCluster' Maximum Time in the SID Cluster (47/89.3.4)
- 'peakTrafficRate' Peak Traffic Rate (24/25.27)
- 'dsResequencing' - Downstream Resequencing (25.17)
- 'minimumBuffer' Minimum Buffer (24/25.35.1)
- 'targetBuffer' Target Buffer (24/25.35.2)
- 'maximumBuffer' Maximum Buffer (24/25.35.3)
- 'aqmDisabled' SF AQM Disabled (24/25.40.1)
- 'classicAqmLatencyTarget' SF AQM Latency Target (24/25.40.2)
- 'dataRateUnit' Data Rate Unit Setting (24/25/70/71.41)
- 'aqmAlgInUse' AQM Algorithm (24/25.40.3)
- 'guaranteedGrantInterval' Guaranteed Grant Interval (24.44)
- 'guaranteedGrantRate' Guaranteed Grant Rate (24.45)
- 'guaranteedGrantRequestInterval' Guaranteed Grant Request Interval (24.46)
- 'immedAqmMaxThrshld' Immediate AQM Maximum Threshold (24/25.40.4)
- 'immedAqmRngExpRampFunc' Immediate AQM Range Exponent of Ramp Function (24/25.40.5)
- 'pgsActivityDetectionDisable' PGS Activity Detection Disable (24.49)

Note that when Service Class names are expanded, the registration or dynamic response message may contain parameters expanded by the CMTS based on a stored service class. These expanded parameters are not indicated by a 1 bit in this attribute. Note that even though some QoS Parameter Set parameters may not be signaled in a message (so that the parameter's bit in this object is 0), the DOCSIS specification requires that default values be used. These default values are reported as the corresponding attribute.

References: [MULPIv4.0] Service Flow Encodings section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.27 ServiceFlowId

This key represents the Service Flow ID for the service flow.

References: [MULPIv4.0] Service Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.28 RequiredAttrMask

This attribute specifies the Required Attribute Mask to compare with the Provisioned Required Attributes when selecting the bonding groups for the service flow.

If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns '00000000'H.

References: [MULPIv4.0] Service Flow Required Attribute Mask section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.29 ForbiddenAttrMask

This attribute specifies the Forbidden Attribute Mask to compare with the Provisioned Forbidden Attributes when selecting the bonding groups for the service flow.

If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns '00000000'H.

References: [MULPIv4.0] Service Flow Forbidden Attribute Mask section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.30 AttrAggrRuleMask

This attribute specifies the Attribute Aggregation Mask to compare the Service Flow Required and Forbidden Attributes with the CMTS dynamically-created bonding group when selecting the bonding groups for the service flow.

If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns '00000000'H.

References: [MULPIv4.0] Service Flow Attribute Aggregation Mask section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.31 AppId

This attribute represents the Application Identifier associated with the service flow for purposes beyond the scope of this specification.

If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns 0.

References: [MULPIv4.0] Application Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.32 MultiplierContentionReqWindow

This attribute specifies the multiplier to be applied by a CM when performing contention request backoff for data requests. This attribute only applies to upstream Service Flows in 3.0 operation. if the referenced parameter is not present in the upstream DOCSIS QoS Parameter Set, or is not applicable, this attribute returns 8.

References: [MULPIv4.0] Multiplier to Contention Request Backoff Window section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.33 MultiplierBytesReq

This attribute specifies the assumed bandwidth request multiplier. This attribute only applies to upstream Service Flows in 3.0 operation. If the referenced parameter is not present in the upstream DOCSIS QoS Parameter Set, or is not applicable, this attribute returns 4.

References: [MULPIv4.0] Multiplier to Number of Bytes Requested section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.34 MaxReqPerSidCluster

This attribute specifies the maximum number of requests that a CM can make within a given SID Cluster before it needs to switch to a different SID Cluster to make further requests. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0. If the referenced parameter is not present in the DOCSIS QoS Parameter Set, this attribute returns 0.

This attribute has been deprecated and replaced with MaxReqPerSidCluster in the ServiceFlow object.

References: [MULPIv4.0] Maximum Requests per SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.35 MaxOutstandingBytesPerSidCluster

This attribute specifies the maximum number of bytes for which a CM can have requests outstanding on a given SID Cluster. If defined number of bytes are outstanding and further requests are required, the CM needs to switch to a different SID Cluster if one is available. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0. If the referenced parameter is not present in the DOCSIS QoS Parameter Set, this attribute returns 0.

This attribute has been deprecated and replaced with MaxOutstandingBytesPerSidCluster in the ServiceFlow object.

References: [MULPIv4.0] Maximum Outstanding Bytes per SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.36 MaxTotBytesReqPerSidCluster

This attribute specifies the maximum total number of bytes a CM can have requested using a given SID Cluster before it needs to switch to a different SID Cluster to make further requests. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0. If the referenced parameter is not present in the DOCSIS QoS Parameter Set, this attribute returns 0.

This attribute has been deprecated and replaced with MaxTotBytesReqPerSidCluster in the ServiceFlow object.

References: [MULPIv4.0] Maximum Total Bytes Requested per SID Cluster section in the Common Radio Frequency Interface Encodings Annex.

7.2.1.6.2.37 MaxTimeInSidCluster

This attribute specifies the maximum time in milliseconds that a CM may use a particular SID Cluster before it has to switch to a different SID Cluster to make further requests. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0. If the referenced parameter is not present in the DOCSIS QoS Parameter Set, this attribute returns 0.

This attribute has been deprecated and replaced with MaxTimeInSidCluster in the ServiceFlow object.

References: [MULPIv4.0] Maximum Time in the SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.38 PeakTrafficRate

This attribute represents the 4-byte value of the rate parameter 'P' of a token-bucket-based peak rate limiter for packets of a service flow. A value of 0 signifies no Peak Traffic Rate is enforced. If the referenced parameter is not present in the corresponding DOCSIS QoS Parameter Set, this attribute returns 0. The value of the DataRateUnitSetting attribute defines the units of PeakTrafficRate.

References: [MULPIv4.0] Peak Traffic Rate section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.39 DsResequencing

This attribute specifies if a resequencing DSID needs to be allocated to the service flow.

The value 'notApplicable' indicates the value of this attribute is not applicable.

The value 'resequencingDsid' indicates that a resequencing DSID is required if the service flow is assigned to a downstream bonding group

The value 'noResequencingDsid' indicates no resequencing DSID is associated with the service flow.

This attribute only applies to downstream Service Flows in 3.0 operation. If the referenced parameter is not present in the corresponding downstream DOCSIS QoS Parameter Set, this attribute returns 'notApplicable'. This parameter is not applicable to upstream DOCSIS QoS Parameter Sets, so the value 'notApplicable' is reported in that case.

References: [MULPIv4.0] Downstream Resequencing section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.40 MinimumBuffer

This attribute represents the configured minimum buffer size for the service flow.

References: [MULPIv4.0] Buffer Control section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.41 TargetBuffer

This attribute represents the configured target buffer size for the service flow. The value 0 indicates that no target buffer size was configured, and the device will use a vendor specific value.

References: [MULPIv4.0] Buffer Control section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.42 MaximumBuffer

This attribute represents the configured maximum buffer size for the service flow. The value 4294967295 indicates that no maximum buffer size was configured, and thus there is no limit to the buffer size.

References: [MULPIv4.0] Buffer Control section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.43 AqmDisabled

If this attribute is set to 'true', AQM is disabled on the upstream or downstream service flow specified by ServiceFlowId.

References: [MULPIv4.0] AQM Encodings section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.44 ClassicAqmLatencyTarget

This attribute provides the target latency for this service flow when operating under Classic Active Queue Management (e.g., DOCSIS-PIE). This parameter will be ignored if the AQM Algorithm used by the Service Flow is ImmediateAqm. For downstream service flows, the value 256 indicates an unknown latency target. The units are in milliseconds.

References: [MULPIv4.0] AQM Encodings section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.2.45 AqmAlgInUse

This attribute specifies the AQM algorithm in use for this service flow.

The value unknown(1) is reported for downstream service flows or when AQM is disabled.

The value other(2) indicates a vendor proprietary algorithm for upstream queue management.

The value docsisPIE(3) indicates the upstream queue management Proportional Integral controller Enhanced (PIE) algorithm.

The value immediateAqm(4) indicates the Immediate Active Queue Management algorithm.

References: [MULPIv4.0] Proportional-Integral-Enhanced Active Queue Management Algorithm Annex.

7.2.1.6.2.46 ImmedAqmMaxThreshold

This attribute specifies the maximum threshold in microseconds of the ramp function used by the Immediate AQM algorithm and the Queue Protection algorithm. This attribute reports the actual ImmedAqmMaxThreshold (MAXTH calculated per the [MULPIv4.0] Annex C, Annex N), rather than the configured value.

References: [MULPIv4.0] Active Queue Management Algorithm Annexes.

7.2.1.6.2.47 ImmedAqmRangeExponentRampFunc

This attribute specifies the range in nanoseconds of the ramp function used by the Immediate AQM algorithm and the Queue Protection algorithm. It is expressed as an exponent of 2, e.g., a value of 19 means the range of the ramp will be 2^19 = 524288 ns (roughly 524 µs).

References: [MULPIv4.0] Active Queue Management Algorithm Annexes.

7.2.1.6.2.48 DataRateUnitSetting

This attribute indicates the base unit for the Service Flow traffic rate attributes Maximum Sustained Traffic Rate (MaxTrafficRate), Minimum Reserved Traffic Rate (MinReservedRate), and Peak Traffic Rate (PeakTrafficRate). The value of this attribute allows for their interpretation in units of bps, kbps, Mbps, or Gbps. The default value for DataRateUnitSetting is bps.

7.2.1.6.2.49 PgsActivityDetectionDisable

This attribute indicates whether the activity detection function for an upstream service flow with the Proactive Grant Service scheduling type is enabled or disabled.

The value 'false' is reported if the upstream PGS service flow is configured to switch between a polling mode and a granting mode based on detection of upstream activity.

The value 'true' is reported if the upstream PGS service flow is configured to continuously provide grants regardless of upstream activity.

7.2.1.6.3 ServiceFlow

The ServiceFlow object describes the set of DOCSIS-QoS Service Flows in a managed device.

References: [MULPIv4.0] Service Flows and Classifiers section.

Table 362 - ServiceFlow Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	N/A
Id	UnsignedInt	key		N/A	N/A
Sid	UnsignedShort	read-only		N/A	N/A
Direction	IfDirection	read-only		N/A	N/A
Primary	Boolean	read-only		N/A	N/A
ParamSetTypeStatus	EnumBits	read-only	active(0), admitted(1), provisioned(2)	N/A	N/A
ChSetId	ChSetId	read-only		N/A	N/A
AttrAssignSuccess	Boolean	read-only		N/A	N/A
Dsid	Dsid	read-only		N/A	N/A
MaxReqPerSidCluster	UnsignedByte	read-only		requests	N/A
MaxOutstandingBytesPerSidCluster	UnsignedInt	read-only		bytes	N/A
MaxTotBytesReqPerSidCluster	UnsignedInt	read-only		bytes	N/A

Attribute Name	Type	Access	Type Constraints	Units	Default
MaxTimeInSidCluster	UnsignedShort	read-only		milliseconds	N/A
BufferSize	UnsignedInt	read-only		bytes	N/A
IatcProfileName	AdminString	read-only	0..16	N/A	N/A
AggregateServiceFlowId	UnsignedInt	read-only		N/A	N/A
Type	Enum	read-only	other(1), standalone(2), classic(3), lowLatency(4), nonLldHqos(5), reserved(6)	N/A	N/A

Table 363 - ServiceFlow Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceFlowSidCluster	Association to ServiceFlowSidCluster	1	0..*	
GrpServiceFlow	Association to GrpServiceFlow	1	0..1	
PktClass	Association to PktClass	1	0..*	
CmtsMacToSrvFlow	Association to CmtsMacToSrvFlow	0..1	1	
AggregateServiceFlow	Aggregation association from AggregateServiceFlow	0..2	0..1	

7.2.1.6.3.1 IfIndex

This key represents the interface index of the MAC Domain of the Service Flow.

7.2.1.6.3.2 Id

This key represents an identifier assigned to a Service Flow by CMTS within a MAC Domain. The value 0 is used only for the purpose of reporting instances of the PktClass object pertaining UDCs and not used for association of QoS classifiers to service flows.

References: [MULPIv4.0] Service Flow Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.3 Sid

Service Identifier (SID) assigned to an admitted or active Service Flow. This attribute reports a value of 0 if a Service ID is not associated with the Service Flow. Only active or admitted upstream Service Flows will have a Service ID (SID).

References: [MULPIv4.0] Service Identifier section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.4 Direction

This attribute represents the direction of the Service Flow.

7.2.1.6.3.5 Primary

This attribute reflects whether Service Flow is the primary or a secondary Service Flow.

7.2.1.6.3.6 ParamSetTypeStatus

This attribute represents the status of the service flow based on the admission state. 'active' bit set to '1' indicates that the service flow is active and that the corresponding QoS ParamSet is stored in the CMTS. 'admitted' bit set to '1' indicates that the service flow resources were reserved and that the corresponding QoS ParamSet is stored in the CMTS. 'provisioned' bit set to '1' indicates that the service flow was defined in the CM config file and that the corresponding QoS ParamSet is stored in the CMTS.

References: [MULPIv4.0] Service Flow section.

7.2.1.6.3.7 ChSetId

This attribute represents the Channel Set Id associated with the service flow.

7.2.1.6.3.8 AttrAssignSuccess

If set to 'true', this attribute indicates that the current channel set associated with the service flow meets the Required and Forbidden Attribute Mask encodings. Since this attribute is not applicable for a CM, the CM always returns 'false'.

References: [MULPIv4.0] Service Flow section.

7.2.1.6.3.9 Dsid

This attribute indicates the DSID associated with the downstream service flow. downstream service flows without a DSID or upstream Service Flows report the value zero.

7.2.1.6.3.10 MaxReqPerSidCluster

This attribute specifies the maximum number of requests that a CM can make within a given SID Cluster before it has to switch to a different SID Cluster to make further requests. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0.

References: [MULPIv4.0] Maximum Requests per SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.11 MaxOutstandingBytesPerSidCluster

This attribute specifies the maximum number of bytes for which a CM can have requests outstanding on a given SID Cluster. If defined number of bytes are outstanding and further requests are required, the CM needs to switch to a different SID Cluster if one is available. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0.

References: [MULPIv4.0] Maximum Outstanding Bytes per SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.12 MaxTotBytesReqPerSidCluster

This attribute specifies the maximum total number of bytes a CM can have requested using a given SID Cluster before it has to switch to a different SID Cluster to make further requests. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0.

References: [MULPIv4.0] Maximum Total Bytes Requested per SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.13 MaxTimeInSidCluster

This attribute specifies the maximum time in milliseconds that a CM may use a particular SID Cluster before it has to switch to a different SID Cluster to make further requests. A value of 0 indicates there is no limit. This attribute only applies to upstream Service Flows in 3.0 operation, in other cases it is reported as 0.

References: [MULPIv4.0] Maximum Time in the SID Cluster section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.14 BufferSize

This attribute indicates the buffer size for the service flow. For the CM this attribute only applies to upstream Service Flows, for the CMTS this attribute only applies to downstream Service Flows, in other cases it is reported as 0.

References: [MULPIv4.0] Buffer Control section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.3.15 IatcProfileName

This attribute indicates the name of the IATC Profile to which this Service Flow belongs. If this Service Flow is not part of an IATC Profile, this attribute returns an empty string.

7.2.1.6.3.16 AggregateServiceFlowId

This attribute indicates the Aggregate Service flow to which this Service Flow belongs. If this Service Flow is not part of an ASF, this attribute returns a '0'.

7.2.1.6.3.17 Type

This attribute reports the type of Service Flow.

'other' - Represents an undefined Service Flow type.

'standalone' - Represents a standalone Service Flow that is not associated with an ASF.

'classic' - Represents a classic Service Flow associated with a Low Latency ASF.

'lowLatency' - Represents a Low Latency Service Flow associated with a Low Latency ASF.

'nonLldHqos' - Represents a Service Flow that is a constituent of an Aggregate Service Flow (ASF) but the ASF is not a Low Latency ASF.

'reserved' - Reserved value used by IPDR Service Definitions.

7.2.1.6.4 AggregateServiceFlow

This object describes the attributes for an aggregate service Flow (ASF). This object contains an instance for every active ASF in each MAC Domain.

References: [MULPIv4.0].

Table 364 - AggregateServiceFlow Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	Interface Index of MAC Domain Interface		
Id	UnsignedInt	Key	ASF Identifier		
Direction	IfDirection	read-only			
Priority	UnsignedByte	read-only	0..7		
MaxAggregateTrafficRate	BitRate	read-only			
MaxTrafficBurst	UnsignedInt	read-only			
MinReservedRate	BitRate	read-only			
MinReservedPkt	UnsignedShort	read-only		bytes	

Attribute Name	Type	Access	Type Constraints	Units	Default
PeakTrafficRate	BitRate	read-only			
DataRateUnitSetting	DataRateUnitType	read-only			'bps'
LowLatencyAsf	Boolean	read-only			
LowLatencySfId	UnsignedInt	read-only			
ClassicSfScn	AdminString	read-only			
LowLatencySfScn	AdminString	read-only			
AqmCouplingFactor	UnsignedByte	read-only	0..255	tenths	
SchedulingWeight	UnsignedByte	read-only			
QpEnable	EnumBits	read-only	queueProtectionEnabled(0)		
QpLatencyThreshold	UnsignedShort	read-only		microseconds	1000
QpQueuingScoreThreshold	UnsignedShort	read-only		microseconds	2000
QpDrainRateExponent	UnsignedByte	read-only		log2(bytes/second)	
AsfQosProfileName	AdminString	read-only	1..16		

Table 365 - AggregateServiceFlow Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceFlow	Aggregation association to ServiceFlow	0..1	0..2	MAC Domain of AggregateServiceFlow

7.2.1.6.4.1 IfIndex

This key represents the interface index of the MAC Domain of the Aggregate Service Flow.

7.2.1.6.4.2 Id

This key represents the ASF Identifier for the Aggregate Service Flow.

7.2.1.6.4.3 Direction

This attribute indicates the Service Flow data direction.

7.2.1.6.4.4 Priority

This attribute specifies the relative priority of an Aggregate Service Flow.

7.2.1.6.4.5 MaxAggregateTrafficRate

This attribute represents the 4-byte value of the maximum sustained traffic rate allowed for this Aggregate Service Flow. The value of the DataRateUnitSetting attribute defines the units of MaxAggregateTrafficRate.

7.2.1.6.4.6 MaxTrafficBurst

This attribute represents the MaxTrafficBurst attribute of the Aggregate Service Flow.

7.2.1.6.4.7 MinReservedRate

This attribute represents the 4-byte value of the guaranteed minimum rate allowed for this Aggregate Service Flow. The value of the DataRateUnitSetting attribute defines the units of MinReservedRate.

7.2.1.6.4.8 MinReservedPkt

This attribute represents the Assumed Minimum Reserved Rate Packet Size of the Aggregate Service Flow.

7.2.1.6.4.9 PeakTrafficRate

This attribute represents the 4-byte value of the Peak Traffic Rate allowed for this Aggregate Service Flow. A value of 0 means the peak traffic rate is not limited. The value of the DataRateUnitSetting attribute defines the units of PeakTrafficRate.

7.2.1.6.4.10 DataRateUnitSetting

This attribute indicates the base unit for the AggregateServiceFlow traffic rate attributes Maximum Aggregate Traffic Rate (MaxAggregateTrafficRate), Minimum Reserved Traffic Rate (MinReservedRate), and Peak Traffic Rate (PeakTrafficRate). The value of this attribute allows for their interpretation in units of bps, kbps, Mbps, or Gbps.

7.2.1.6.4.11 LowLatencyAsf

This attribute indicates if the Aggregate Service Flow is being used for Low Latency services. This implies the ASF is describing a Dual Queue SF setup underneath the ASF.

7.2.1.6.4.12 LowLatencySfId

This attribute indicates the SFID of the Low Latency Service flow under this ASF.

7.2.1.6.4.13 ClassicSfScn

This attribute represents the Service Class Name from which the parameter set values for the classic service flow were derived.

7.2.1.6.4.14 LatencySfScn

This attribute represents the Service Class Name from which the parameter set values for the low latency service flow were derived.

7.2.1.6.4.15 AqmCouplingFactor

This attribute represents the coupling factor for the AQMs between the Classic service flow and the Latency service flow.

7.2.1.6.4.16 SchedulingWeight

This attribute represents the scheduling weight, as the implied ratio (out of 256), for the Latency Queue/Service Flow (within the ASF).

7.2.1.6.4.17 QpEnable

This attribute indicates the Queue Protection status of this Aggregated Service Flow. If the queueProtectionEnabled bit (bit 0) is set to '0', Queue Protection is disabled. If the queueProtectionEnabled bit is set to '1', Queue Protection is enabled.

References: [MULPIv4.0] Queue Protection section.

7.2.1.6.4.18 QpLatencyThreshold

This attribute represents the latency threshold for the Queue Protection function in the Low Latency Service Flow.

References: [MULPIv4.0] Queue Protection section.

7.2.1.6.4.19 QpQueuingScoreThreshold

This attribute represents the Queuing Score Threshold for the Queue Protection function in the Low Latency Service Flow.

7.2.1.6.4.20 QpDrainRateExponent

This attribute represents the drain rate exponent for the Queue Protection function in the Low Latency Service Flow.

7.2.1.6.4.21 AsfQosProfileName

This attribute is the ASF QoS Profile Name associated with this object instance. [MULPIv4.0] defines this attribute as a null-terminated string of no more than 16 ASCII characters.

7.2.1.6.5 CmtsMacToSrvFlow

This object provides the mapping of unicast service flows with the cable modem the service flows belongs to.

Table 366 - CmtsMacToSrvFlow Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmMac	MacAddress	key		N/A	N/A
ServiceFlowId	UnsignedInt	key	1..4294967295	N/A	N/A
IfIndex	InterfaceIndex	read-only	Interface Index of MAC Domain interface	N/A	N/A

Table 367 - CmtsMacToSrvFlow Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
ServiceFlow	Association to ServiceFlow	1	0..1	

7.2.1.6.5.1 CmMac

This key represents the MAC address for the referenced CM.

7.2.1.6.5.2 ServiceFlowId

This key represents the identifier of the Service Flow.

7.2.1.6.5.3 IfIndex

This attribute represents the interface index of the MAC domain of the Service Flow and where the Cable Modem is registered.

7.2.1.6.6 ServiceFlowSidCluster

This object defines the SID clusters associated with an upstream service flow.

References: [MULPIv4.0] Service Flow SID Cluster Assignments section in the Encodings for Configuration and MAC-Layer Messaging Annex.

Table 368 - ServiceFlowSidCluster Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	Interface Index of MAC Domain interface	N/A	N/A
ServiceFlowId	UnsignedInt	Key	1.. 4294967295	N/A	N/A
Id	UnsignedByte	Key	0..7	N/A	N/A
Ucid	ChId	Key	1..255	N/A	N/A
Sid	UnsignedInt	Read-only	1..16383	N/A	N/A

7.2.1.6.6.1 IfIndex

This key represents the interface index of the MAC Domain of the Service Flow SID cluster.

7.2.1.6.6.2 ServiceFlowId

This key represents the Service Flow ID for the service flow.

7.2.1.6.6.3 Id

This key represents the identifier of the SID Cluster.

References: [MULPIv4.0] SID Cluster ID section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.6.4 Ucid

This key represents the upstream channel ID mapped to the corresponding SID.

7.2.1.6.6.5 Sid

This attribute represents the SID assigned to the upstream channel in this SID Cluster.

7.2.1.6.7 GrpServiceFlow

This object provides extensions to the service flow information for Group Service Flows (GSFs).

References: [MULPIv4.0] QoS Support for Joined IP Multicast Traffic section.

Table 369 - GrpServiceFlow Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	N/A
ServiceFlowId	UnsignedInt	key	1.. 4294967295	N/A	N/A
IsDef	Boolean	read-only		N/A	N/A
QosCfgId	UnsignedShort	read-only		N/A	N/A
NumSess	UnsignedShort	read-only	1..65535	sessions	N/A
SrcAddr	IpAddress	read-only		N/A	N/A
GrpAddr	IpAddress	read-only		N/A	N/A

7.2.1.6.7.1 IfIndex

This key represents the interface index of the MAC Domain of the Group Service Flow.

7.2.1.6.7.2 ServiceFlowId

This key represents the Service Flow ID for the Service Flow.

References: [MULPIv4.0] QoS section.

7.2.1.6.7.3 IsDef

This attribute indicates whether the GSF QoS Parameter Set corresponds to the Default Group Service Flow.

References: [OSSIv3.0] Annex M.

7.2.1.6.7.4 QosCfgId

This attribute indicates the Group QoS Configuration (GQC) identifier used of the creation of this GSF. The value zero indicates that the service flow is using the default service flow policy.

References: [OSSIv3.0] Annex M.

7.2.1.6.7.5 NumSess

This attribute indicates the number of sessions that are configured in an aggregated Service Flow. If this is a single session replication, the value of this attribute is 1.

References: [OSSIv3.0] Annex M.

7.2.1.6.7.6 SrcAddr

This attribute indicates the specific multicast Source Address that is configured in a single session Service Flow. If this is an aggregate Service Flow (NumSess attribute reports a value greater than 1), this attribute returns one of the multicast source addresses for the session. For the case of Any Source Multicast (ASM), this attribute reports a value of 0.0.0.0 for IPv4 or 0::/0 for IPv6.

7.2.1.6.7.7 GrpAddr

This attribute indicates the specific Multicast Group Address that is configured in a single session Service Flow. If this is an aggregate Service Flow (NumSess attribute reports a value greater than 1), this attribute returns the multicast group address associated with the SrcAddr for the session.

7.2.1.6.8 GrpPktClass

This object provides additional packet classification information for Group Classifier References (GCRs) in a Group Service Flow (GSF).

References: [MULPIv4.0] QoS Support for Joined IP Multicast Traffic section.

Table 370 - GrpPktClass Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	N/A
ServiceFlowId	UnsignedInt	key	1..4294967295	N/A	N/A
PktClassId	UnsignedShort	key	1..65535	N/A	N/A
GrpCfgId	UnsignedInt	read-only	1..4294967295	N/A	N/A

7.2.1.6.8.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies.

7.2.1.6.8.2 ServiceFlowId

This key represents the Service Flow ID of the service flow.

References: [MULPIv4.0] QoS section.

7.2.1.6.8.3 PktClassId

This key represents the Classifier ID of a GCR associated with a GSF.

References: [MULPIv4.0] QoS section.

7.2.1.6.8.4 GrpCfgId

This attribute indicates the GC identifier used of the creation of this GSF.

References: [OSSIv3.0] Annex M.

7.2.1.6.9 CmtsDsid

This object describes DSID information stored in the CMTS.

The CMTS reports the current status of existing DSIDs. When a DSID is created during the registration process or a DBC transaction, a corresponding object instance is created. If a DSID is deleted or changed via a DBC message the corresponding object instance is deleted or updated respectively.

Table 371 - CmtsDsid Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	N/A
Dsid	Dsid	key		N/A	N/A
Usage	EnumBits	read-only	resequencing(0) multicastCapable(1) multicastReplication(2) bonding(3)	N/A	N/A
DsChSet	ChSetId	read-only		N/A	N/A
ReseqWaitTime	UnsignedByte	read-only	0 | 1..180	hundredMicroseconds	N/A
ReseqWarnThrshld	UnsignedByte	read-only	0..179	hundredMicroseconds	N/A
StatusHldoffTimerSeqOutOfRng	UnsignedShort	read-only		20 milliseconds	N/A
CurrentSeqNum	UnsignedShort	read-only		N/A	N/A

7.2.1.6.9.1 IfIndex

This key represents the interface index of the MAC Domain associated with the DSID.

7.2.1.6.9.2 Dsid

This key represents the DSID.

7.2.1.6.9.3 Usage

This attribute indicates the properties of the DSID. The bits are defined as follows:

- 'resequencing'
  This bit is set to 1 for a Resequencing DSID.
- 'multicastCapable'
  This bit is set to 1 for a DSID that is capable of transporting multicast traffic (i.e., the DSID has multicast forwarding attributes).
- 'multicastReplication'
  This bit is set to 1 for a DSID that is used for transporting a multicast replication (i.e., there is a corresponding instance of the CmtsReplSess object).
- 'bonding'
  This bit is set to a 1 for a DSID that is associated with a bonding group.

References: [OSSIv3.0] Annex M; [MULPIv4.0] DSID Encodings section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.6.9.4 DsChSet

This attribute represents the Downstream Channel Set over which the DSID is being resequenced.

7.2.1.6.9.5 ReseqWaitTime

This attribute represents the DSID Resequencing Wait Time that is used for this DSID. This attribute is only valid when the Usage attribute has the resequencing bit set to 1. This attribute returns a value of 0 when the Usage attribute has the resequencing bit set to 0.

7.2.1.6.9.6 ReseqWarnThrshld

This attribute represents the DSID Resequencing Warning Threshold that is used for this DSID. The value of 0 indicates that the threshold warnings are disabled. This attribute is only valid when the Usage attribute has the resequencing bit set to 1. This attribute returns a value of 0 when the Usage attribute has the resequencing bit set to0.

7.2.1.6.9.7 StatusHldoffTimerSeqOutOfRng

This attribute represents the hold-off timer for reporting Out-of-Range Events via the CM-STATUS MAC Management message. This attribute is only valid when the Usage attribute has the resequencing bit set to 1. This attribute returns a value of 0 when the Usage attribute has the resequencing bit set to 0.

7.2.1.6.9.8 LastSeqNum

This attribute reports the value of the most recent sequence number assigned by the CMTS for this DSID. This attribute is only valid when the Usage attribute has the resequencing bit set to 1. This attribute returns a value of 0 when the Usage attribute has the resequencing bit set to 0.

7.2.1.6.10 IP Multicast QoS Event Behaviors

This section defines the behavior and trigger mechanisms for several of the Multicast QoS event definitions defined in Annex D, Format and Content for Event, SYSLOG, and SNMP Notification (Normative).

Event ID 89010104 reflects that a particular Group Service Flow is dropping packets as a result of a) the incoming data rate exceeding the rate-shaping bounds defined by the combination of Maximum Sustained Traffic Rate, Maximum Traffic Burst, and Peak Traffic Rate in the Group QoS Configuration, or b) the available capacity of the DCS is insufficient to support forwarding. When event reporting is administratively enabled, the CMTS MUST generate event ID 89010104 when the condition of packet loss is detected. The CMTS SHOULD detect this condition when packet loss due to AQM or buffer overflow exceeds one packet per second for each of the most recent three seconds.

Event ID 89010105 reflects that a particular Group Service Flow is no longer dropping packets as a result of a) the incoming data rate exceeding the rate-shaping bounds defined by the combination of Maximum Sustained Traffic Rate, Maximum Traffic Burst, and Peak Traffic Rate in the Group QoS Configuration, or b) the available capacity of the DCS is insufficient to support forwarding. When event reporting is administratively enabled, the CMTS MUST generate Event ID 89010105 when the condition of packet loss is no longer detected. Once a particular multicast session is in a "dropping packets" state (as indicated by the generation of event ID 89010104), the CMTS SHOULD detect this condition when packet loss due to AQM or buffer overflow equals zero packets per second for each of the most recent three seconds.

Admitted Multicast Aggregate Bandwidth is defined as the sum of the Minimum Reserved Traffic Rates of each Group Service Flow that has been admitted on a given CMTS cable interface. Note that for some vendors this CMTS cable interface will be a cable-mac interface. For others, it will be a DOCSIS Downstream Channel Set. In either case, this CMTS cable interface exists as a row entry in the ifTable (and therefore has an ifIndex which can be referenced in the defined event messages).

The IGMP and MLD protocol event messages include a threshold for determining whether ingress packet loss is occurring for IGMP/MLD protocol messages received from clients. For the IGMP/MLD protocol packet loss Event IDs 89010106 through 89010111, the configuration and logic to determine how a threshold crossing is calculated for the high and low thresholds is vendor-specific.

7.2.1.7 DOCS-SEC-MIB Performance Management Information Model

The objects in the DOCS-SEC-MIB are taken from the DOCS-SEC-MIB specified in Annex Q of [OSSIv3.0] ; the DocsSecCmtsCertRevocationListStatus object only includes the read-only attributes. Otherwise, these objects are used without modification for the CCAP.

Reference: [OSSIv3.0], [DOCS-SEC-MIB]

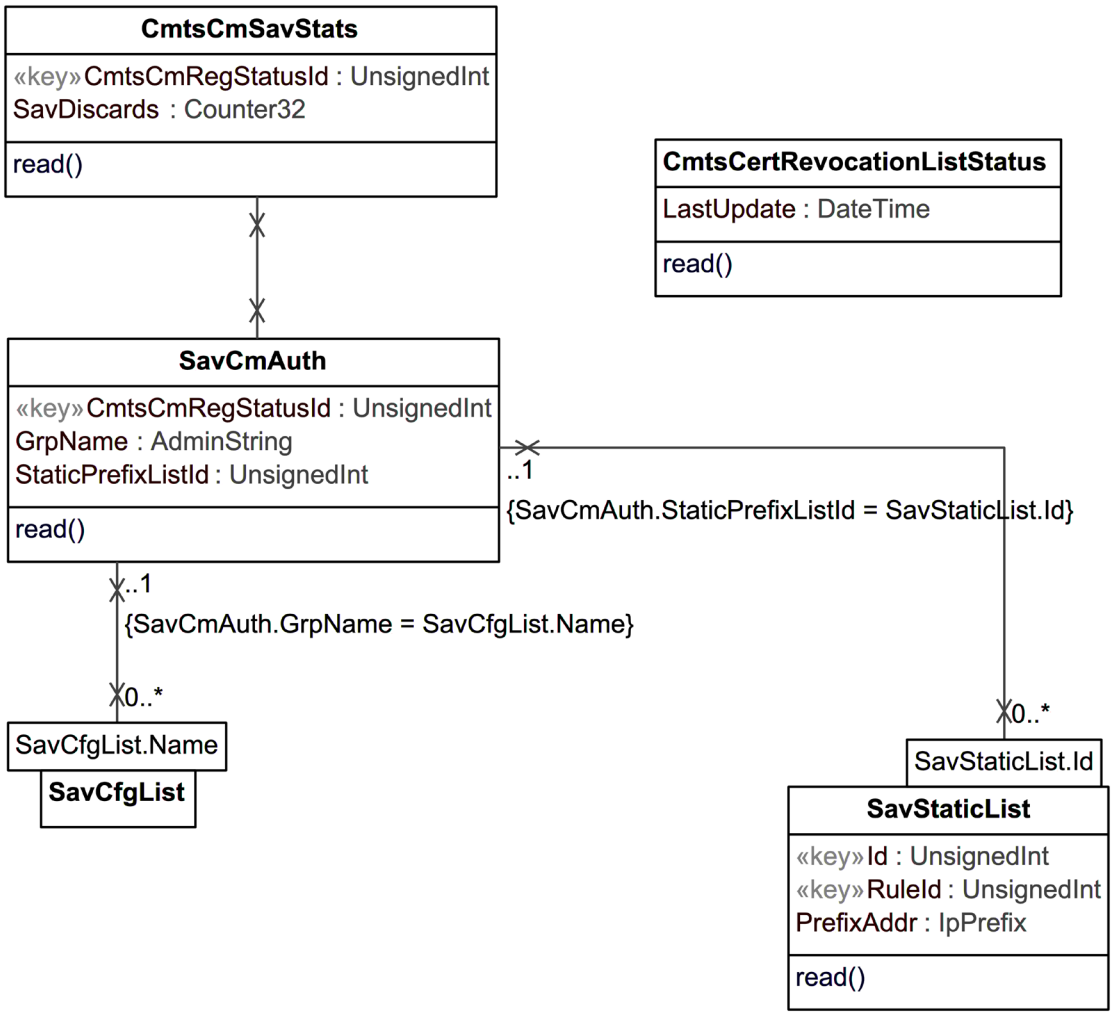


Figure 58 - DOCSIS Security Performance Management Information Model

7.2.1.7.1 SavCmAuth

The SavCmAuth object defines a read-only set of SAV policies associated with a CM that the CMTS will use in addition to the CMTS verification of an operator assigned IP Address being associated with a CM. When the CMTS has not resolved a source address of a CM CPE, the CMTS verifies if the CM CPE is authorized to pass traffic based on this object. These object policies include a list of subnet prefixes (defined in the SavStaticList object) or a SAV Group Name that could reference a CMTS configured list of subnet prefixes (defined in SavCfgList object) or vendor-specific policies. The CMTS populates the attributes of this object for a CM from that CM's config file.

This object is only applicable when the SrcAddrVerificationEnabled attribute of the MdCfg object is 'true' and the CmAuthEnable attribute of the CmtsSavCtrl object is 'true'.

The CMTS is not required to persist instances of this object across reinitializations.

References: [OSSIv3.0] Annex O, MdCfg section; [SECv4.0] Secure Provisioning section; [MULPIv4.0] Encodings for Configuration and MAC-Layer Messaging Annex.

Table 372 - SavCmAuth Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	key	1..4294967295	N/A	N/A
GrpName	AdminString	read-only		N/A	N/A
StaticPrefixListId	UnsignedInt	read-only		N/A	N/A

7.2.1.7.1.1 CmtsCmRegStatusId

This attribute is a key which uniquely identifies the CM. This attribute matches an index value of the CmtsCmRegStatus object.

7.2.1.7.1.2 GrpName

This attribute references the Name attribute of the SavCfgList object of a CM. If the CM signaled group name is not configured in the CMTS, the CMTS ignores this attribute value for the purpose of Source Address Verification. The CMTS MUST allow the modification of the GrpName object and use the updated SAV rules for newly discovered CPEs from CMs. When a source IP address is claimed by two CMs (e.g., detected as duplicated), the CMTS MUST use the current SAV rules defined for both CMs in case the SAV GrpName rules may have been updated. In the case of a persisting conflict, it is up to vendor-implementation to decide what CM should hold the SAV authorization.

The zero-length string indicates that no SAV Group was signaled by the CM. The zero-length value or a non-existing reference in the SavCfgList object means the SavCfgListName is ignored for the purpose of SAV.

References: [MULPIv4.0] Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.7.1.3 StaticPrefixListId

This attribute identifies the reference to a CMTS created subnet prefix list based on the CM signaled static prefix list TLV elements. The CMTS may reuse this attribute value to reference more than one CM when those CMs have signaled the same subnet prefix list to the CMTS.

The value zero indicates that no SAV static prefix encodings were signaled by the CM.

7.2.1.7.2 SavStaticList

The SavStaticList object defines a subnet prefix extension to the SavCmAuth object based on CM statically signaled subnet prefixes to the CMTS.

When a CM signals to the CMTS static subnet prefixes, the CMTS MUST create a List Id to be referenced by the CM in the SavCmAuth StaticPrefixListId attribute. When a CM signals to the CMTS static subnet prefixes, the CMTS MAY reference an existing List Id associated to previously registered CMs in case of those subnet prefixes associated with the List Id match the ones signaled by the CM.

The CMTS MAY persist instances of the SavStaticList object across reinitializations.

References: [MULPIv4.0] Encodings for Configuration and MAC-Layer Messaging Annex.

Table 373 - SavStaticList Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Id	UnsignedInt	key	1..4294967295	N/A	N/A
RuleId	UnsignedInt	key	1..4294967295	N/A	N/A
PrefixAddr	IpPrefix	read-only		N/A	N/A

7.2.1.7.2.1 Id

This key uniquely identifies the index that groups multiple subnet prefix rules. The CMTS assigns this value per CM or may reuse it among multiple CMs that share the same list of subnet prefixes.

7.2.1.7.2.2 RuleId

This attribute is the key that identifies a particular static subnet prefix rule of an instance of this object.

7.2.1.7.2.3 PrefixAddr

This attribute corresponds to the IP address and prefix length of this subnet prefix rule.

7.2.1.7.3 CmtsCmSavStats

This object provides a read-only list of SAV counters for different service theft indications.

Table 374 - CmtsCmSavStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	key	1..4294967295	N/A	N/A
SavDiscards	Counter32	read-only		N/A	N/A

7.2.1.7.3.1 CmtsCmRegStatusId

This key uniquely identifies the CM. This attribute matches an index value of the CmtsCmRegStatus object.

7.2.1.7.3.2 SavDiscards

This attribute provides the information about number of dropped upstream packets due to SAV failure.

7.2.1.7.4 CmtsCertRevocationListStatus

The CmtsCertRevocationListStatus object defines CCAP Certificate Revocation List status information.

This object is only applicable when the CertRevocationMethod attribute of the CmtsCertificate object is set to 'crl' or 'crlAndOcsp'.

The CMTS and CCAP MUST persist the values of the Url and RefreshInterval attributes of the CmtsCertRevocationList object across reinitializations.

References: [SECv4.0] BPI+ X.509 Certificate Profile and Management section

Table 375 - CmtsCertRevocationListStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
LastUpdate	DateTime	read-only		N/A	N/A

7.2.1.7.4.1 LastUpdate

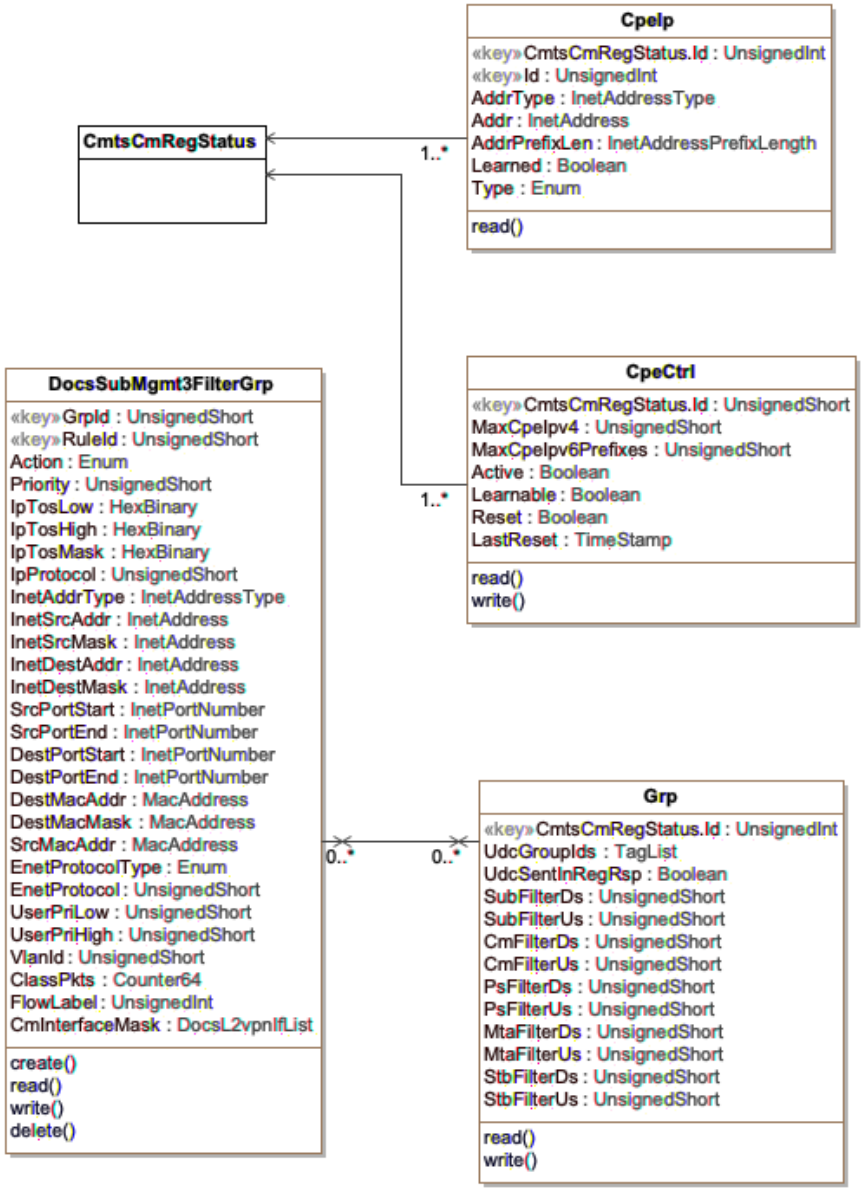
This attribute contains the last date and time when the CRL was retrieved by the CMTS. This attribute returns January 1, year 0000, 00:00:00.0 if the CRL has not been updated.

7.2.1.7.5 SavCfgList

The SavCfgList configuration object defines the CMTS configured subnet prefix extension to the SavCmAuth object. Refer to the DOCSIS Security Configuration Information Model in Section 6.5.6.2 for the definition of the SavCfgList object.

7.2.1.8 DOCSIS Subscriber Management Performance Management Information Model

This section details the DOCSIS performance objects for Subscriber Management reporting features defined in DOCSIS 4.0. The information model for these features is shown below.


CpeIp
«key» CmtsCmRegStatus.Id : UnsignedInt
«key» Id : UnsignedInt
AddrType : InetAddressType
Addr : InetAddress
AddrPrefixLen : InetAddressPrefixLength
Learned : Boolean
Type : Enum
read()
CmtsCmRegStatus
1..*
1..*
CpeCtrl
«key» CmtsCmRegStatus.Id : UnsignedShort
MaxCpeIpv4 : UnsignedShort
MaxCpeIpv6Prefixes : UnsignedShort
Active : Boolean
Learnable : Boolean
Reset : Boolean
LastReset : TimeStamp
read()
write()
DocsSubMgmt3FilterGrp
«key» GrpId : UnsignedShort
«key» RuleId : UnsignedShort
Action : Enum
Priority : UnsignedShort
IpTosLow : HexBinary
IpTosHigh : HexBinary
IpTosMask : HexBinary
IpProtocol : UnsignedShort
InetAddrType : InetAddressType
InetSrcAddr : InetAddress
InetSrcMask : InetAddress
InetDestAddr : InetAddress
InetDestMask : InetAddress
SrcPortStart : InetPortNumber
SrcPortEnd : InetPortNumber
DestPortStart : InetPortNumber
DestPortEnd : InetPortNumber
DestMacAddr : MacAddress
DestMacMask : MacAddress
SrcMacAddr : MacAddress
EnetProtocolType : Enum
EnetProtocol : UnsignedShort
UserPriLow : UnsignedShort
UserPriHigh : UnsignedShort
VlanId : UnsignedShort
ClassPkts : Counter64
FlowLabel : UnsignedInt
CmInterfaceMask : DocsL2vpnIfList
create()
read()
write()
delete()
0..*
0..*
Grp
«key» CmtsCmRegStatus.Id : UnsignedInt
UdcGroupIds : TagList
UdcSentInRegRsp : Boolean
SubFilterDs : UnsignedShort
SubFilterUs : UnsignedShort
CmFilterDs : UnsignedShort
CmFilterUs : UnsignedShort
PsFilterDs : UnsignedShort
PsFilterUs : UnsignedShort
MtaFilterDs : UnsignedShort
MtaFilterUs : UnsignedShort
StbFilterDs : UnsignedShort
StbFilterUs : UnsignedShort
read()
write()

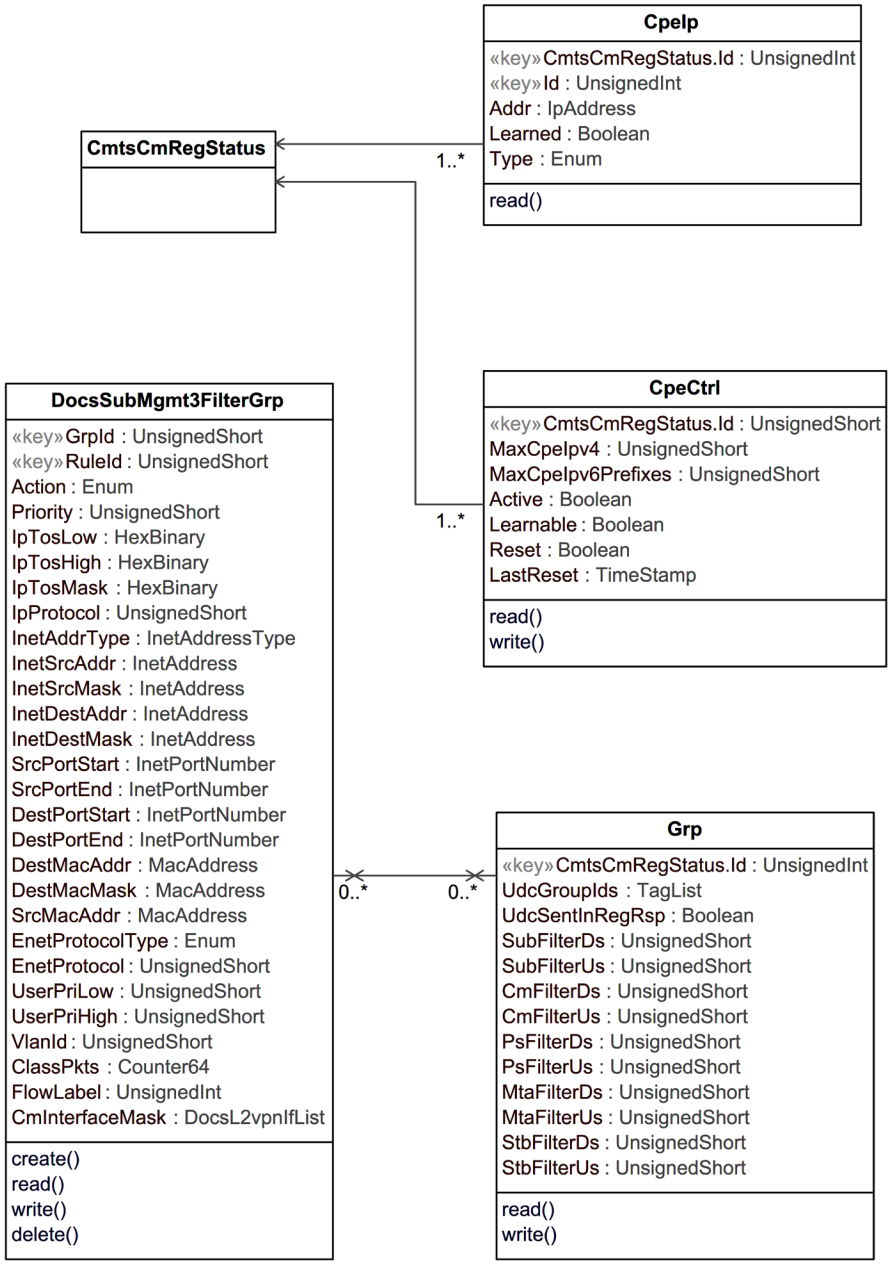


Figure 59 - DOCSIS Subscriber Management Performance Information Model

7.2.1.8.1 CmtsCmRegStatus

Refer to Section 7.2.2.2.1 CmtsCmRegStatus for a description of this class.

7.2.1.8.2 CpeCtrl

The CpeCtrl object maintains per-CM traffic policies enforced by the CMTS. The CMTS acquires the CM traffic policies through the CM registration process, or in the absence of some or all of those parameters, from the Base object. The CM information and controls are meaningful and used by the CMTS, but only after the CM is operational.

Reference: [DOCS-SUBMGT3-MIB] docsSubmgt3CpeCtrlTable

Table 376 - CpeCtrl Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	key	1..4294967295	N/A	N/A
MaxCpeIpv4	UnsignedShort	read-write	0..1023	N/A	N/A
MaxCpeIpv6Prefixes	UnsignedShort	read-write	0..1023	N/A	N/A
Active	Boolean	read-write		N/A	N/A
Learnable	Boolean	read-write		N/A	N/A
Reset	Boolean	read-write		N/A	N/A
LastReset	TimeStamp	read-write		N/A	N/A

7.2.1.8.2.1 CmtsCmRegStatusId

This key attribute is the CMTS generated unique identifier of a CM for status report purposes.

7.2.1.8.2.2 MaxCpeIpv4

This attribute represents the number of simultaneous IPv4 addresses permitted for CPEs connected to the CM. When the MaxCpeIpv4 attribute is set to zero (0), all IPv4 CPE traffic from the CM is dropped. The CMTS configures this attribute with whichever of the 'Subscriber Management CPE IPv4 List' or 'Subscriber Management Control-MaxCpeIPv4' signaled encodings is greater, or in the absence of all of those provisioning parameters, with the CpeMaxIpv4Def from the Base object. This limit applies to learned and DOCSIS-provisioned entries but not to entries added through some administrative process (e.g., statically) at the CMTS. Note that this attribute is only meaningful when the Active attribute of the CM is set to 'true'.

References: [MULPIv4.0] Subscriber Management TLVs section of the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.8.2.3 MaxCpeIpv6Prefixes

This attribute represents the maximum number of simultaneous IPv6 IA_PDs (delegated prefixes) that are permitted for CPEs connected to the CM. When the MaxCpeIpv6Prefixes is set to zero (0), all IPv6 CPE traffic from the CM is dropped. The CMTS configures this attribute with whichever of the ('Subscriber Management CPE IPv6 List (TLV 67)' plus 'Subscriber Management CPE IPv6 Prefix List (TLV 61)') or ('Subscriber Management Control Max CPE IPv6 Addresses (TLV 63)') signaled encodings is greater, or in the absence of all of those provisioning parameters, with the MaxIpv6PrefixesDef from the Base object. This limit applies to learned and DOCSIS-provisioned entries but not to entries added through some administrative process at the CMTS. Note that this attribute is only meaningful when the Active attribute of the CM is set to 'true'.

IPv6 IA_PDs are counted against the CpeCtrlMaxCpeIpv6Prefixes in order to limit the number of simultaneous IA_PDs permitted for the CM's CPEs.

References: [MULPIv4.0] Subscriber Management TLVs section of the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.8.2.4 Active

This attribute controls the application of subscriber management to this CM. If this is set to 'true', CMTS-based CPE control is active, and all the actions required by the various filter policies and controls apply at the CMTS. If this is set to false, no subscriber management filtering is done at the CMTS (but other filters may apply). If not set through DOCSIS provisioning, this object defaults to the value of the Active attribute of the Base object.

References: [MULPIv4.0] Subscriber Management TLVs section of the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.8.2.5 Learnable

This attribute controls whether the CMTS may learn (and pass traffic for) CPE IP addresses associated with a CM. If this is set to 'true', the CMTS may learn up to the CM MaxCpeIp value less any DOCSIS-provisioned entries related to this CM. The nature of the learning mechanism is not specified here. If not set through DOCSIS provisioning, this object defaults to the value of the CpeLearnableDef attribute from the Base object. Note that this attribute is only meaningful if docsSubMgtCpeCtrlActive is 'true' to enforce a limit in the number of CPEs learned. CPE learning is always performed for the CMTS for security reasons.

References: [MULPIv4.0] Subscriber Management TLVs section of the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.8.2.6 Reset

If set to 'true', this attribute commands the CMTS to delete the instances denoted as 'learned' addresses in the CpeIp object. This attribute always returns false on read.

7.2.1.8.2.7 LastReset

This attribute represents the system Up Time of the last set to 'true' of the Reset attribute of this instance. Zero if never reset.

7.2.1.8.3 CpeIp

The CpeIp object defines the list of IP Addresses behind the CM known by the CMTS. If the Active attribute of the CpeCtrl object associated with a CM is set to 'true' and the CMTS receives an IP packet from a CM that contains a source IP address that does not match one of the CPE IP addresses associated with this CM, one of two things occurs. If the number of CPE IPs is less than the MaxCpeIp of the CpeCtrl object for that CM, the source IP address is added to this object and the packet is forwarded; otherwise, the packet is dropped.

Reference: [DOCS-SUBMGT3-MIB] docsSubmgt3CpeIpTable

Table 377 - CpeIp Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	key	1..4294967295	N/A	N/A
Id	UnsignedInt	key	1..1023	N/A	N/A
Addr	IpAddress	read-only		N/A	N/A
Learned	Boolean	read-only		N/A	N/A
Type	Enum	read-only	cpe(1), ps(2), mta(3), stb(4), tea(5), erouter(6), dva(7), sg(8), card(9), pta(10), tr(11)	N/A	N/A

7.2.1.8.3.1 CmtsCmRegStatusId

This key attribute is the CMTS generated unique identifier of a CM for status reporting purposes.

7.2.1.8.3.2 Id

This attribute represents a unique identifier for a CPE IP of the CM. An instance of this attribute exists for each CPE provisioned in the 'Subscriber Management CPE IPv4 Table' or 'Subscriber Management CPE IPv6 Table' encodings. An entry is created either through the included CPE IP addresses in the provisioning object, or CPEs learned from traffic sourced from the CM.

References: [MULPIv4.0] Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.1.8.3.3 Addr

This attribute represents the IP address either set from provisioning or learned via address gleaning of the DHCP exchange or some other means.

7.2.1.8.3.4 Learned

This attribute is set to 'true' when the IP address was learned from IP packets sent upstream rather than via the CM provisioning process.

7.2.1.8.3.5 Type

This attribute represents the type of CPE based on the following classifications:

'cpe' - Regular CPE clients

'ps' - CableHome Portal Services Element (PS)

'mta' - PacketCable Multimedia Terminal Adapter (MTA)

'stb' - Digital Set-top Box (STB)

'tea' - T1/E1 Emulation adapter (TEA)

'erouter' - Embedded Router (eRouter)

'dva' - PacketCable 2.0 Digital Voice Adapter (DVA)

'sg' - PacketCable Security, Monitoring, and Automation Gateway (SG)

'card' - OpenCable CableCARD

'pta' - Performance Test Agent (PTA)

'tr' - OpenCable Tuning Resolver (TR)

Reference: [eDOCSIS]

7.2.1.8.4 Grp

The Grp object defines the set of downstream and upstream filter groups that the CMTS applies to traffic associated with that CM.

References: [MULPIv4.0] Subscriber Management TLVs section in the Encodings for Configuration and MAC-Layer Messaging Annex [DOCS-SUBMGT3-MIB] docsSubmgt3GrpTable.

Table 378 - Grp Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
CmtsCmRegStatusId	UnsignedInt	key	1..4294967295	N/A	N/A
UdcGroupIds	TagList	read-only		N/A	
UdcSentInRegRsp	Boolean	read-only		N/A	
SubFilterDs	UnsignedShort	read-write	0..1024	N/A	N/A
SubFilterUs	UnsignedShort	read-write	0..1024	N/A	N/A
CmFilterDs	UnsignedShort	read-write	0..1024	N/A	N/A

Attribute Name	Type	Access	Type Constraints	Units	Default
CmFilterUs	UnsignedShort	read-write	0..1024	N/A	N/A
PsFilterDs	UnsignedShort	read-write	0..1024	N/A	N/A
PsFilterUs	UnsignedShort	read-write	0..1024	N/A	N/A
MtaFilterDs	UnsignedShort	read-write	0..1024	N/A	N/A
MtaFilterUs	UnsignedShort	read-write	0..1024	N/A	N/A
StbFilterDs	UnsignedShort	read-write	0..1024	N/A	N/A
StbFilterUs	UnsignedShort	read-write	0..1024	N/A	N/A

7.2.1.8.4.1 CmtsCmRegStatusId

This key attribute is the CMTS generated unique identifier of a CM for status report purposes.

7.2.1.8.4.2 UdcGroupIds

This attribute represents the filter group(s) associated with the CM signaled 'Upstream Drop Classifier Group ID' encodings during the registration process. UDC Group IDs are integer values and this attribute reports them as decimal numbers that are space-separated. The zero-length string indicates that the CM didn't signal UDC Group IDs.

This attribute provides two functions:

- Communicate the CM the configured UDC Group ID(s), irrespective of the CM being provisioned to filter upstream traffic based on IP Filters or UDCs.
- Optionally, and with regards to the CMTS, if the value of the attribute UdcSentInReqRsp is 'true', indicates that the filtering rules associated with the Subscriber Management Group ID(s) will be sent during registration to the CM. It is vendor specific whether the CMTS updates individual CM UDCs after registration when rules are changed in the Grp object.

7.2.1.8.4.3 UdcSentInRegRsp

This attribute represents the CMTS upstream filtering status for this CM. The value 'true' indicates that the CMTS has sent UDCs to the CM during registration process. In order for a CMTS to send UDCs to a CM, the CMTS MAC Domain needs to be enabled via the MAC Domain attribute SendUdcRulesEnabled and the CM had indicated the UDC capability support during the registration process. The value 'false' indicates that the CMTS was not enabled to send UDCs to the CMs in the MAC Domain, or the CM did not advertise UDC support in its capabilities encodings, or both. Since the CMTS capability to send UDCs to CMs during the registration process is optional, the CMTS is not required to instantiate this attribute.

7.2.1.8.4.4 SubFilterDs

This attribute represents the filter group applied to traffic destined for subscriber's CPE attached to the referenced CM (attached to CM CPE interfaces). This value corresponds to the 'Subscriber Downstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterDownDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic destined to hosts attached to this CM.

7.2.1.8.4.5 SubFilterUs

This attribute represents the filter group applied to traffic originating from subscriber's CPE attached to the referenced CM (attached to CM CPE interfaces). This value corresponds to the 'Subscriber Upstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterUpDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic originating from hosts attached to this CM.

7.2.1.8.4.6 CmFilterDs

This attribute represents the filter group applied to traffic destined for the CM itself. This value corresponds to the 'CM Downstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the CmFilterDownDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic destined to this CM.

7.2.1.8.4.7 CmFilterUs

This attribute represents the filter group applied to traffic originating from the CM itself. This value corresponds to the 'Subscriber Upstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterUpDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic originating from this CM.

7.2.1.8.4.8 PsFilterDs

This attribute represents the filter group applied to traffic destined to the Embedded CableHome Portal Services Element or the Embedded Router on the referenced CM. This value corresponds to the 'PS Downstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterDownDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic destined to the Embedded CableHome Portal Services Element or Embedded Router on this CM.

7.2.1.8.4.9 PsFilterUs

This attribute represents the filter group applied to traffic originating from the Embedded CableHome Portal Services Element or Embedded Router on the referenced CM. This value corresponds to the 'PS Upstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterUpDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic originating from the Embedded CableHome Portal Services Element or Embedded Router on this CM.

7.2.1.8.4.10 MtaFilterDs

This attribute represents the filter group applied to traffic destined to the Embedded Multimedia Terminal Adapter on the referenced CM. This value corresponds to the 'MTA Downstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterDownDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic destined to the Embedded Multimedia Terminal Adapter on this CM.

7.2.1.8.4.11 MtaFilterUs

This attribute represents the filter group applied to traffic originating from the Embedded Multimedia Terminal Adapter on the referenced CM. This value corresponds to the 'MTA Upstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterUpDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic originating from the Embedded Multimedia Terminal Adapter on this CM.

7.2.1.8.4.12 StbFilterDs

This attribute represents the filter group applied to traffic destined for the Embedded Set-Top Box on the referenced CM. This value corresponds to the 'STB Downstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterDownDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic destined to the Embedded Set-Top Box on this CM.

7.2.1.8.4.13 StbFilterUs

This attribute represents the filter group applied to traffic originating from the Embedded Set-Top Box on the referenced CM. This value corresponds to the 'STB Upstream Group' value of the 'Subscriber Management Filter Groups' encoding signaled during the CM registration or in its absence, to the SubFilterUpDef attribute of the Base object. The value zero or a filter group ID not configured in the CMTS means no filtering is applied to traffic originating from the Embedded Set-Top Box on this CM.

7.2.1.8.5 FilterGrp

The FilterGrp configuration object describes a set of filter or classifier criteria. Refer to the DOCSIS Subscriber Management Configuration Information Model in Section 6.5.6.3 for the definition of the FilterGrp object.

7.2.1.9 CCAP Topology Performance Management Information Model

The RfPortFnCfg object is taken from the CLAB-TOPO-MIB specified in Annex Q of [OSSIv3.0] and used without modification for the CCAP.

The FiberNodeCfg object is taken from the CCAP Configuration Information Model; it is defined in Section 6.5.4.12 FiberNodeCfg.

Reference: [OSSIv3.0], [DOCS-IF3-MIB], [CLAB-TOPO-MIB]

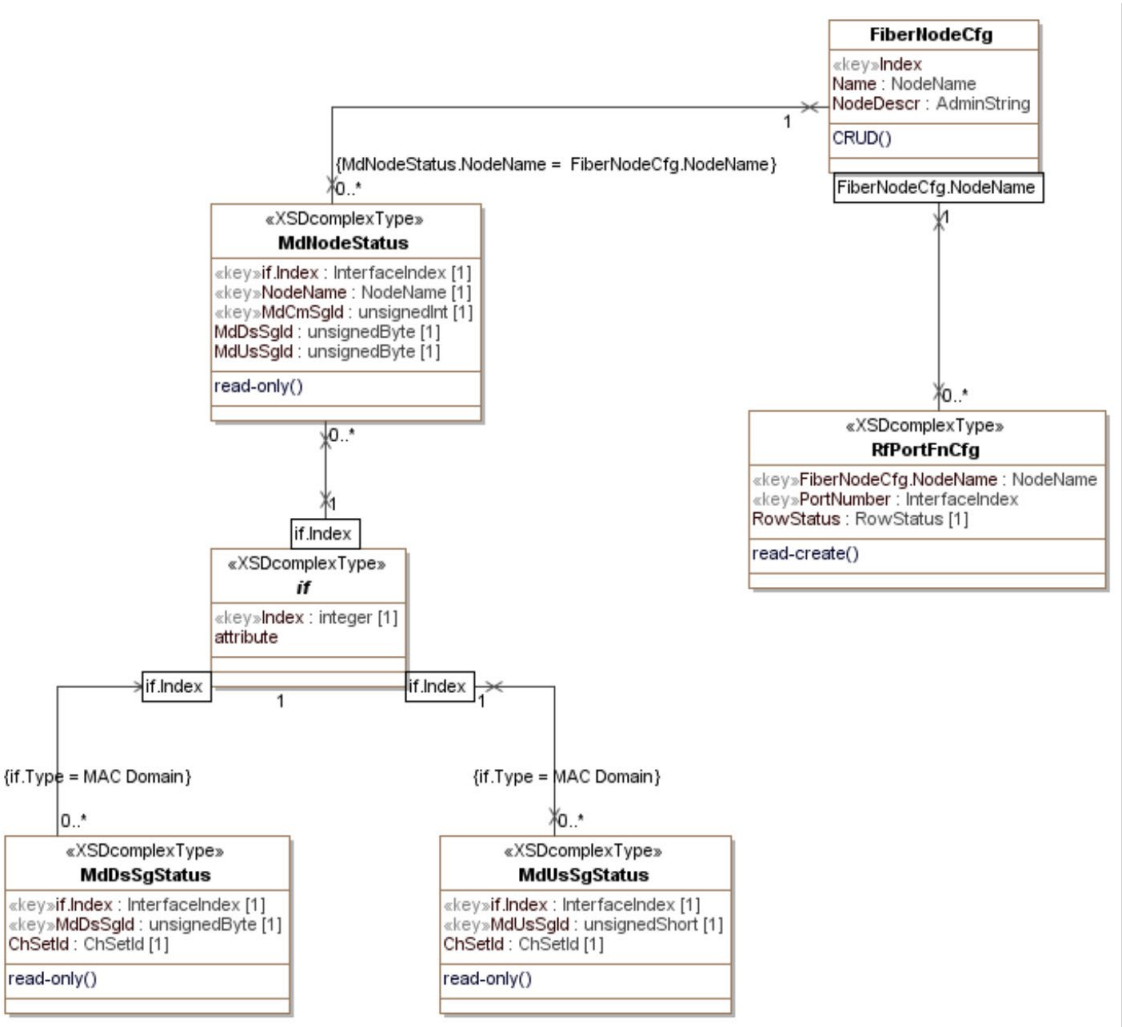


Figure 60 - CCAP Topology Performance Management Information Model

7.2.1.9.1 MdNodeStatus

This object reports the MD-DS-SG-ID and MD-US-SG-ID associated with a MD-CM-SG-ID within a MAC Domain and the Fiber Nodes reached by the MD-CM-SG.

Table 379 - MdNodeStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	N/A
NodeName	NodeName	key	SIZE (1..64)	N/A
MdCmSgId	UnsignedInt	key	1..4294967295	N/A
MdDsSgId	UnsignedByte	read-only	1..255	N/A
MsUsSgId	UnsignedByte	read-only	1..255	N/A

7.2.1.9.1.1 IfIndex

This key represents the interface index of the MAC Domain associated with the fiber node to which this instance applies.

7.2.1.9.1.2 NodeName

This key represents the name of a fiber node associated with a MD-CM-SG of a MAC Domain.

7.2.1.9.1.3 MdCmSgId

This attribute is a key and indicates the MD-CM-SG-ID of this instance. A particular MdCmSgId in a MAC Domain is associated with one or more Fiber Nodes.

7.2.1.9.1.4 MdDsSgId

This attribute corresponds to the MD-DS-SG-ID of the MD-CM-SG of this object instance. The MdDsSgId values are unique within a MAC Domain.

7.2.1.9.1.5 MdUsSgId

This attribute corresponds to the MD-US-SG-ID of the MD-CM-SG of this object instance. The MdUsSgId values are unique within a MAC Domain.

7.2.1.9.2 MdDsSgStatus

This object returns the list of downstream channel set associated with a MAC Domain MD-DS-SG-ID.

Table 380 - MdDsSgStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	N/A	N/A
MdDsSgId	UnsignedByte	key	1..255	N/A	N/A
ChSetId	ChSetId	read-only		N/A	N/A

7.2.1.9.2.1 IfIndex

This key represents the interface index of the MAC Domain to which the MD-DS-SG-ID applies.

7.2.1.9.2.2 MdDsSgId

This key represents a MD-DS-SG-ID in a Mac Domain.

7.2.1.9.2.3 ChSetId

This attribute represents a reference to the list of downstream channels of the MD-DS-SG-ID.

7.2.1.9.3 MdUsSgStatus

This object returns the list of upstream channels associated with a MAC Domain MD-US-SG-ID.

Table 381 - MdUsSgStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	InterfaceIndex of MAC Domain interface	N/A
MdUsSgId	UnsignedByte	key	1..255	N/A
ChSetId	ChSetId	read-only		N/A

7.2.1.9.3.1 IfIndex

This key represents the interface index of the MAC Domain to which the MD-DS-SG-ID applies.

7.2.1.9.3.2 MdUsSgId

This key represents a MD-US-SG-ID in a Mac Domain.

7.2.1.9.3.3 ChSetId

This attribute represents a reference to the list of upstream channels of the MD-US-SG-ID.

7.2.1.10 CCAP-MIB Performance Management Information Model

The CCAP-MIB defines the following:

- Objects that provide a link between an identifier of a CCAP interface used in the YANG model and its corresponding standard ifIndex MIB object from the ifTable and entPhysicalIndex MIB object from the ENTITY-MIB.
- Objects that can be used for video input program bitrate monitoring. Both the input program bitrate and input program requested bitrate can be accessed.
- Objects that can be used to determine the status of the ECMD and ECMG.

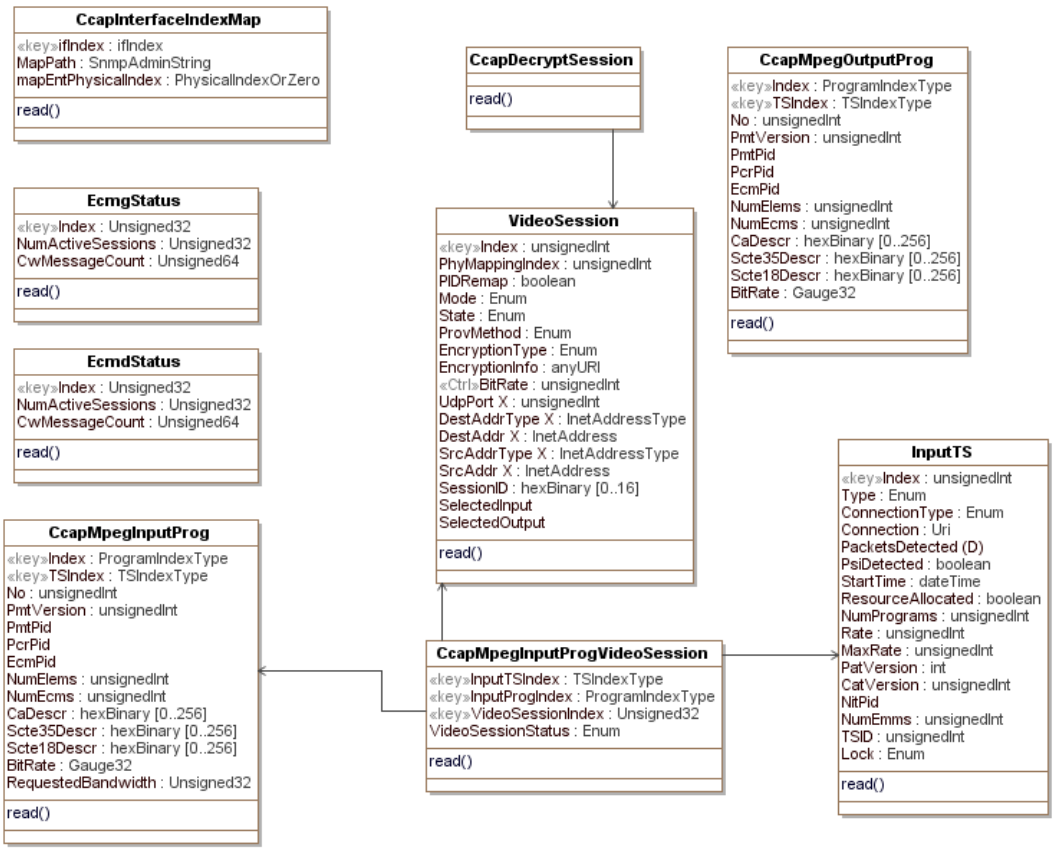


Figure 61 - CCAP-MIB Performance Management Information Model

The objects that make up the CCAP-MIB are described in the following sections.

7.2.1.10.1 CcapInterfaceIndexMap

This object reports the corresponding device path for the Interface index defined by an object instance.

Table 382 - CcapInterfaceIndexMap Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	key			
MapPath	SnmpAdminString	read-only			
mapEntPhysicalIndex	PhysicalIndexOrZero	read-only			

7.2.1.10.1.1 IfIndex

The index corresponds to the Interface MIB index for interfaces of IANA interface types:

- MAC Interface: docsCableMaclayer - 127
- Downstream Channel: docsCableDownstream - 128
- Upstream Interface: docsCableUpstream - 129
- Logical Upstream Channel: docsCableUpstreamChannel - 205
- Upstream RF Port: docsCableUpstreamRfPort - 256
- Downstream RF Port: cableDownstreamRfPort - 257

7.2.1.10.1.2 MapPath

This attribute indicates the CCAP node XPath expression that identifies the resource associated with the interface index. For example, the path value of the resource associated with an upstream logical channel with index = 5, in upstream physical channel index = 7, in an Upstream RF port number = 15, from an US RF Line Card, in slot number = 3, chassis id = 1 is represented as:

- /ccap/chassis[id="1"]
- /slot[number="3"]
- /rf-line-card
- /us-rf-port[number="15"]
- /upstream-physical-channel[index="7"]
- /upstream-logical-channel[index="5"]

NOTE: Line breaks in this example were added for clarity.

7.2.1.10.1.3 mapEntPhysicalIndex

This attribute corresponds to the entPhysicalIndex associated with the resource. The value is zero (0) if undefined.

7.2.1.10.2 EcmgStatus

This object allows for the monitoring of the interface to an Entitlement Control Message Generator (ECMG).

Table 383 - EcmgStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Index	UnsignedInt	Key			
NumActiveSessions	UnsignedInt	read-only			
CwMessageCount	UnsignedLong	read-only			

7.2.1.10.2.1 Index

This is an index for an instance of this object. It is a pointer to a defined Ecmg object.

7.2.1.10.2.2 NumActiveSessions

The current number of encryption sessions managed by the ECMG.

7.2.1.10.2.3 CwMessageCount

A running 64-bit counter that increments by one, every time the Encryptor receives one CW message from the ECMG. The counter is reset at boot time.

7.2.1.10.3 EcmdStatus

This object allows for the monitoring of the interface to an Entitlement Control Message Decoder (ECMD).

Table 384 - EcmdStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Index	UnsignedInt	Key			
NumActiveSessions	UnsignedInt	read-only			
CwMessageCount	UnsignedLong	read-only			

7.2.1.10.3.1 EcmdIndex

This is an index for an instance of this object. It is a pointer to a defined Ecmd object.

7.2.1.10.3.2 NumActiveSessions

The current number of decryption sessions managed by the ECMD.

7.2.1.10.3.3 CwMessageCount

A running 64-bit counter that increments by one, every time the Decryptor receives one CW message from the ECMD. The counter is reset at boot time.

7.2.1.10.4 CcapMpegInputProg

This object augments the mpegInputProgTable of the SCTE-HMS-MPEG-MIB with two additional attributes:

- BitRate
- RequestedBandwidth

No further modifications have been made to this table.

Reference: [SCTE 154-4]

Table 385 - CcapMpegInputProg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
BitRate	Gauge32	read-only		BPS	
RequestedBandwidth	UnsignedInt	read-only			

7.2.1.10.4.1 BitRate

Indicates the measured MPEG input program bitrate in bps.

7.2.1.10.4.2 RequestedBandwidth

Requested bandwidth for this MPEG input program. This value is used to validate the total QAM bandwidth before allowing the creation of a new session. It is also used to validate the input program bandwidth overflow situation during the transmission. In the case of special stream without PCR, it is used to limit the output bandwidth of that special program.

A zero (0) value is returned if no bandwidth validation is done on this program.

7.2.1.10.5 CcapMpegOutputProg

This object augments the mpegOutputProgTable of the SCTE-HMS-MPEG-MIB with the addition of a BitRate attribute.

No further modifications have been made to this table.

Reference: [SCTE 154-4]

Table 386 - CcapMpegOutputProg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
BitRate	Gauge32	read-only		BPS	

7.2.1.10.5.1 BitRate

Indicates the measured MPEG output program bitrate in bps.

7.2.1.10.6 VideoSession

The VideoSession object is taken from the SCTE-HMS-MPEG-MIB specified in [SCTE 154-4] and used without modification for the CCAP.

7.2.1.10.7 CcapDecryptSession

The CcapDecryptSession extends the existing VideoSession object from the SCTE-HMS-MPEG-MIB specified in [SCTE 154-4] and used without modification for the CCAP. This table is only populated with video sessions that require CCAP decryption.

Reference: [SCTE 154-4]

7.2.1.10.8 CcapMpegInputProgVideoSession

This object reports the list of video sessions that the MPEG input program are feeding.

Table 387 - CcapMpegInputProgVideoSession Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
InputTSIndex	TSIndexType	key			
InputProgIndex	ProgramIndexType	key			
VideoSessionIndex	UnsignedInt	key			
VideoSessionStatus	Enum	read-only	active(1), closed(2)		

Table 388 - CcapMpegInputProgVideoSession Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CcapMpegInputProg	Directed association to CcapMpegInputProg			
VideoSession	Directed association to VideoSession			
InputTS	Directed association to InputTS			

7.2.1.10.8.1 InputTSIndex

The index of the input TS.

7.2.1.10.8.2 InputProgIndex

The index of the input program.

7.2.1.10.8.3 VideoSessionIndex

The index of the video session.

7.2.1.10.8.4 VideoSessionStatus

The status of the video session.

7.2.1.10.9 InputTS

The InputTS object is taken from the SCTE-HMS-MPEG-MIB specified in [SCTE 154-4] and used without modification for the CCAP.

Reference: [SCTE 154-4]

7.2.1.11 SCTE-HMS-MPEG-MIB Performance Management State Information Model

The objects in the SCTE-HMS-MPEG-MIB: State Objects are taken from [SCTE 154-4] and used with the following modifications for the CCAP.

The CcapMpegInputProg object replaces the MpegInputProg object from the SCTE-HMS-MPEG-MIB. It is defined in Section 7.2.1.10.4, CcapMpegInputProg.

The CcapMpegOutputProg object replaces the MpegOutputProg object from the SCTE-HMS-MPEG-MIB. It is defined in Section 7.2.1.10.5, CcapMpegOutputProg.

Reference: [SCTE 154-4]

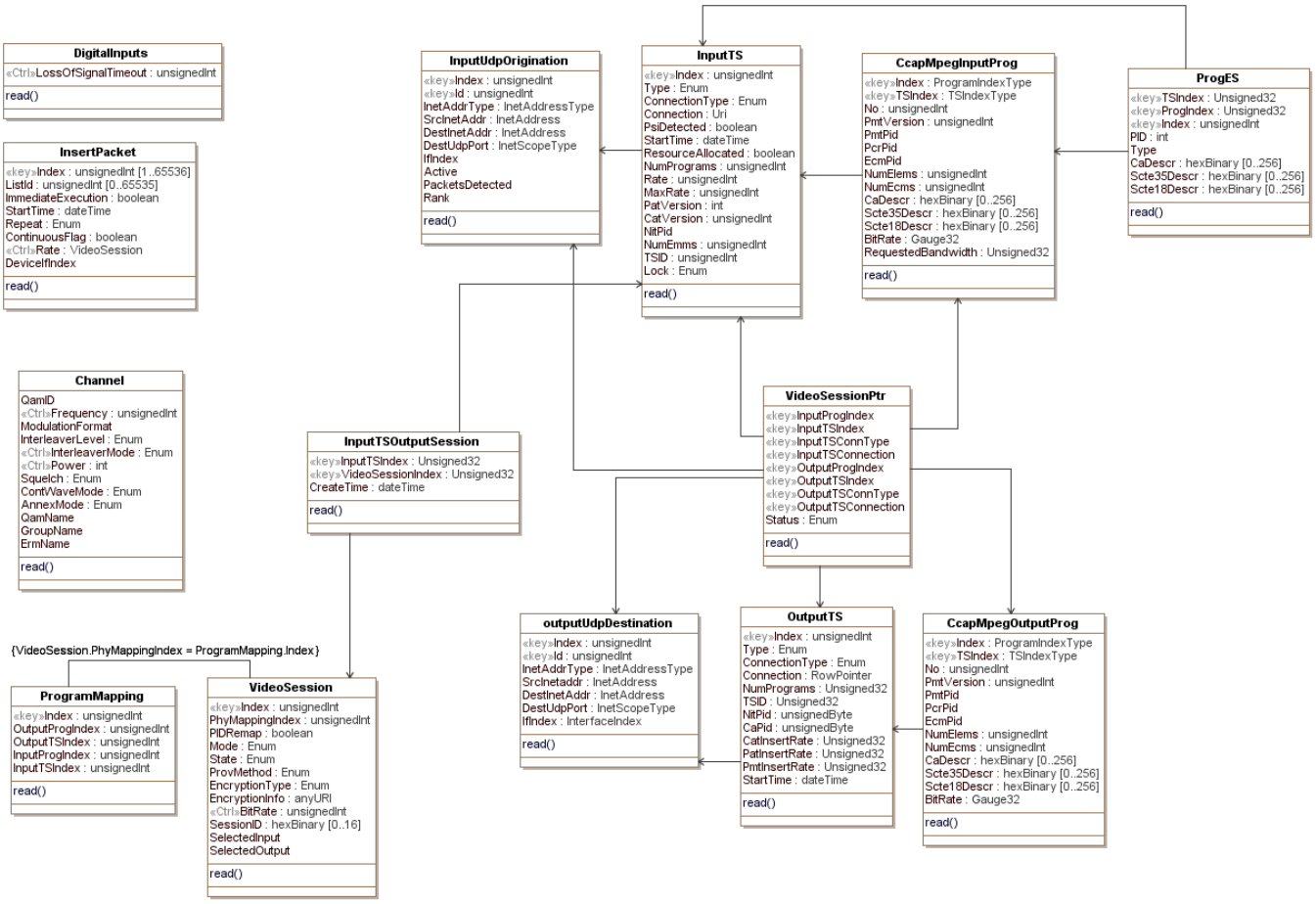


Figure 62 - SCTE-HMS-MPEG-MIB Performance Management State Information Model

7.2.1.12 DOCS-DRF-MIB Performance Management State Information Model

The objects in the DOCS-DRF-MIB: State Objects are taken from the DOCS-DRF-MIB [DRFI] specified in Annex A of [M-OSSI] and used without modification for the CCAP.

References: [M-OSSI], DOCS-DRF-MIB, [DRFI]

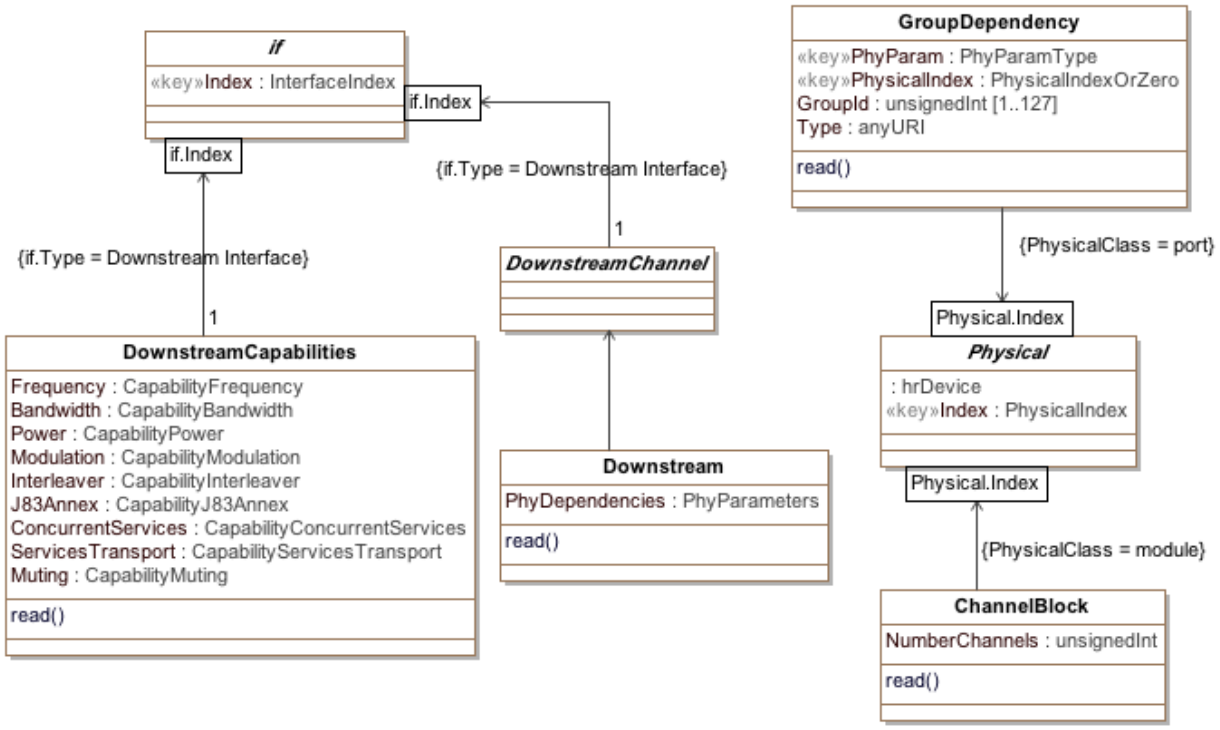


Figure 63 - DOCS-DRF-MIB Performance Management State Information Model

7.2.1.13 CCAP System Status Information Model

The following diagram illustrates the collection of system status reporting objects specific to the CCAP/CMTS.

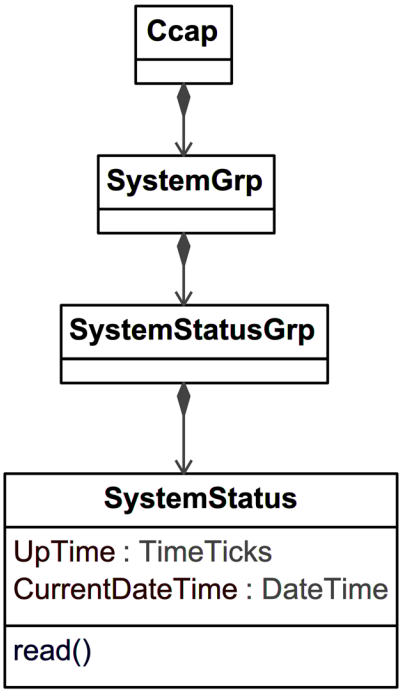


Figure 64 - System Status Information Model

7.2.1.13.1 Ccap

This object serves as the root of the CCAP/CMTS System Status Information Model. This object is defined in section 6.5.3.1 and included here for reference.

7.2.1.13.2 SystemGrp

The SystemGrp object is the primary container of CCAP/CMTS system management objects.

7.2.1.13.3 SystemStatusGrp

The SystemStatusGrp object is the primary container of CCAP/CMTS system status reporting management objects.

Table 389 - SystemStatusGrp Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SystemStatus	Directed Composition	1	1	N/A

7.2.1.13.4 SystemStatus

The SystemStatus object includes CCAP/CMTS system reporting attributes.

Table 390 - SystemStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Multiplicity
UpTime	TimeTicks	read-only		hundredths of a second	1
CurrentDateTime	DateTime	read-only			0..1

7.2.1.13.4.1 UpTime

This attribute reports the time (in hundredths of a second) since the CCAP/CMTS was last re-initialized.

Reference: [RFC 2790] hrSystemUptime

7.2.1.13.4.2 CurrentDateTime

This attribute reports the CCAP/CMTS notion of the current local date and time of day.

Reference: [RFC 2790] hrSystemDate

7.2.1.14 CCAP MAC Domain Status Information Model

The following diagram illustrates the collection of MAC Domain performance management objects specific to the CCAP/CMTS.

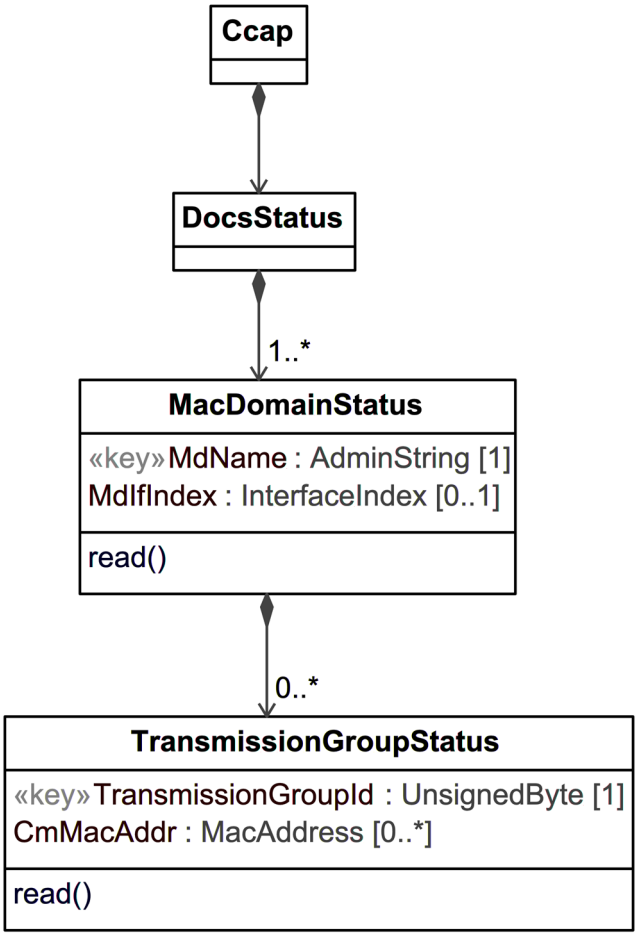


Figure 65 - MAC Domain Status Information Model

7.2.1.14.1 Ccap

This object serves as the root of the CCAP/CMTS MAC Domain Status Information Model. This object is defined in section 6.5.3.1 and included here for reference.

7.2.1.14.2 DocsStatus

The DocsStatus object is the primary container of DOCSIS state and statistics performance management objects.

Table 391 - DocsStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
MacDomainStatus	Directed Composition	1	1..*	N/A

7.2.1.14.3 MacDomainStatus

The MacDomainStatus object is the primary container for the CCAP/CMTS MAC Domain performance management objects. The object associations to TransmissionGroupStatus are specific to an FDX CCAP/CMTS.

Table 392 - MacDomainStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Multiplicity
MdName	AdminString	Key			1
MdIfIndex	InterfaceIndex	read-only			0..1

Table 393 - MacDomainStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TransmissionGroupStatus	Directed Composition	1	0..*	N/A

7.2.1.14.3.1 MdName

This key attribute represents the name of the MAC Domain.

7.2.1.14.3.2 MdIfIndex

This optional attribute represents the Interface Index of the MAC Domain.

7.2.1.14.4 TransmissionGroupStatus

The TransmissionGroupStatus object includes Transmission Group status information as reported by an FDX CCAP/CMTS.

Table 394 - TransmissionGroupStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Multiplicity
TransmissionGroupId	UnsignedByte	Key			1
CmMacAddr	MacAddress	read-only			0..*

7.2.1.14.4.1 TransmissionGroupId

This key attribute is the Transmission Group (TG) ID associated with the FDX-capable CM Transmission Group Assignments.

7.2.1.14.4.2 CmMacAddr

This attribute is a list of CM MAC Addresses assigned to the Transmission Group ID.

7.2.2 Statistical Data Information Models

7.2.2.1 DOCS-IF-MIB Performance Management Stats Information Model

The objects in the DOCS-IF-MIB are taken from [RFC 4546] and used without modification for the CCAP.

Reference: [RFC 4546]

Figure 66 - DOCS-IF-MIB Performance Management Stats Information Model

7.2.2.2 CMTS CM Status Information Model

This section defines status and performance management objects for CMs which are instantiated at the CCAP, thus providing the NMS a central place to retrieve critical CM-related information without having to poll individual CMs.

Reference: [DOCS-IF3-MIB], [DOCS-IF31-MIB], [DOCS-IF40-MIB]

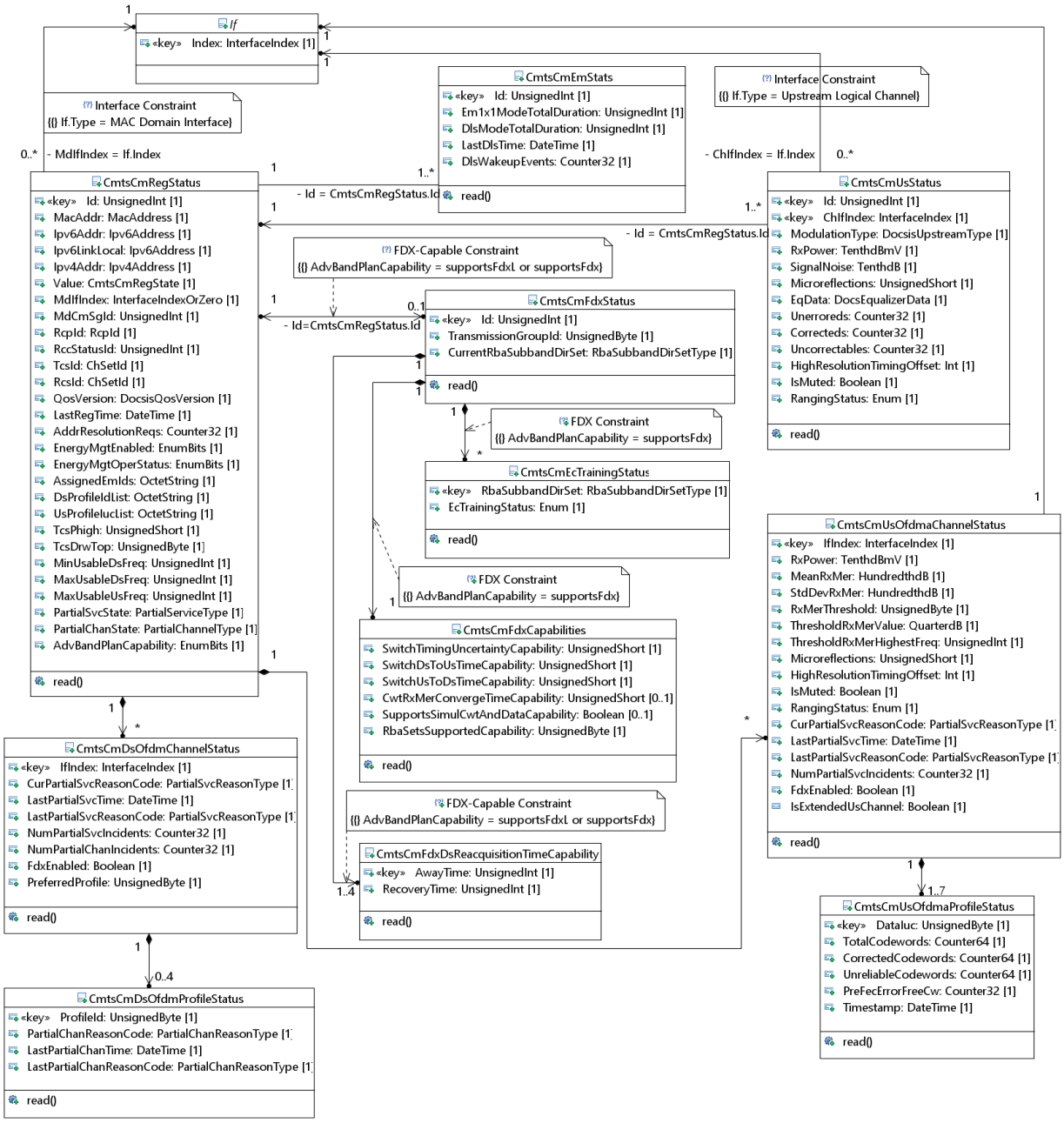


Figure 67 - CMTS CM Status Information Model

7.2.2.2.1 CmtsCmRegStatus

The CmtsCmRegStatus object defines attributes that represent the CM's registration status as tracked by the CMTS. Refer to the individual attribute definitions for applicability to DOCSIS 3.0, 3.1, and 4.0 Cable Modems.

The CCAP MAY preserve CmtsCmRegStatus values across cable modem reboots.

Table 395 - CmtsCmRegStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Id	UnsignedInt	key	1..4294967295	N/A
MacAddr	MacAddress	read-only		N/A
Ipv6Addr	Ipv6Address	read-only		N/A
Ipv6LinkLocal	Ipv6Address	read-only		N/A
Ipv4Addr	Ipv4Address	read-only		N/A
Value	CmtsCmRegState	read-only		N/A
MdIfIndex	InterfaceIndexOrZero	read-only		N/A
MdCmSgId	UnsignedInt	read-only		N/A
RcpId	RcpId	read-only		N/A
RccStatusId	UnsignedInt	read-only		N/A
RcsId	ChSetId	read-only		N/A
TcsId	ChSetId	read-only		N/A
QosVersion	DocsisQosVersion	read-only		N/A
LastRegTime	DateTime	read-only		N/A
AddrResolutionReqs	Counter32	read-only		N/A
EnergyMgtEnabled	EnumBits	read-only	em1x1Mode(0), dlsMode(1)	N/A
EnergyMgtOperStatus	EnumBits	read-only	em1x1Mode(0), dlsMode(1)	N/A
AssignedEmIds	OctetString	read-only	SIZE(0 | 2 | 4 | 6)	N/A
DsProfileIdList	OctetString	read-only	SIZE (0 | 6..72)	N/A
UsProfileIucList	OctetString	read-only	SIZE (0 | 6..72)	N/A
TcsPhigh	UnsignedShort	read-only	0 | 68..320	QuarterdBmV
TcsDrwTop	UnsignedByte	read-only	N/A	QuarterdBmV
MinUsableDsFreq	UnsignedInt	read-only		Hz
MaxUsableDsFreq	UnsignedInt	read-only		Hz
MaxUsableUsFreq	UnsignedInt	read-only		Hz
PartialSvcState	PartialServiceType	read-only		N/A
PartialChanState	PartialChannelType	read-only		N/A
AdvBandPlanCapability	EnumBits	read-only	supportsFdxL(0), supportsFdx(1), supportsFdd(2)	N/A

Table 396 - CmtsCmRegStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmEmStats	Association to CmtsCmEmStats	1	1..*	
CmtsCmUsStatus	Directed association to CmtsCmUsStatus	1	1..*	
CmtsCmUsOfdmaChannelStatus	Directed composition to CmtsCmUsOfdmaChannelStatus	1	0..*	
CmtsCmDsOfdmChannelStatus	Directed composition to CmtsCmDsOfdmChannelStatus	1	0..*	
CmtsCmFdxStatus	Association (with constraint) to CmtsCmFdxStatus	1	0..*	AdvBandPlanCapability = supportsFdxL or supportsFdx

7.2.2.2.1.1 Id

This key attribute uniquely identifies a CM. The CMTS MUST assign a single id value for each CM MAC address seen by the CMTS. The CMTS SHOULD ensure that the association between an Id and MAC Address remains constant during CMTS uptime.

7.2.2.2.1.2 MacAddr

This attribute demotes the MAC address of the CM. If the CM has multiple MAC addresses, this is the MAC address associated with the MAC Domain interface.

7.2.2.2.1.3 Ipv6Addr

This attribute denotes the IPv6 address of the CM. If the CM has no Internet address assigned, or the Internet address is unknown, the value of this attribute is the all zeros address.

7.2.2.2.1.4 Ipv6LinkLocal

This attribute denotes the IPv6 local scope address of the CM.

7.2.2.2.1.5 Ipv4Addr

This attribute demotes the IPv4 address of the CM. If the CM has no IP address assigned, or the IP address is unknown, this object returns 0.0.0.0.

7.2.2.2.1.6 Value

This attribute denotes the current CM connectivity state.

References: [MULPIv4.0] Cable Modem Initialization and Reinitialization section.

7.2.2.2.1.7 MdIfIndex

This attribute denotes the interface Index of the CMTS MAC Domain where the CM is active. If the interface is unknown, the CMTS returns a value of zero.

7.2.2.2.1.8 MdCmSgId

This attribute denotes the ID of the MAC Domain CM Service Group Id (MD-CM-SG-ID) in which the CM is registered. If the ID is unknown, the CMTS returns a value of zero.

References: [MULPIv4.0] Cable Modem Service Group (CM-SG) section.

7.2.2.2.1.9 RcpId

This attribute denotes the RCP-ID associated with the CM if it is in DOCSIS 3.0 mode. If the RCP-ID is unknown or the CM is in DOCSIS 4.0 mode, the CMTS returns a five-octet long string of zeros.

References: [MULPIv4.0] RCP-ID section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.2.2.1.10 RccStatusId

This attribute denotes the RCC Id the CMTS used to configure the CM receive channel set during the registration process, if it is in DOCSIS 3.0 mode. If unknown or the CM is in DOCSIS 4.0 mode, the CMTS returns the value zero.

7.2.2.2.1.11 RcsId

This attribute denotes the Receive Channel Set (RCS) that the CM is currently using. If the RCS is unknown, the CMTS returns the value zero.

References: [MULPIv4.0] Cable Modem Physical Receive Channel Configuration section and the Receive Channels section in the Encodings for Configuration and MAC-Layer Messaging Annex.

7.2.2.2.1.12 TcsId

This attribute denotes Transmit Channel Set (TCS) the CM is currently using. If the TCS is unknown, the CMTS returns the value zero.

References: [MULPIv4.0] Changes to the Transmit Channel Set section.

7.2.2.2.1.13 QosVersion

This attribute denotes the queuing services the CM registered and will always report DOCSIS 1.1 QoS mode since DOCSIS 1.0 CoS mode was deprecated in DOCSIS 3.1.

7.2.2.2.1.14 LastRegTime

This attribute denotes the last time the CM registered.

7.2.2.2.1.15 AddrResolutionReqs

This attribute denotes the number of upstream packets received on the SIDs assigned to a CM that are any of the following:

- Upstream IPv4 ARP Requests
- Upstream IPv6 Neighbor Solicitation Requests
- (For Routing CMTSs) Upstream IPv4 or IPv6 packets to unresolved destinations in locally connected downstream in the HFC.

Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated MAC Domain interface.

References: [SECv4.0] Secure Provisioning section; [RFC 2863].

7.2.2.2.1.16 EnergyMgtEnabled

This attribute indicates which, if any, of the Energy Management Features are enabled for this CM. If this attribute returns em1x1Mode(0) bit set, the CM is configured with the Energy Management 1x1 Feature enabled. If this attribute returns dlsMode(1) bit set, the CM is configured with the DLS Mode feature enabled. If this attribute returns all bits cleared, the CM will not request to operate in any Energy Management mode of operation.

NOTE: This attribute only indicates if an Energy Management Feature is enabled/disabled via the CM config file and registration request/response exchange and does not indicate whether the CM is actively operating in an Energy Management Mode.

References: [MULPIv4.0] Energy Management Features section.

7.2.2.2.1.17 EnergyMgtOperStatus

This attribute indicates whether the CM is currently operating in an Energy Management Mode. If this attribute returns em1x1Mode(0) bit set, the CM is operating in Energy Management 1x1 Mode. If this attribute returns dlsMode(1) bit set, the CM is operating in DLS Mode. If this attribute returns all bits cleared, the CM is not operating in any Energy Management Mode. This attribute always returns 0x00 (no bits set) in the case when EnergyMgtEnabled is set to 0x00 (no Energy Management Features enabled).

NOTE: dlsMode(1) and em1x1Mode(0) are mutually exclusive, thus a return value where both of these bits are 'true' is invalid.

References: [MULPIv4.0] Energy Management 1x1 Mode Indicator section.

7.2.2.2.1.18 AssignedEmIds

This attribute reports the set of CMTS-assigned EM-IDs for this CM. This attribute is encoded as an array 16-bit binary values with up to 3 elements. The broadcast EM-ID is not included in the list. This is generally displayed as a comma-delimited list of EM-IDS such as: DF13,ABAB,0002. If the EM-ID is unknown, the CMTS returns a zero-length string.

This object is applicable to DOCSIS 4.0 modems but not to versions of DOCSIS modems prior to 3.1. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns a zero-length string.

References: [MULPIv4.0] DOCSIS Light Sleep Feature section.

7.2.2.2.1.19 DsProfileIdList

This attribute is a variable length series of hexadecimal octets where each series entry consists of the following fields (encoded in the following order):

The ifIndex (4 octets) of the OFDM channel where the downstream Profile IDs are assigned.

The number or count of Profile IDs (1 octet with valid values of 1-4) assigned to the CM on that channel.

The list of Profile IDs (1 octet each with valid values of 0-15) assigned to this CM on that channel. Profile ID 0 is commonly referred to as Profile A. Likewise, Profile IDs 1, 2 and 3 are commonly referred to as Profiles B, C and D.

The CCAP MUST encode each OFDM channel in a CM's RCS as a separate n-octet entry in the DsProfileIdList.

Examples: a CM with a single OFDM channel (ifIndex 34) and four assigned profiles (Profiles IDs 0, 8, 9 and 10) would have a ProfileIdList value of 0x00000022040008090A. A CM with a 2 OFDM channel bonding group each with two assigned profiles (Profile IDs 0 and 15 on channel with ifIndex 34 and Profile IDs 0 and 14 on channel with ifIndex 35) would have a DsProfileIdList value of 0x0000002202000F0000002302000E.

The CCAP MUST NOT include the transitional profile or test profile in the DsProfileIdList.

Note that octet string lengths greater than 18 are optional.

This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns a zero-length octet string.

7.2.2.2.1.20 UsProfileIucList

This attribute is a variable length series of hexadecimal octets where each series entry consists of the following fields (encoded in the following order):

- The ifIndex (4 octets) of the OFDMA channel where the Profile IUCs are assigned.
- The number (or count) of Data IUCs (1 octet with valid values of 1-2) assigned to this CM on that channel.
- The list of Data IUCs (1 octet each with valid values of 5, 6, 9-13) assigned to this CM on that channel.

The CCAP MUST encode each OFDMA channel in a CM's TCS as a separate n-octet entry in the UsProfileIucList.

Examples: a CM with a single OFDMA channel (ifIndex 36) and two assigned Data IUCs (5 and 6) would have a ProfileIdList value of 0x00000024020506. A CM with a 2 OFDMA channel bonding group each with one assigned Data IUC (IUC 5 on channel with ifIndex 34 and IUC 13 on channel with ifIndex 35) would have a UsProfileIucList value of 0x00000022010500000023010D.

The CCAP MUST NOT include transitional IUCs or test IUCs in the UsProfileIucList.

This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns a zero-length octet string.

7.2.2.2.1.21 TcsPhigh

This attribute reports the $P_{1.6hi}$ value for the CM's Transmit Channel Set [PHYv4.0]. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns zero.

7.2.2.2.1.22 TcsDrwTop

This attribute reports the level of the top of the Dynamic Range Window. The value is expressed in dBmV and is the result of a calculation equal to $P_{1.6hi}$ - $P_{1.6load_min_set}$ [PHYv4.0]. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns zero.

7.2.2.2.1.23 MinUsableDsFreq

This attribute is the higher of the CCAP's minimum supported downstream frequency and the CM's minimum supported downstream frequency. It indicates the lowest downstream frequency the CCAP can use to communicate with this CM taking into account the capabilities of both devices. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns zero.

7.2.2.2.1.24 MaxUsableDsFreq

This attribute is the lower of the CCAP's maximum supported downstream frequency and the CM's maximum supported downstream frequency. It indicates the highest downstream frequency the CCAP can use to communicate with this CM taking into account the capabilities of both devices. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns zero.

7.2.2.2.1.25 MaxUsableUsFreq

This attribute is the lower of the CCAP's maximum supported upstream frequency and the CM's maximum supported upstream frequency. It indicates the highest upstream frequency the CCAP can use to receive signals from this CM taking into account the capabilities of both devices. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns zero.

7.2.2.2.1.26 PartialSvcState

This attribute indicates the type of "bonding group" issue that this CM is experiencing, based on what the MAC-layer shows. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns 'other'.

7.2.2.2.1.27 PartialChanState

This attribute is a bit-field which indicates the type of OFDM channel issue that this CM is experiencing, based on what the MAC-layer shows. See PartialChannelType for further detail. This object is applicable to DOCSIS 4.0 modems but not to DOCSIS modems prior to 3.1 modems. If the CM is a pre-DOCSIS 3.1 modem, the CMTS returns no bits set (0x0).

7.2.2.2.1.28 AdvBandPlanCapability

This attribute indicates the ability of the DOCSIS 4.0 CM to participate in Advanced Band Plan Operation as an FDX, FDD, or FDX-L.

- If the 'supportsFdxL' bit (bit 0) is set to '1', the CM is able to operate as an FDX-L CM.
- If the 'supportsFdx' bit (bit 1) is set to '1', the CM is able to operate as an FDX CM.
- If the 'supportsFdd' bit (bit 2) is set to '1', the CM is able to operate as an FDD CM.
- The 'supportsFdxL' and 'supportsFdx' options are mutually exclusive.

References: [MULPIv4.0] Common TLV Encodings annex, Advanced Band Plan Capability section

7.2.2.2.2 CmtsCmUsStatus

The CmtsCmUsStatus object defines status information of the CM currently in use by Upstream Logical Channels, as reported by the CMTS.

Attributes Unerroreds, Correcteds, and Uncorrectables return upstream Forward Error Correction (FEC) statistics per channel values. These attributes provide operators with Proactive Network Maintenance data by means of a query of the CmtsCmUsStatus object.

Table 397 - CmtsCmUsStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Id	UnsignedInt	key	1..4294967295	N/A
ChIfIndex	InterfaceIndex	key		N/A
ModulationType	DocsisUpstreamType	read-only		N/A
RxPower	TenthdBmV	read-only		dBmV
SignalNoise	TenthdB	read-only		dB
Microreflections	UnsignedShort	read-only		dBc
EqData	DocsEqualizerData	read-only		N/A
Unerroreds	Counter32	read-only		N/A
Correcteds	Counter32	read-only		N/A
Uncorrectables	Counter32	read-only		N/A
HighResolutionTimingOffset	Int	read-only		19.0734 ps
IsMuted	Boolean	read-only		N/A
RangingStatus	Enum	read-only	other(1), aborted(2), retriesExceeded(3), success(4), continue(5), timeoutT4(6)	N/A

7.2.2.2.2.1 Id

This key attribute represents the CMTS assigned Id to the CM in the CmtsCmRegStatus object.

7.2.2.2.2.2 ChIfIndex

This key attribute represents an upstream logical interface. The CMTS instantiates each one of the channels in the current Transmit Channel Set of the CM in this object.

7.2.2.2.2.3 ModulationType

This attribute represents the modulation type currently used by this upstream channel.

7.2.2.2.2.4 RxPower

This attribute represents the receive power of this upstream channel. The reported value represents the total average power for the channel regardless of whether the CM is reporting Pr, total average power, or P1.6r, the power spectral density in an equivalent 1.6 MHz spectrum.

7.2.2.2.2.5 SignalNoise

This attribute represents Signal/Noise ratio as perceived for upstream data from the CM on this upstream channel.

7.2.2.2.2.6 Microreflections

This attribute represents microreflections received on this upstream channel.

7.2.2.2.2.7 EqData

This attribute represents the equalization data for the CM on this upstream channel.

7.2.2.2.2.8 Unerroreds

This attribute represents the codewords received without error from the CM on this upstream channel. Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated upstream channel.

References: [RFC 2863].

7.2.2.2.2.9 Correcteds

This attribute represents the codewords received with correctable errors from the CM on this upstream channel. Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated upstream channel.

References: [RFC 2863].

7.2.2.2.2.10 Uncorrectables

This attribute represents the codewords received with uncorrectable errors from the CM on this upstream channel. Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated upstream channel.

References: [RFC 2863].

7.2.2.2.2.11 HighResolutionTimingOffset

This attribute represents the current measured round-trip time on this CM's upstream channel in units of 1/(256*204.8MHz)=19.0734 ps. This attribute returns zero if the value is unknown.

7.2.2.2.2.12 IsMuted

This attribute has a value 'true' to indicate that the CM's upstream channel has been muted via CM-CTRL-REQ/CM-CTRL-RSP message exchange.

References: [MULPIv4.0] Media Access Control Specification section.

7.2.2.2.2.13 RangingStatus

This attribute denotes ranging status of the CM on this upstream channel as reported by the CMTS.

The enumerated values associated with the RangingStatus are:

- 'other' indicates any state not described below.
- 'aborted' indicates that the CMTS has sent a ranging abort.
- 'retriesExceeded' indicates CM ranging retry limit has been exceeded.
- 'success' indicates that the CMTS has sent a ranging success in the ranging response.
- 'continue' indicates that the CMTS has sent a ranging continue in the ranging response.
- 'timeoutT4' indicates that the T4 timer expired on the CM.

References: [MULPIv4.0] Media Access Control Specification section.

7.2.2.2.3 CmtsCmUsOfdmaChannelStatus

The CmtsCmUsOfdmaChannelStatus object reports the status information of the OFDMA upstream channels assigned to the CM’s Transmit Channel Set (TCS) and Extended Transmit Channel Set (TCS_EXT) as reported by the CMTS. This object contains information on extended OFDMA upstream channels (FDX or FDD) and pre-DOCSIS 4.0 OFDMA upstream channels.

Table 398 - CmtsCmUsOfdmaChannelStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	Interface Index of upstream interface	N/A
RxPower	TenthdBmV	read-only		dBmV
MeanRxMer	HundredthdB	read-only		dB
StdDevRxMer	HundredthdB	read-only		dB
RxMerThreshold	UnsignedByte	read-write	1..99	Percentile
ThresholdRxMerValue	HundredthdB	read-only		dB
ThresholdRxMerHighestFreq	UnsignedInt	read-only		Hz
Microreflections	UnsignedShort	read-only		dBc
HighResolutionTimingOffset	Int	read-only		19.0734 ps
IsMuted	Boolean	read-only		N/A
RangingStatus	Enum	read-only	other(1), aborted(2), retriesExceeded(3), success(4), continue(5), timeoutT4(6)	N/A
CurPartialSvcReasonCode	PartialSvcReasonType	read-only		
LastPartialSvcTime	DateTime	read-only		
LastPartialSvcReasonCode	PartialSvcReasonType	read-only		
NumPartialSvcIncidents	Counter32	read-only		
FdxEnabled	Boolean	read-only		N/A
IsExtendedUsChannel	Boolean	read-only		N/A

Table 399 - CmtsCmUsOfdmaChannelStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmUsOfdmaProfileStatus	Directed composition to CmtsCmUsOfdmaProfileStatus	1	1..*	

7.2.2.2.3.1 IfIndex

This key attribute is the unique index of an OFDMA upstream interface. The CMTS instantiates each one of the channels in the current Transmit Channel Set (TCS) and Extended Transmit Channel Set (TCS_EXT) of the CM in this object.

7.2.2.2.3.2 RxPower

This attribute is the total received power in a specified OFDMA upstream channel, normalized to power in a 1.6 MHz bandwidth, at the RF input port of the CMTS for a given CM.

Reference: [PHYv4.0] Upstream Channel Power section

7.2.2.2.3.3 MeanRxMer

This attribute is the mean of the dB values of the RxMER measurements of all active subcarriers. The mean is computed directly on the dB values as follows:

Mean = sum of (RxMER dB values) / number of RxMER values

Reference: [PHYv4.0] Upstream Receive Modulation Error Ratio (RxMER) Per Subcarrier section

7.2.2.2.3.4 StdDevRxMer

This attribute is the standard deviation of the dB values of the RxMER measurements of all active subcarriers. The standard deviation is computed directly on the dB values as follows:

StdDev = sqrt(sum of (RxMER dB values - RxMER_mean)^2 / number of RxMER values)

7.2.2.2.3.5 RxMerThreshold

This attribute specifies the percentile (such as 2nd percentile or 5th percentile) of all active subcarriers in an OFDM upstream channel at which the ThresholdRxMerValue occurs. That is, (Percentile) % of the subcarriers have RxMER <= ThresholdRxMerValue.

7.2.2.2.3.6 ThresholdRxMerValue

This attribute is the RxMER value corresponding to the specified RxMerThreshold percentile value. The CCAP sorts the subcarriers in ascending order of RxMER, resulting in a post-sorting subcarrier index ranging from 1 to the number of active subcarriers. If the percentile value corresponds to a non-integer post-sorting subcarrier index, the post-sorting index is truncated (floor function is applied); that is, the post-sorting index is selected which is the greatest integer less than or equal to the corresponding percentile value. For example, if there are 3677 active subcarriers and the 2nd percentile is specified, the CCAP computes floor(3677*0.02) = 73. That is, the RxMER value of the 73rd subcarrier in the sorted list is associated with the 2nd percentile.

7.2.2.2.3.7 ThresholdRxMerHighestFreq

This attribute is the frequency in Hz of the highest-frequency subcarrier having RxMER = ThresholdRxMer value.

7.2.2.2.3.8 Microreflections

This attribute represents microreflections received on this OFDMA upstream channel.

7.2.2.2.3.9 HighResolutionTimingOffset

This attribute represents the current measured round-trip time on this CM's OFDMA upstream channel in units of 1/(256*204.8MHz)=19.0734 ps. This attribute returns zero if the value is unknown.

7.2.2.2.3.10 IsMuted

This attribute has a value 'true' to indicate that the CM's OFDMA upstream channel has been muted via CM-CTRL-REQ/CM-CTRL-RSP message exchange.

References: [MULPIv4.0] Media Access Control Specification section.

7.2.2.2.3.11 RangingStatus

This attribute denotes ranging status of the CM on this OFDMA upstream channel as reported by the CMTS.

The enumerated values associated with the RangingStatus are:

- Other: 'other' indicates any state not described below.
- Aborted: 'aborted' indicates that the CMTS has sent a ranging abort.
- retriesExceeded: 'retriesExceeded' indicates CM ranging retry limit has been exceeded.
- Success: 'success' indicates that the CMTS has sent a ranging success in the ranging response.
- Continue: 'continue' indicates that the CMTS has sent a ranging continue in the ranging response.
- timeoutT4: 'timeoutT4' indicates that the T4 timer expired on the CM.

References: [MULPIv4.0] Media Access Control Specification section.

7.2.2.2.3.12 CurPartialSvcReasonCode

This attribute returns the current CM-STATUS Event Code which indicates the reason that this CM is experiencing Partial Service with a bonding group utilizing this OFDMA upstream channel. A value of 0 indicates that the CM is not currently experiencing Partial Service involving this OFDMA upstream channel.

7.2.2.2.3.13 LastPartialSvcTime

This attribute returns the date and time when the MAC indicated that this CM recovered from its most recent Partial Service incident on this OFDMA upstream channel. A value of January 1, year 0000, 00:00:00 indicates that the CM has not experienced Partial Service involving this OFDMA upstream channel during the CCAP's history of this CM.

7.2.2.2.3.14 LastPartialSvcReasonCode

This attribute returns the last CM-STATUS Event Code which indicates the reason that this CM was experiencing Partial Service on this OFDMA upstream channel. (Note: if the CM is currently experiencing Partial Service, this is the Event Code from the previous Partial Service event.) A value of 0 indicates that the CM has not experienced Partial Service involving this OFDMA upstream channel during the CCAP's history of this CM.

7.2.2.2.3.15 NumPartialSvcIncidents

This attribute returns the number of Partial Service incidents the MAC layer has reported for this CM on this OFDMA upstream channel.

7.2.2.2.3.16 FdxEnabled

This attribute reports if the CM's OFDMA upstream channel is enabled for FDX.

A value of 'true' indicates the FDX-capable CM's OFDMA upstream channel is an FDX Extended Upstream Channel contained within a full duplex sub-band. In this case, the IsExtendedUsChannel attribute also reports a value of 'true'.

A value of 'false' indicates the FDX-capable CMs OFDMA upstream channel is not an FDX Extended Upstream Channel.

A non-FDX-capable CM always reports a value of 'false'.

7.2.2.2.3.17 IsExtendedUsChannel

This attribute reports whether the CM's OFDMA upstream channel is an Extended Upstream Channel.

A value of 'true' indicates the OFDMA upstream channel is an Extended Upstream Channel. If the attribute FdxEnabled reports a value of 'true', the OFDMA upstream channel is an FDX Extended Upstream Channel. Otherwise, the OFDMA upstream channel is an FDD Extended Upstream Channel.

A value of 'false' indicates the OFDMA upstream channel is a non-extended upstream channel.

7.2.2.2.4 CmtsCmUsOfdmaProfileStatus

The CmtsCmUsOfdmaProfileStatus object defines current status information of the CM on each OFDMA upstream channel profile, as reported by the CMTS.

Table 400 - CmtsCmUsOfdmaProfileStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
DataIuc	UnsignedByte	Key	5|6|9|10|11|12|13	
TotalCodewords	Counter64	read-only		codewords
CorrectedCodewords	Counter64	read-only		codewords
UnreliableCodewords	Counter64	read-only		codewords
PreFecErrorFreeCw	Counter32	read-only		codewords

Attribute Name	Type	Access	Type Constraints	Units
Timestamp	DateTime	read-only		

7.2.2.2.4.1 DataIuc

This key attribute is the DataIuc associated with this upstream OFDMA profile.

7.2.2.2.4.2 TotalCodewords

This attribute represents the count of the total number of FEC codewords received from the CM on this Profile/Data IUC for this upstream OFDMA channel.

Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated upstream OFDMA channel.

7.2.2.2.4.3 CorrectedCodewords

This attribute represents the count of codewords received that failed the pre-decoding syndrome check but passed the post-decoding syndrome check from the CM on this Profile/Data IUC for this upstream OFDMA channel.

Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated upstream OFDMA channel.

7.2.2.2.4.4 UnreliableCodewords

This attribute represents the count of codewords that failed the post-decoding syndrome check received from the CM on this Profile/Data IUC for this upstream OFDMA channel.

Discontinuities in the value of this counter can occur at re-initialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime for the associated upstream OFDMA channel.

7.2.2.2.4.5 PreFecErrorFreeCw

This attribute reports the count of codewords received on this OFDMA channel and this Data IUC that passed pre-decoding syndrome check.

7.2.2.2.4.6 Timestamp

This attribute reports the date and time when the upstream FEC statistics values were collected for the modem using this Data IUC on the OFDMA channel.

7.2.2.2.5 CmtsCmDsOfdmChannelStatus

The CmtsCmDsOfdmChannelStatus object defines current status information of the CM on each OFDM downstream channel, as reported by the CMTS. A separate instance exists for every OFDM downstream channel of every CM currently assigned to an OFDM downstream channel.

The CCAP SHOULD create instances of the CmtsCmDsOfdmChannelStatus object even if no partial service or partial channel event has occurred with respect to this OFDM downstream channel, so that the PreferredProfile attribute is available.

The CCAP SHOULD persist instances of the CmtsCmDsOfdmChannelStatus object across CM reinitialization.

Table 401 - CmtsCmDsOfdmChannelStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	Key	Interface Index of downstream interface	
CurPartialSvcReasonCode	PartialSvcReasonType	read-only		
LastPartialSvcTime	DateTime	read-only		

Attribute Name	Type	Access	Type Constraints	Units
LastPartialSvcReasonCode	PartialSvcReasonType	read-only		
NumPartialSvcIncidents	Counter32	read-only		
NumPartialChanIncidents	Counter32	read-only		
FdxEnabled	Boolean	read-only		N/A
PreferredProfile	UnsignedByte	read-only		

Table 402 - CmtsCmDsOfdmChannelStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmDsOfdmProfileStatus	Directed composition to CmtsCmDsOfdmProfileStatus	1	0..4	

7.2.2.2.5.1 IfIndex

This key attribute is the unique index of an OFDM downstream interface. The CMTS instantiates each one of the channels in the current Receive Channel Set of the CM in this object.

7.2.2.2.5.2 CurPartialSvcReasonCode

This attribute returns the current CM-STATUS Event Code which indicates the reason that this CM is experiencing Partial Service with a bonding group utilizing this OFDM downstream channel. A value of 0 indicates that the CM is not currently experiencing Partial Service involving this OFDM downstream channel.

7.2.2.2.5.3 LastPartialSvcTime

This attribute returns the date and time when the MAC indicated that this CM recovered from its most recent Partial Service incident on this OFDM downstream channel.

7.2.2.2.5.4 LastPartialSvcReasonCode

This attribute returns the last CM-STATUS Event Code which indicates the reason that this CM was experiencing Partial Service on this OFDM downstream channel. (Note: if the CM is currently experiencing Partial Service, this is the Event Code from the previous Partial Service event.) A value of 0 indicates that the CM has not experienced Partial Service involving this OFDM downstream channel during the CCAP's history of this CM.

7.2.2.2.5.5 NumPartialSvcIncidents

This attribute returns the number of Partial Service incidents the MAC layer has reported for this CM on this OFDM downstream channel.

7.2.2.2.5.6 NumPartialChanIncidents

This attribute returns the number of Partial Channel incidents the MAC layer has reported for this CM on this OFDM downstream channel.

7.2.2.2.5.7 FdxEnabled

This attribute reports if the CM’s OFDM downstream channel is enabled for FDX.

A value of 'true' indicates the FDX-capable CM's OFDM downstream channel is an FDX Downstream Channel contained within a full duplex sub-band.

A value of 'false' indicates the FDX-capable CMs OFDM downstream channel is not an FDX Downstream Channel.

A non-FDX-capable CM always reports a value of 'false'.

7.2.2.2.5.8 PreferredProfile

This attribute indicates the ID of the profile that has been determined by the CCAP to be the preferred profile for unicast downstream traffic. The CCAP changes the preferred profile ID depending on changing channel conditions.

7.2.2.2.6 CmtsCmDsOfdmProfileStatus

The CmtsCmDsOfdmProfileStatus object defines current status information of the CM on each OFDM downstream channel profile, as reported by the CMTS. If the CM has never experienced a partial channel event with respect to this profile since the last CCAP reinitialization, no instance should exist for this object. Instances of this object exist only for profiles most recently assigned to the channel for this CM.

The CCAP SHOULD persist instances of CmtsCmDsOfdmProfileStatus object when the CM is re-initialized or when the profile is unassigned from the CM.

The CCAP SHOULD remove instances of the CmtsCmDsOfdmProfileStatus object if the profile configuration is modified or the channel is removed from the CM's receive channel set.

Table 403 - CmtsCmDsOfdmProfileStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
ProfileId	UnsignedByte	Key	0..15	
PartialChanReasonCode	PartialChanReasonType	read-only		
LastPartialChanTime	DateTime	read-only		
LastPartialChanReasonCode	PartialChanReasonType	read-only		

7.2.2.2.6.1 ProfileId

This key attribute is a unique index and is the identifier of the downstream profile associated with the OFDM downstream channel. The value of this attribute is zero-based due to constraints of the definition of Profile Id.

Reference: [MULPIv4.0] Downstream Profile Descriptor (DPD) section

7.2.2.2.6.2 PartialChanReasonCode

This attribute returns the current CM-STATUS Event Code which indicates the reason that this CM is in a Partial Channel state utilizing this Profile on this downstream OFDM channel. A value of 0 indicates that the CM is not currently experiencing Partial Channel involving this Profile on this OFDM channel.

7.2.2.2.6.3 LastPartialChanTime

This attribute returns the date and time when the MAC indicated that this CM recovered from its most recent Partial Channel incident for this Profile on this downstream OFDM channel.

7.2.2.2.6.4 LastPartialChanReasonCode

This attribute returns the last CM-STATUS Event Code which indicates the reason that this CM was experiencing a Partial Channel event for this Profile on this downstream OFDM channel. A value of 0 indicates that the CM has not experienced a Partial Channel incident involving this Profile on this OFDM channel since the profile was last assigned to this CM.

7.2.2.2.7 CmtsCmEmStats

The CmtsCmEmStatus object defines Energy Management mode statistics for the CM as reported by the CMTS. For example, such metrics can provide insight into configuration of appropriate EM 1x1 Mode Activity Detection thresholds on the CM and/or to get feedback on how/if the current thresholds are working well or are causing user experience issues.

Table 404 - CmtsCmEmStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Id	UnsignedInt	key	1..4294967295	N/A
Em1x1ModeTotalDuration	UnsignedInt	read-only		seconds
DlsModeTotalDuration	UnsignedInt	read-only		seconds
LastDlsTime	DateTime	read-only		
DlsWakeupEvents	Counter32	read-only		

7.2.2.2.7.1 Id

This key attribute represents the CMTS assigned Id to the CM in the CmtsCmRegStatus object. An instance of this object is created for every CM capable of Energy Management (either 1x1 or DLS).

7.2.2.2.7.2 Em1x1ModeTotalDuration

This attribute indicates the total time duration, in seconds since registration, the CM identified by Id has been in Energy Management 1x1 mode, as controlled by the DBC-REQ Energy Management 1x1 Mode Indicator TLV.

7.2.2.2.7.3 DlsModeTotalDuration

This attribute indicates the total time duration, in seconds since registration, the CM identified by Id has been in DOCSIS Light Sleep mode.

7.2.2.2.7.4 LastDlsTime

This attribute indicates the time of the last DLS wakeup event for this CM. If this CM is currently in DLS mode, then this attribute returns 0.

7.2.2.2.7.5 DlsWakeupEvents

This attribute indicates the total number of wakeup events that this CM has experienced over the CCAP's history for this CM.

7.2.2.2.8 CmtsCmFdxStatus

The CmtsCmFdxStatus object reports current status information of an FDX-capable CM as reported by an FDX CMTS. An instance of this object is created when a CM registers and reports it is FDX-capable via TLV 5.63 (Advanced Band Plan Capability TLV).

Table 405 - CmtsCmFdxStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Id	UnsignedInt	key	1..4294967295	N/A
TransmissionGroupId	UnsignedByte	read-only		N/A
CurrentRbaSubbandDirSet	RbaSubbandDirSetType	read-only		N/A

Table 406 - CmtsCmFdxStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmEcTrainingStatus	Directed Composition Association (with constraint) to CmtsCmEcTrainingStatus	1	0..*	AdvBandPlanCapability = supportsFdx
CmtsCmFdxCapabilities	Directed Composition Association (with constraint) to CmtsCmFdxCapabilities	1	1	AdvBandPlanCapability = supportsFdx

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
CmtsCmFdxDsReacquisition TimeCapability	Directed Composition Association (with constraint) to CmtsCmFdxDs ReacquisitionTimeCapability	1	1..4	AdvBandPlanCapability = supportsFdxL or supportsFdx

7.2.2.2.8.1 Id

This key attribute represents the FDX CMTS assigned Id to the FDX-capable CM in the CmtsCmRegStatus object.

7.2.2.2.8.2 TransmissionGroupId

This attribute reports the Transmission Group (TG) ID associated with the FDX-capable CM Transmission Group Assignment identified by the Id key attribute. A value of zero (0) indicates no active Transmission Group is assigned to the FDX-capable CM.

Reference: [MULPIv4.0] Common TLV Encodings annex, Transmission Group ID section

7.2.2.2.8.3 CurrentRbaSubbandDirSet

This attribute reports the RBA Sub-band Direction Set that is currently assigned to the FDX-capable CM identified by the Id key attribute.

Reference: [MULPIv4.0] Resource Block Assignment (RBA)section

7.2.2.2.9 CmtsCmEcTrainingStatus

The CmtsCmEcTrainingStatus object reports the EC training status of up to eight possible RBA Sub-band Direction Sets for which the FDX CM can concurrently maintain EC training, as reported by an FDX CMTS for each instance of the Id key attribute of the CmtsCmFdxStatus object. The CmtsCmEcTrainingStatus object is associated with a single CmtsCmFdxStatus object, constrained to FDX CM instances. An FDX CMTS reports the EC training status that it maintains per RBA sub-band direction set per FDX CM according to the requirements in [MULPIv4.0].

An FDX CMTS does not create instances of CmtsCmEcTrainingStatus for an FDX-L CM.

Reference: [MULPIv4.0] CM Echo Cancellation section

Table 407 - CmtsCmEcTrainingStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
RbaSubbandDirSet	RbaSubbandDirSetType	Key			
EcTrainingStatus	Enum	read-only	converged(1), notConverged(2), notApplicable(3)		

7.2.2.2.9.1 RbaSubbandDirSet

This key attribute reports an RBA Sub-band Direction Set for an FDX CM identified by the Id key attribute of the CmtsCmFdxStatus object.

Reference: [MULPIv4.0] Resource Block Assignment (RBA) section.

7.2.2.2.9.2 EcTrainingStatus

This attribute reports the Echo Cancellation Training (ECT) status for an FDX CM of the RBA Sub-band Direction Set identified by the RbaSubbandDirSet key attribute and the Id key attribute of the CmtsCmFdxStatus object.

'converged' – Echo Cancellation Training is converged.

'notConverged' – Echo Cancellation Training is not converged.

'notApplicable' – No Echo Cancellation Training required, i.e., for unidirectional RBA Direction Sets (e.g., 000 or 111).

Reference: [MULPIv4.0] Common TLV Encodings annex, EC Training Status section

7.2.2.2.10 CmtsCmFdxCapabilities

The CmtsCmFdxCapabilities object aggregates FDX-specific capabilities of an FDX CM as reported in various TLV 5.X sub-TLVs of a CM REG-REQ and REG-RSP messages as reported by the CCAP.

References: [MULPIv4.0] Common TLV Encodings annex, Modem Capabilities Encoding.

Table 408 - CmtsCmFdxCapabilities Object Attributes

Attribute Name	Type	Access	Type Constraints	Multiplicity	Units	Default
SwitchTimingUncertaintyCapability	UnsignedShort	read-only		1	usecs	
SwitchDsToUsTimeCapability	UnsignedShort	read-only		1	usecs	
SwitchUsToDsTimeCapability	UnsignedShort	read-only		1	usecs	
CwtRxMerConvergeTimeCapability	UnsignedShort	read-only		0..1	msecs	
SupportsSimulCwtAndDataCapability	Boolean	read-only		0..1		
RbaSetsSupportedCapability	UnsignedByte	read-only	1..8	1		

7.2.2.2.10.1 SwitchTimingUncertaintyCapability

This attribute reports the FDX CM's RBA switching timing uncertainty capability, in microseconds, as reported in REG-REQ TLV 5.65.

References: [MULPIv4.0] Common TLV Encodings annex, FDX Switching Software Timing Uncertainty

7.2.2.2.10.2 SwitchDsToUsTimeCapability

This attribute reports the FDX CM's reported DS to US RBA switching time capability, in microseconds, as reported in REG-REQ TLV 5.66.

References: [MULPIv4.0] Common TLV Encodings annex, FDX DS to US Switching Time

7.2.2.2.10.3 SwitchUsToDsTimeCapability

This attribute reports the FDX CM's reported US to DS RBA switching time capability, in microseconds, as reported in REG-REQ TLV 5.67.

References: [MULPIv4.0] Common TLV Encodings annex, FDX US to DS Switching Time

7.2.2.2.10.4 CwtRxMerConvergeTimeCapability

This attribute reports the FDX CM's reported Continuous Wave Tone (CWT) RxMER Measurement convergence time capability, in milliseconds, as reported in REG-REQ TLV 5.69.

References: [MULPIv4.0] Common TLV Encodings annex, CWT RxMER Measurement Convergence Time

7.2.2.2.10.5 SupportsSimulCwtAndDataCapability

This attribute reports whether the FDX CM supports simultaneous CWT and Data, as reported in REG-REQ TLV 5.73.

The value 'true' indicates the CM supports simultaneous CWT and Data.

The value 'false' indicates the CM does not support simultaneous CWT and Data.

References: [MULPIv4.0] Common TLV Encodings annex, CWT Simultaneous Data Transmission Capability

7.2.2.2.10.6 RbaSetsSupportedCapability

This attribute reports the number of RBA direction sets supported by the FDX CM, as reported in REG-REQ TLV 5.75.

References: [MULPIv4.0] Common TLV Encodings annex, Echo Cancelling RBA sub-band Direction Sets Supported

7.2.2.2.11 CmtsCmFdxDsReacquisitionTimeCapability

The CmtsCmFdxDsReacquisitionTimeCapability object contains a pair of attributes that associate an AwayTime with a RecoveryTime.

An FDX-Capable CM reports in REG-REQ TLV 5.72 up to four DsReacquisitionTimeCapability pairs ordered by increasing AwayTime. See the [MULPIv4.0] section referenced below for which DsReacquisitionTimeCapability pair applies when an FDX sub-band is assigned to the downstream direction for a CM.

References: [MULPIv4.0] Common TLV Encodings annex, t-ds-reacquisition capability

Table 409 - CmtsCmFdxDsReacquisitionTimeCapability Object Attributes

Attribute Name	Type	Access	Type Constraints	Multiplicity	Units	Default
AwayTime	UnsignedInt	Key		1	usecs	
RecoveryTime	UnsignedInt	read-only		1	DS Symbols	

7.2.2.2.11.1 AwayTime

This key attribute reports a maximum number of consecutive microseconds an FDX sub-band is not assigned to the downstream direction (i.e., “away” from downstream) for which a pair’s RecoveryTime attribute applies.

7.2.2.2.11.2 RecoveryTime

This attribute reports the minimum number of physical DS OFDM symbols (including cyclic prefix) the FDX-Capable CM requires to recover receiving downstream data on an FDX sub-band after it switches to the downstream direction.

7.2.2.3 MAC Domain Statistics Information Model

The CCAP MUST implement the MAC Domain Statistics Information Model defined in [CCAP-OSSIv3.1].

7.2.2.4 DOCS-L2VPN-MIB Statistics Information Model

The objects in the DOCS-L2VPN-MIB: Statistics Objects are taken from the DOCS-L2VPN-MIB specified in Annex A of [L2VPN] and are used without modification for the CCAP.

Reference: [L2VPN], DOCS-L2VPN-MIB

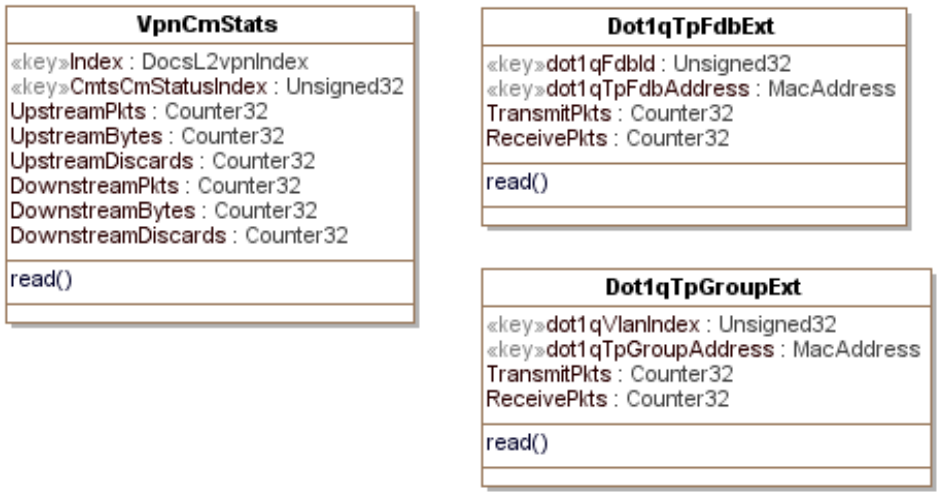


Figure 68 - DOCS-L2VPN-MIB Statistics Information Model

7.2.2.5 DOCSIS Multicast Performance Management Information Model

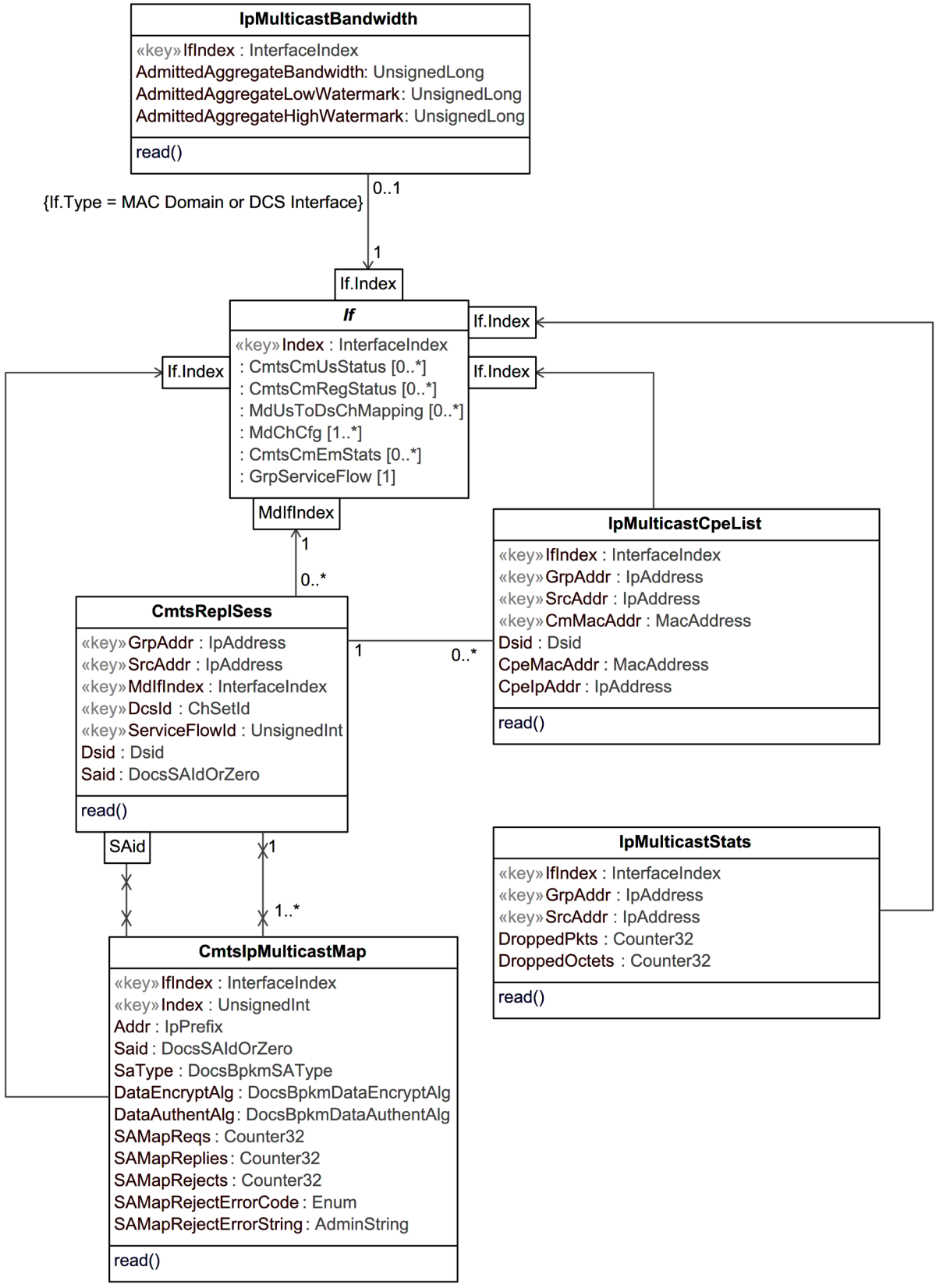
The following object in the DOCS-MCAST-MIB is taken from the [DOCS-MCAST-MIB] and used without modification for the CCAP:

- CmtsReplSess

The CmtsIpMulticastMap object is taken from the DOCS-IETF-BPI2-MIB specified in [RFC 4131] and used without modification for the CCAP.

This Information Model provides the replication and reporting aspects of multicast sessions for the CMTS. The components of the Multicast status reporting model are:

- CmtsReplSess, Multicast Sessions replications per MAC domain for the CMTS.
- Aggregate Admitted Multicast Bandwidth either per MAC domain or Downstream Channel Set.


IpMulticastBandwidth
«key»IfIndex : InterfaceIndex
AdmittedAggregateBandwidth: UnsignedLong
AdmittedAggregateLowWatermark: UnsignedLong
AdmittedAggregateHighWatermark: UnsignedLong
read()
{If.Type = MAC Domain or DCS Interface}
0..1
1
If.Index
If
«key»Index : InterfaceIndex
: CmtsCmUsStatus [0..*]
: CmtsCmRegStatus [0..*]
: MdUsToDsChMapping [0..*]
: MdChCfg [1..*]
: CmtsCmEmStats [0..*]
: GrpServiceFlow [1]
If.Index
If.Index
If.Index
MdIfIndex
1
0..*
CmtsReplSess
«key»GrpAddr : IpAddress
«key»SrcAddr : IpAddress
«key»MdIfIndex : InterfaceIndex
«key»DcsId : ChSetId
«key»ServiceFlowId : UnsignedInt
Dsid : Dsid
Said : DocsSAIdOrZero
read()
1
0..*
IpMulticastCpeList
«key»IfIndex : InterfaceIndex
«key»GrpAddr : IpAddress
«key»SrcAddr : IpAddress
«key»CmMacAddr : MacAddress
Dsid : Dsid
CpeMacAddr : MacAddress
CpeIpAddr : IpAddress
read()
SAid
1
1..*
IpMulticastStats
«key»IfIndex : InterfaceIndex
«key»GrpAddr : IpAddress
«key»SrcAddr : IpAddress
DroppedPkts : Counter32
DroppedOctets : Counter32
read()
CmtsIpMulticastMap
«key»IfIndex : InterfaceIndex
«key»Index : UnsignedInt
Addr : IpPrefix
Said : DocsSAIdOrZero
SaType : DocsBpkmSAType
DataEncryptAlg : DocsBpkmDataEncryptAlg
DataAuthentAlg : DocsBpkmDataAuthentAlg
SAMapReqs : Counter32
SAMapReplies : Counter32
SAMapRejects : Counter32
SAMapRejectErrorCode : Enum
SAMapRejectErrorString : AdminString
read()

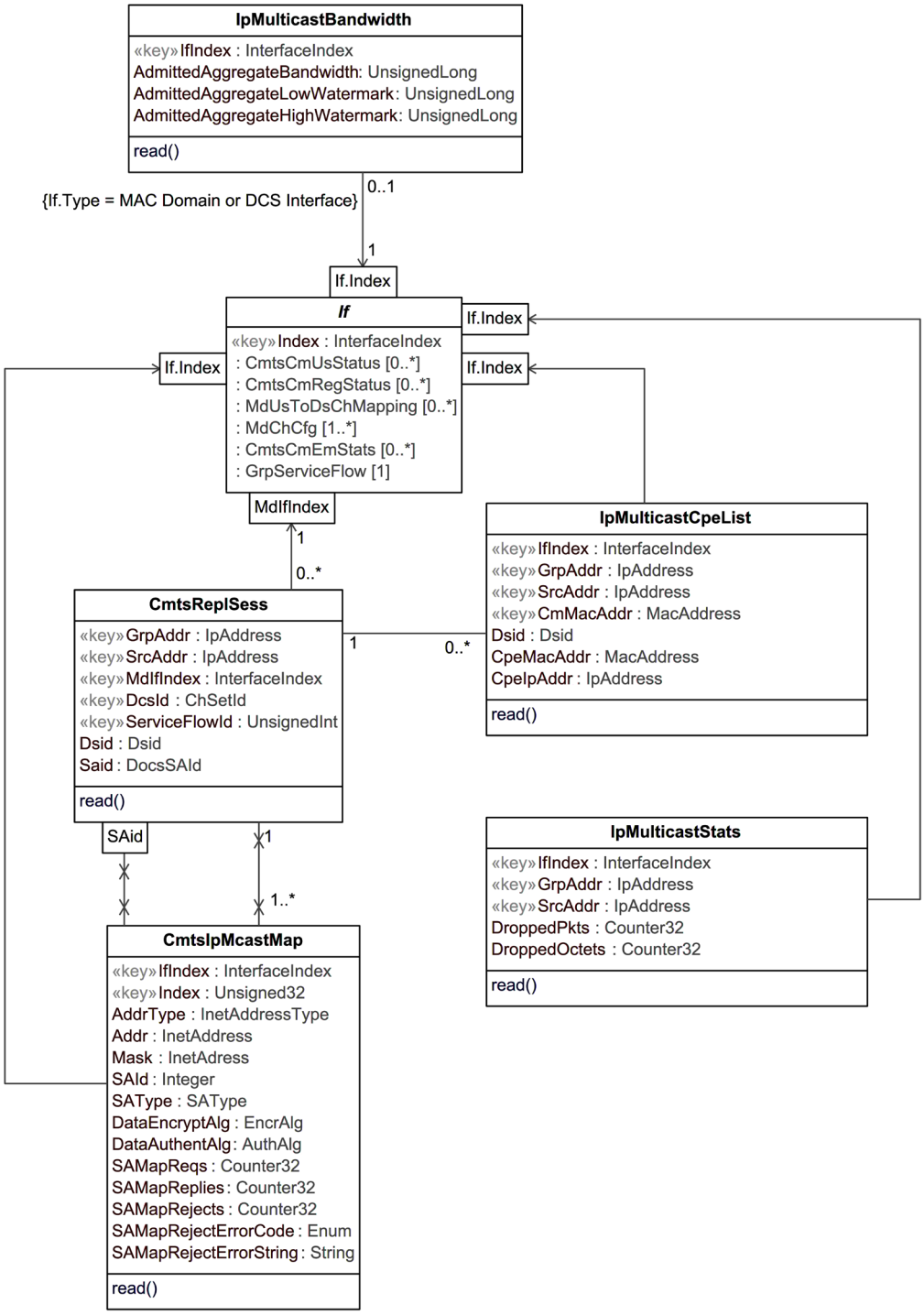


Figure 69 - DOCSIS Multicast Performance Management Information Model

7.2.2.5.1 CmtsReplSess

The CmtsReplSess object describes the replication of IP Multicast sessions onto the different Downstream Channel Sets of a CMTS. Each DCS may be either a single downstream channel or a bonding group of multiple downstream channels. Each IP Multicast session is identified by a combination of IP source and IP Destination group address

(S,G). The CMTS replicates each IP packet in an (S,G) session onto one or more Downstream Channel Sets (DCSs), each of which is implemented in a MAC Domain. The CMTS assigns each replication a Downstream Service ID (DSID) that is unique per MAC Domain.

Reference: [DOCS-MCAST-MIB] docsMcastCmtsReplSessTable

Table 410 - CmtsReplSess Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
GrpAddr	IpAddress	key		N/A	N/A
SrcAddr	IpAddress	key		N/A	N/A
MdIfIndex	InterfaceIndex	key		N/A	N/A
DcsId	ChSetId	key		N/A	N/A
ServiceFlowId	UnsignedInt	key	1..4294967295	N/A	N/A
Dsid	Dsid	read-only		N/A	N/A
Said	DocsSAidOrZero	read-only		N/A	N/A

7.2.2.5.1.1 GrpAddr

This key attribute defines the group G of a particular (S,G) IP multicast session.

7.2.2.5.1.2 SrcAddr

This key attribute identifies a specific Multicast Source Address. A Source Address that is all zeros is defined as 'all source addresses (*, G)'.

References: [RFC 3306] sections 6 and 7.

7.2.2.5.1.3 MdIfIndex

This key attribute defines the MAC Domain Interface index of the channel to which the (S,G) session is replicated.

7.2.2.5.1.4 DcsId

This key attribute provides the reference for the Downstream Channel within a MAC Domain that the multicast session (S,G) is replicated to.

7.2.2.5.1.5 ServiceFlowId

This key attribute indicates the service flow into which packets are classified for this replication of the multicast session (S,G).

7.2.2.5.1.6 Dsid

This attribute defines the Downstream Service ID (DSID) label with which the CMTS labels all packets of the (S,G) session on the DCS of a MAC Domain. The DSID value is unique per MAC domain.

7.2.2.5.1.7 Said

This attribute defines the Security Association ID (SAID) of this multicast replication session. The value 0 indicates no SAID associated with this session.

7.2.2.5.2 IpMulticastStats

The IpMulticastStats object contains statistics for the IP multicast session identified by the combination of IP source and IP destination group address (S,G).

Table 411 - IpMulticastStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Ethernet Interface(s)	N/A	N/A
GrpAddr	IpAddress	key		N/A	N/A
SrcAddr	IpAddress	key		N/A	N/A
DroppedPkts	Counter32	read-only		packets	N/A
DroppedOctets	Counter32	read-only		bytes	N/A

7.2.2.5.2.1 IfIndex

This key attribute defines the Ethernet Interface index to which the (S,G) IP multicast session applies.

7.2.2.5.2.2 GrpAddr

This key attribute defines 'G' as the group address for a particular (S,G) IP multicast session.

7.2.2.5.2.3 SrcAddr

This key attribute defines 'S' as the source address for a particular (S,G) IP multicast session. For the case of Any Source Multicast (ASM), this attribute uses a value of 0.0.0.0 for IPv4 or 0::/0 for IPv6.

7.2.2.5.2.4 DroppedPkts

This attribute returns a count of the packets dropped by the CMTS Forwarder process for a particular IP multicast session prior to replication to the outbound interface(s) (e.g., MAC domain interfaces). These packet drops can occur whenever there are no replications for this IP multicast session, or where an IP multicast packet for the specific S,G is not forwarded to the outbound interface(s).

7.2.2.5.2.5 DroppedOctets

This attribute returns a count of the octets for packets dropped by the CMTS Forwarder process for a particular IP multicast session prior to replication to the outbound interface(s).

7.2.2.5.3 IpMulticastCpeList

The IpMulticastCpeList object contains CPE information for the IP multicast session identified by the combination of IP source and IP destination group address (S,G), MAC Domain interface and CM MAC address.

Table 412 - IpMulticastCpeList Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	MAC Domain interface(s)	N/A	N/A
GrpAddr	IpAddress	key		N/A	N/A
SrcAddr	IpAddress	key		N/A	N/A
CmMacAddr	MacAddress	key		N/A	N/A
Dsid	Dsid	read-only		N/A	N/A
CpeMacAddr	MacAddress	read-only		N/A	N/A
CpeIpAddr	IpAddress	read-only		N/A	N/A

7.2.2.5.3.1 IfIndex

This key attribute defines the MAC Domain Interface index to which the (S,G) IP multicast session applies.

7.2.2.5.3.2 GrpAddr

This key attribute defines 'G' as the group address for a particular (S,G) IP multicast session.

7.2.2.5.3.3 SrcAddr

This key attribute defines 'S' as the source address for a particular (S,G) IP multicast session. For the case of Any Source Multicast (ASM), this attribute uses a value of 0.0.0.0 for IPv4 or 0::/0 for IPv6.

7.2.2.5.3.4 CmMacAddr

This key attribute defines the CM MAC address of a particular (S,G) IP multicast session.

7.2.2.5.3.5 Dsid

This attribute defines the Downstream Service ID (DSID) label with which the CMTS labels all packets of a particular (S,G) IP multicast session.

7.2.2.5.3.6 CpeMacAddr

This attribute returns the CPE MAC address for the (S,G) IP multicast session.

7.2.2.5.3.7 CpeIpAddr

This attribute returns the CPE IP address for the (S,G) IP multicast session.

7.2.2.5.4 IpMulticastBandwidth

The IpMulticastBandwidth object describes the admitted aggregate bandwidth of IP Multicast sessions onto the different Downstream Channel Sets or MAC Domain Interfaces of a CMTS. In addition to the current aggregate multicast bandwidth, the high and low watermarks are included as attributes.

Table 413 - IpMulticastBandwidth Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	MAC Domain or DCS Interfaces	N/A	N/A
AdmittedAggregateBandwidth	UnsignedLong	read-only		bps	N/A
AdmittedAggregateLowWatermark	UnsignedLong	read-only		bps	N/A
AdmittedAggregateHighWatermark	UnsignedLong	read-only		bps	N/A

7.2.2.5.4.1 IfIndex

This key attribute represents the MAC Domain Interface or Downstream Channel Set interface index associated with the Admitted Multicast Aggregate Bandwidth data.

Note that for some vendors this CMTS cable interface will be a cable-mac interface. For others, it will be a DOCSIS Downstream Channel Set. In either case, this CMTS cable interface exists as a row entry in the ifTable (and therefore has an ifIndex which can be used as an index for this object).

7.2.2.5.4.2 AdmittedAggregateBandwidth

This attribute reports the Admitted Multicast Aggregate Bandwidth which is defined as the sum of the Minimum Reserved Traffic Rates of each Group Service Flow that has been admitted on a given CMTS cable interface.

7.2.2.5.4.3 AdmittedAggregateLowWatermark

This attribute reports the low watermark threshold for Admitted Multicast Aggregate Bandwidth events.

7.2.2.5.4.4 AdmittedAggregateHighWatermark

This attribute reports the high watermark threshold for Admitted Multicast Aggregate Bandwidth events.

7.2.2.5.5 CmtsIpMulticastMap

The CmtsIpMulticastMap object maps multicast IP addresses to SAIDs. If a multicast IP address is mapped by multiple instances of this object, the instance with the lowest Index is utilized for the mapping.

Reference: [RFC 4131] docsBpi2CmtsIpMulticastMapTable

Table 414 - CmtsIpMulticastMap Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	MAC Domain Interface	N/A	N/A
Index	UnsignedInt	key	1..4294967295		
Addr	IpPrefix	read-only		N/A	N/A
Said	DocsSAIdOrZero	read-only		N/A	N/A
SaType	DocsBpkmSAType	read-only		packets	N/A
DataEncryptAlg	DocsBpkmDataEncryptAlg	read-only		bytes	N/A
AuthentAlg	DocsBpkmDataAuthentAlg	read-only		N/A	N/A
SaMapRequests	Counter32	read-only		N/A	N/A
SaMapReplies	Counter32	read-only		N/A	N/A
SaMapRejects	Counter32	read-only		N/A	N/A
SaMapRejectErrorCode	Enum	read-only	none(1), unknown(2), noAuthForRequestedDSFlow(9), dsFlowNotMappedToSA(10)	N/A	N/A
SaMapRejectErrorString	AdminString	read-only	SIZE (0..128)	N/A	N/A

7.2.2.5.5.1 IfIndex

This key attribute defines the CMTS MAC Domain Interface index to which the mapping applies.

7.2.2.5.5.2 Index

This key attribute defines a unique index to which the mapping applies.

7.2.2.5.5.3 Addr

This attribute represents the IP multicast address and mask to be mapped.

7.2.2.5.5.4 Said

This attribute represents the multicast SAID to be used in this IP multicast address mapping.

7.2.2.5.5.5 SaType

This attribute represents the type of security association. The value 'dynamic' does not apply to CMs running in BPI mode. Unicast BPI TEKs utilize the 'primary' encoding, and multicast BPI TEKs utilize the 'static' encoding.

7.2.2.5.5.6 DataEncryptAlg

This attribute represents the data encryption algorithm for this IP.

7.2.2.5.5.7 AuthentAlg

This attribute represents the data authentication algorithm for this IP.

7.2.2.5.5.8 SaMapRequests

This attribute reports the number of times the CMTS has received an SA Map Request message for this IP.

Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.

7.2.2.5.5.9 SaMapReplies

This attribute reports the number of times the CMTS has transmitted an SA Map Reply message for this IP.

Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.

7.2.2.5.5.10 SaMapRejects

This attribute reports the number of times the CMTS has transmitted an SA Map Reject message for this IP.

Discontinuities in the value of this counter can occur at re-initialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime.

7.2.2.5.5.11 SaMapRejectErrorCode

This attribute reports the enumerated description of the Error-Code in the most recent SA Map Reject message sent in response to an SA Map Request for this IP. It reports the value 'unknown' if the last Error-Code Value was 0 and 'none' if no SA MAP Reject message has been received since instance creation.

7.2.2.5.5.12 SaMapRejectErrorString

This attribute reports the text string in the most recent SA Map Reject message sent in response to an SA Map Request for this IP. It is a zero length string if no SA Map Reject message has been received since instance creation.

7.2.2.6 DOCSIS QoS Statistical Performance Management Information Model

The section defines statistical performance management objects in the DOCS-QOS3-MIB.

Reference: [DOCS-QOS3-MIB]

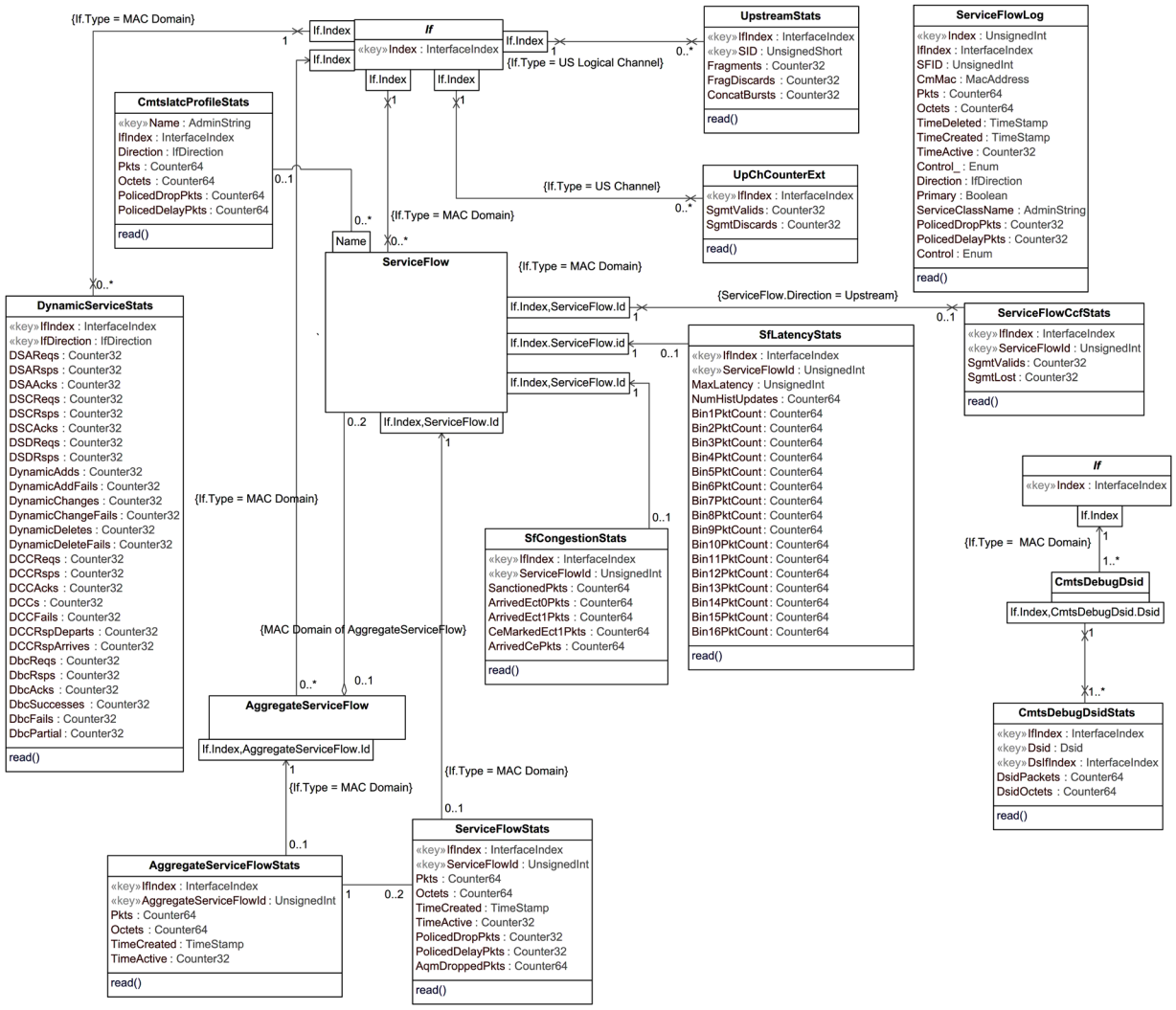


Figure 70 - DOCSIS QoS Statistical Performance Management Information Model

7.2.2.6.1 ServiceFlowStats

This object describes statistics associated with the Service Flows in a managed device.

Table 415 - ServiceFlowStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	N/A
ServiceFlowId	Unsigned32	key	1..4294967295	N/A	N/A
Pkts	Counter64	read-only		packets	N/A
Octets	Counter64	read-only		bytes	N/A
Created	TimeStamp	read-only		N/A	N/A
Active	Counter32	read-only		seconds	N/A
PolicedDropPkts	Counter32	read-only		packets	N/A
PolicedDelayPkts	Counter32	read-only		packets	N/A
AqmDroppedPkts	Counter64	read-only		packets	N/A

Table 416 - AggregateServiceFlowStats Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
AggregateServiceFlow	Directed Association to AggregateServiceFlow	0..1	1	
ServiceFlowStats	Association to ServiceFlow	1	0..2	

7.2.2.6.1.1 IfIndex

This key represents the interface index of the MAC Domain of the Service Flow.

7.2.2.6.1.2 ServiceFlowId

This key represents an identifier assigned to a Service Flow by CMTS within a MAC Domain.

7.2.2.6.1.3 Pkts

For outgoing Service Flows, this attribute counts the number of Packet Data PDUs forwarded to this Service Flow. For incoming upstream CMTS service flows, this attribute counts the number of Packet Data PDUs actually received on the Service Flow identified by the SID for which the packet was scheduled. CMs not classifying downstream packets may report this attribute's value as 0 for downstream Service Flows. This attribute does not count MAC-specific management messages. Particularly for UGS flows, packets sent on the primary Service Flow in violation of the UGS grant size should be counted only by the instance of this attribute that is associated with the primary service flow. Unclassified upstream user data packets (i.e., non- MAC-management) forwarded to the primary upstream Service Flow should be counted by the instance of this attribute that is associated with the primary service flow. This attribute does include packets counted by ServiceFlowPolicedDelayPkts but does not include packets counted by ServiceFlowPolicedDropPkts. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.1.4 Octets

This attribute indicates the count of the number of octets from the byte after the MAC header HCS to the end of the CRC for all packets counted in the ServiceFlowPkts attribute for this row. Note that this counts the octets after payload header suppression and before payload header expansion have been applied. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.1.5 Created

This attribute indicates the value of sysUpTime when the service flow was created.

7.2.2.6.1.6 Active

This attribute indicates the number of seconds that the service flow has been active. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.1.7 PolicedDropPkts

For outgoing service flows, this attribute counts the number of Packet Data PDUs classified to this service flow dropped due to: (1) exceeding the selected Buffer Size for the service flow (see the Buffer Control section in the Encodings for Configuration and MAC-Layer Messaging Annex of [MULPIv4.0]); or (2) UGS packets dropped due to exceeding the Unsolicited Grant Size with a Request/Transmission policy that requires such packets to be dropped. Classified packets dropped due to other reasons needs to be counted in ifOutDiscards for the interface of this service flow. This attribute reports 0 for incoming service flows. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.1.8 PolicedDelayPkts

This attribute counts only outgoing packets delayed in order to maintain the Maximum Sustained Traffic Rate. This attribute will always report a value of 0 for UGS flows because the Maximum Sustained Traffic Rate does not apply. This attribute is 0 for incoming service flows. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.1.9 AqmDroppedPkts

For downstream service flows on which Active Queue Management is enabled, this attribute reports the count of the number of Packet Data PDUs classified to this service flow dropped due to Active Queue Management drop decisions. Counts of classified packets dropped due to other reasons are reported in either PolicedDropPkts or ifOutDiscards for the interface of this service flow, depending on the reason for the discard. The CCAP reports zero for this attribute for upstream service flows.

7.2.2.6.2 AggregateServiceFlowStats

The object provides Aggregate Service Flow statistics on a per ASF basis.

The CMTS MUST create an instance of AggregateServiceFlowStats for every ASF instantiated in the MAC Domain.

Table 417 - AggregateServiceFlowStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A	
AggregateServiceFlowId	UnsignedInt	key	1..4294967295	N/A	
Pkts	Counter64	read-only		packets	
Octets	Counter64	read-only		octets	
TimeCreated	TimeStamp	read-only		N/A	
TimeActive	Counter32	read-only		seconds	

7.2.2.6.2.1 IfIndex

This key represents the interface index of the MAC Domain of the Aggregate Service Flow.

7.2.2.6.2.2 AggregateServiceFlowId

This key represents the identifier assigned to an Aggregate Service Flow by the CMTS. The AsfId is unique within a MAC Domain.

7.2.2.6.2.3 Pkts

This attribute provides the sum of the Packet Data PDUs forwarded on the Low Latency and Classic Service Flows aggregated within this ASF.

7.2.2.6.2.4 Octets

This attribute represents the sum of the number of octets for the Low Latency and Classic Service Flows aggregated within this ASF. For each packet, the count begins from the byte after the MAC header HCS to the end of the CRC.

7.2.2.6.2.5 TimeCreated

This attribute indicates the value of sysUpTime when the aggregate service flow was created.

7.2.2.6.2.6 TimeActive

This attribute indicates the number of seconds that the aggregate service flow has been active. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.3 UpstreamStats

This object describes statistics associated with upstream service flows. All counted frames need to be received without a Frame Check Sequence (FCS) error.

Table 418 - UpstreamStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	Interface Index of Upstream Logical Channel	N/A
SID	UnsignedShort	key		N/A
Fragments	Counter32	read-only		fragments
FragDiscards	Counter32	read-only		fragments
ConcatBursts	Counter32	read-only		headers

7.2.2.6.3.1 IfIndex

This key represents the interface index of the logical upstream interface to which this instance applies.

7.2.2.6.3.2 SID

This key identifies a service ID for an admitted or active upstream service flow.

7.2.2.6.3.3 Fragments

This attribute indicates the number of fragmentation headers received on an upstream service flow, regardless of whether the fragment was correctly reassembled into a valid packet. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.3.4 FragDiscards

This attribute indicates the number of upstream fragments discarded and not assembled into a valid upstream packet. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.3.5 ConcatBursts

This attribute indicates the number of concatenation headers received on an upstream service flow. This counter's last discontinuity is the ifCounterDiscontinuityTime for of the associated MAC Domain interface index.

7.2.2.6.4 DynamicServiceStats

This object describes statistics associated with the Dynamic Service Flows, Dynamic Channel Changes and Dynamic Bonding Changes in a managed device within a MAC Domain. For each MAC Domain there are two instances for the for the upstream and downstream direction. On the CMTS, the downstream direction instance indicates messages transmitted or transactions originated by the CMTS. The upstream direction instance indicates messages received or transaction originated by the CM. On the CM, the downstream direction instance indicates messages received or transactions originated by the CMTS. The upstream direction instance indicates messages transmitted by the CM or transactions originated by the CM.

Table 419 - DynamicServiceStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface	N/A
IfDirection	IfDirection	read-only		N/A
DSAReqs	Counter32	read-only		messages
DSARsps	Counter32	read-only		messages
DSAAcks	Counter32	read-only		messages
DSCReqs	Counter32	read-only		messages
DSCRsps	Counter32	read-only		messages
DSCAcks	Counter32	read-only		messages
DSDReqs	Counter32	read-only		messages
DSDRsps	Counter32	read-only		messages
DynamicAdds	Counter32	read-only		messages
DynamicAddFails	Counter32	read-only		messages
DynamicChanges	Counter32	read-only		messages
DynamicChangeFails	Counter32	read-only		messages
DynamicDeletes	Counter32	read-only		messages
DynamicDeleteFails	Counter32	read-only		messages
DCCReqs	Counter32	read-only		messages
DCCRsps	Counter32	read-only		messages
DCCAcks	Counter32	read-only		messages
DCCs	Counter32	read-only		messages
DCCFails	Counter32	read-only		messages
DCCRspDeparts	Counter32	read-only		messages
DCCRspArrives	Counter32	read-only		messages
DbcReqs	Counter32	read-only		messages
DbcRsps	Counter32	read-only		messages
DbcAcks	Counter32	read-only		messages
DbcSuccesses	Counter32	read-only		transactions
DbcFails	Counter32	read-only		transactions
DbcPartial	Counter32	read-only		transactions

7.2.2.6.4.1 IfIndex

This key represents the interface index of the MAC Domain.

7.2.2.6.4.2 IfDirection

This attribute indicates the interface direction for the instance the statistics are collected.

7.2.2.6.4.3 DSAReqs

This attribute indicates the number of Dynamic Service Addition Requests, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Addition section; [RFC 2863].

7.2.2.6.4.4 DSARsps

The number of Dynamic Service Addition Responses, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Addition section; [RFC 2863].

7.2.2.6.4.5 DSAAcks

The number of Dynamic Service Addition Acknowledgements, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Addition section; [RFC 2863].

7.2.2.6.4.6 DSCReqs

The number of Dynamic Service Change Requests, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Change section; [RFC 2863].

7.2.2.6.4.7 DSCRsps

The number of Dynamic Service Change Responses, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Change section; [RFC 2863].

7.2.2.6.4.8 DSCAcks

The number of Dynamic Service Change Acknowledgements, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Change section; [RFC 2863].

7.2.2.6.4.9 DSDReqs

The number of Dynamic Service Delete Requests, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Deletion section; [RFC 2863].

7.2.2.6.4.10 DSDRsps

The number of Dynamic Service Delete Responses, including retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Change section; [RFC 2863].

7.2.2.6.4.11 DynamicAdds

The number of successful Dynamic Service Addition transactions. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Addition section; [RFC 2863].

7.2.2.6.4.12 DynamicAddFails

The number of failed Dynamic Service Addition transactions. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Addition section; [RFC 2863].

7.2.2.6.4.13 DynamicChanges

The number of successful Dynamic Service Change transactions. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Change section; [RFC 2863].

7.2.2.6.4.14 DynamicChangeFails

The number of failed Dynamic Service Change transactions. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Change section; [RFC 2863].

7.2.2.6.4.15 DynamicDeletes

The number of successful Dynamic Service Delete transactions. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Delete section; [RFC 2863].

7.2.2.6.4.16 DynamicDeleteFails

The number of failed Dynamic Service Delete transactions. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Service Delete section; [RFC 2863].

7.2.2.6.4.17 DCCReqs

The number of Dynamic Channel Change Request messages traversing an interface. This count is nonzero only on downstream direction rows. This count should include the number of retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.18 DCCRsps

The number of Dynamic Channel Change Response messages traversing an interface. This count is nonzero only on upstream direction rows. This count should include the number of retries. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.19 DCCAcks

The number of Dynamic Channel Change Acknowledgement messages traversing an interface. This count is nonzero only on downstream direction rows. This count should include the number of retries. Discontinuities in the

value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.20 DCCs

The number of successful Dynamic Channel Change transactions. This count is nonzero only on downstream direction rows. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.21 DCCFails

The number of failed Dynamic Channel Change transactions. This count is nonzero only on downstream direction rows. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.22 DccRspDeparts

This attribute contains the number of Dynamic Channel Change Response (depart) messages. It only applies to upstream direction. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.23 DccRspArrives

This attribute contains the number of Dynamic Channel Change Response (arrive) messages and should include retries. It only applies to the upstream direction. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Downstream and/or Upstream Channel Changes section; [RFC 2863].

7.2.2.6.4.24 DbcReqs

This attribute contains the number of Dynamic Bonding Change Requests, including retries, that were transmitted by the CMTS in the MAC domain. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Bonding Change (DBC) section; [RFC 2863].

7.2.2.6.4.25 DbcRsps

This attribute contains the number of Dynamic Bonding Change Responses, including retries, that were transmitted by the CM and received by the CMTS in the MAC domain. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Bonding Change (DBC) section; [RFC 2863].

7.2.2.6.4.26 DbcAcks

This attribute contains the number of Dynamic Bonding Change Acknowledgements, including retries that were transmitted by the CMTS and received by the CM in the MAC domain. Discontinuities in the value of this counter

can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Bonding Change (DBC) section; [RFC 2863].

7.2.2.6.4.27 DbcSuccesses

This attribute contains the number of fully successful Dynamic Bonding Change transactions and does not include DBC transactions that result in Partial Service. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Bonding Change (DBC) section; [RFC 2863].

7.2.2.6.4.28 DbcFails

This attribute contains the number of failed Dynamic Bonding Change transactions. Note that Partial Service is not considered a failed transaction. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Bonding Change (DBC) section; [RFC 2863].

7.2.2.6.4.29 DbcPartial

This attribute contains the number of unsuccessful Dynamic Bonding Change transactions that result in Partial Service. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Dynamic Bonding Change (DBC) section; [RFC 2863].

7.2.2.6.5 ServiceFlowLog

This object contains a log of the disconnected Service Flows in a managed device.

Table 420 - ServiceFlowLog Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Index	UnsignedInt	key		N/A	N/A
IfIndex	InterfaceIndex	read-only		N/A	N/A
SFID	UnsignedInt	read-only		N/A	N/A
CmMac	MacAddress	read-only		N/A	N/A
Pkts	Counter64	read-only		packets	N/A
Octets	Counter64	read-only		bytes	N/A
TimeDeleted	TimeStamp	read-only		N/A	N/A
TimeCreated	TimeStamp	read-only		N/A	N/A
TimeActive	Counter32	read-only		seconds	N/A
Direction	RfMacIfDirection	read-only		N/A	N/A
Primary	Boolean	read-only		N/A	N/A
ServiceClassName	SnmpAdminString	read-only		N/A	N/A
PolicedDropPkts	Counter32	read-only		packets	N/A
PolicedDelayPkts	Counter32	read-only		packets	N/A
Control	Enum	read-write	active(1) destroy(6)	N/A	N/A

7.2.2.6.5.1 Index

This key indicates a unique index for a logged service flow.

7.2.2.6.5.2 IfIndex

This attribute indicates the MAC Domain Interface index where the service flow was present.

7.2.2.6.5.3 SFID

This attribute indicates the identifier assigned to the service flow.

7.2.2.6.5.4 CmMac

This attribute indicates the MAC address of the cable modem associated with the service flow.

7.2.2.6.5.5 Pkts

This attribute indicates the final value of the Pkts attribute in the ServiceFlowStats object for the service flow.

7.2.2.6.5.6 Octets

This attribute indicates the final value of the Pkts attribute in the ServiceFlowStats object for the service flow.

7.2.2.6.5.7 TimeDeleted

This attribute indicates the value of sysUpTime when the service flow was deleted.

7.2.2.6.5.8 TimeCreated

This attribute indicates the value of sysUpTime when the service flow was created.

7.2.2.6.5.9 TimeActive

This attribute indicates the total time that the service flow was active.

7.2.2.6.5.10 Direction

This attribute indicates the value of Service Flow direction for the service flow.

7.2.2.6.5.11 Primary

If set to 'true', this attribute indicates that the Service Flow in the log was a Primary Service Flow, otherwise, a Secondary Service Flow.

7.2.2.6.5.12 ServiceClassName

This attribute indicates the value of ServiceClassName for the provisioned QoS Parameter Set of the service flow.

7.2.2.6.5.13 PolicedDropPkts

This attribute indicates the final value of PolicedDropPkts attribute of the ServiceFlowStats object for the service flow.

7.2.2.6.5.14 PolicedDelayPkts

This attribute indicates the final value of PolicedDelayPkts attribute of the ServiceFlowStats object for the service flow.

7.2.2.6.5.15 Control

This attribute when set to 'destroy' removes this instance from the object. Reading this attribute returns the value 'active'.

7.2.2.6.6 UpChCounterExt

This object provides extensions for upstream channel bonding.

References: [MULPIv4.0] Channel Bonding section.

Table 421 - UpChCounterExt Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of upstream channel	N/A	N/A
SgmtValids	Counter32	read-only		segments	N/A
SgmtDiscards	Counter32	read-only		segments	N/A

7.2.2.6.6.1 IfIndex

This key represents the interface index of the upstream channel to which this instance applies.

7.2.2.6.6.2 SgmtValids

This attribute contains the number of segments correctly received on the upstream channel. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated upstream channel.

References: [MULPIv4.0] Upstream and Downstream Common Aspects section; [RFC 2863].

7.2.2.6.6.3 SgmtDiscards

This attribute represents the total number of discarded segments on this channel due to segment HCS problems. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated upstream channel.

References: [MULPIv4.0] Continuous Concatenation and Fragmentation section; [RFC 2863].

7.2.2.6.7 ServiceFlowCcfStats

This object provides upstream service flow statistics on upstream fragments for Continuous Concatenation and Fragmentation (CCF). This table will only capture service flow statistics for flows with segment headers set to ON. Any service flow established with segment headers OFF will not be counted in this table and will instead be counted in the normal ServiceFlowStats table. The CMTS MAY choose to not instantiate the ServiceFlowCcfStats object for service flows that do not use CCF or return a zero value for the individual counter statistics.

References: [MULPIv4.0] Continuous Concatenation and Fragmentation section.

Table 422 - ServiceFlowCcfStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface		
ServiceFlowId	UnsignedInt	key	1..4294967295		
SgmtValids	Counter32	read-only		segments	
SgmtLost	Counter32	read-only		segments	

7.2.2.6.7.1 IfIndex

This key represents the interface index of the upstream channel to which this instance applies.

7.2.2.6.7.2 ServiceFlowId

This key represents the Service Flow ID for the service flow.

References: [MULPIv4.0] QoS section.

7.2.2.6.7.3 SgmtValids

This attribute contains the number of segments counted on this service flow regardless of whether the fragment was correctly reassembled into valid packets. This attribute only gathers information for Segment Header On service flows. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Continuous Concatenation and Fragmentation section; [RFC 2863].

7.2.2.6.7.4 SgmtLost

This attribute counts the number of segments which the CMTS segment reassembly function determines were lost. This attribute only gathers information for Segment Header On service flows. Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ifCounterDiscontinuityTime of the associated MAC Domain interface index.

References: [MULPIv4.0] Continuous Concatenation and Fragmentation section; [RFC 2863].

7.2.2.6.8 CmtsIatcProfileStats

This object provides IATC statistics on a per profile basis. The IATC Profile statistics are associated with a DOCSIS channel or bonding group and one or more Service Flows.

The CMTS is not required to persist instances of this object across reinitializations.

References: [MULPIv4.0] IATC Profiles

Table 423 - CmtsIatcProfileStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Name	AdminString	Key	1..16	N/A	N/A
IfIndex	UnsignedInt	read-only	Index of channel or bonding group	N/A	N/A
Direction	IfDirection	read-only		N/A	N/A
Pkts	Counter64	read-only		packets	N/A
Octets	Counter64	read-only		bytes	N/A
PolicedDropPkts	Counter64	read-only		packets	N/A
PolicedDelayPkts	Counter64	read-only		packets	N/A

7.2.2.6.8.1 Name

This key represents the IATC Profile to which this instance applies.

7.2.2.6.8.2 IfIndex

This attribute represents the index, such as the ifIndex, of the DOCSIS channel or the index of the bonding group to which this instance applies.

7.2.2.6.8.3 Direction

This attribute indicates the direction to which the IATC Profile is applied.

7.2.2.6.8.4 Pkts

This attribute counts the number of Packet Data PDUs forwarded to this IATC Profile.

7.2.2.6.8.5 Octets

This attribute counts the number of octets forwarded to this IATC Profile.

7.2.2.6.8.6 PolicedDropPkts

This attribute counts the number of dropped Packet Data PDUs classified to this IATC Profile.

7.2.2.6.8.7 PolicedDelayPkts

This attribute counts the number of delayed Packet Data PDUs classified to this IATC Profile.

7.2.2.6.9 CmtsDebugDsidStats

The CMTS Debug DSID Stats object describes statistics at the CMTS for the forwarding of DSID-labeled downstream packets.

The CMTS creates an instance for every combination of MAC Domain, DSID value, and downstream channel on which packets labeled with that DSID are transmitted. The CMTS MUST NOT delete CmtsDebugDsidStats instances while the corresponding CmtsDebugDsid object control instance exists.

The CMTS MUST NOT persist instances created in the CmtsDebugDsidStats object across reinitializations.

Table 424 - CmtsDebugDsidStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of MAC Domain interface		
Dsid	Dsid	key	0..1048575		
DsIfIndex	InterfaceIndex	key	InterfaceIndex of downstream channel		
DsidPackets	Counter32	read-only		packets	
DsidOctets	Counter32	read-only		octets	

7.2.2.6.9.1 IfIndex

This key represents the interface index of the MAC Domain to which this instance applies.

7.2.2.6.9.2 Dsid

This key represents the Downstream Service ID (DSID).

7.2.2.6.9.3 DsIfIndex

This key represents an Interface Index of a downstream channel that belongs to the DSID.

7.2.2.6.9.4 DsidPackets

This attribute is a counter which contains the number of packets transmitted by the CMTS which are labeled with the DSID on the downstream channel. Discontinuities in the value of this counter can occur as indicated by the value of ifCounterDiscontinuityTime of the associated Downstream interface index.

7.2.2.6.9.5 DsidOctets

This attribute counts the number of bytes transmitted by the CMTS which are labeled with the DSID on the downstream interface. Discontinuities in the value of this counter can occur as indicated by the value of ifCounterDiscontinuityTime of the associated Downstream interface index.

7.2.2.6.10 SfLatencyStats

This object defines Service Flow latency statistics of downstream service flows. The SfLatencyStats object entry describes latency statistics such as histogram of latencies, Max Latency, Number of histogram updates at the CMTS for the downstream service flow. The CMTS MUST create an instance of SfLatencyStats object for every combination of MAC Domain and ServiceFlowId on which latency histogram calculation is enabled. The CMTS MUST delete the instance of SfLatencyStats when histogram calculation is disabled for a service flow.

The CMTS MUST NOT delete SfLatencyStats instances while the corresponding SfLatencyHistCfg instance is active. The CMTS MUST NOT persist instances created in the SfLatencyStats object across reinitializations.

References: [MULPIv4.0]

Table 425 - SfLatencyStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	Interface index of MAC Domain Interface	N/A	
ServiceFlowId	UnsignedInt	Key	1.. 4294967295		
MaxLatency	UnsignedInt	read-only		microseconds	
NumHistUpdates	Counter64	read-only		-	
Bin1PktCount	Counter64	read-only		packets	
Bin2PktCount	Counter64	read-only		packets	
Bin3PktCount	Counter64	read-only		packets	
Bin4PktCount	Counter64	read-only		packets	
Bin5PktCount	Counter64	read-only		packets	
Bin6PktCount	Counter64	read-only		packets	
Bin7PktCount	Counter64	read-only		packets	
Bin8PktCount	Counter64	read-only		packets	
Bin9PktCount	Counter64	read-only		packets	
Bin10PktCount	Counter64	read-only		packets	
Bin11PktCount	Counter64	read-only		packets	
Bin12PktCount	Counter64	read-only		packets	
Bin13PktCount	Counter64	read-only		packets	
Bin14PktCount	Counter64	read-only		packets	
Bin15PktCount	Counter64	read-only		packets	
Bin16PktCount	Counter64	read-only		packets	

7.2.2.6.10.1 IfIndex

This key represents the interface index of the MAC Domain of the Service Flow.

7.2.2.6.10.2 ServiceFlowId

This key represents the Service Flow to which this instance applies.

7.2.2.6.10.3 MaxLatency

This attribute represents maximum latency observed for this service flow, during this latency histogram calculation period, in microseconds.

7.2.2.6.10.4 NumHistUpdates

This attribute represents the count of updates to the queue latency histogram. In cases where a latency estimate is not generated for every packet (e.g., subsampling in the case of Low Latency Service Flow or estimates every update

interval in the case of Classic Service Flow) this attribute provides information regarding the fidelity of the histogram bin counts. In the case of a Classic Service Flow, this counter will only increment if packets have been enqueued during the last update interval.

7.2.2.6.10.5 Bin1PktCount to Bin16PktCount

These attributes represent the count of packets whose latency falls within each histogram bin. If the number of bin edges configured is 'n' then only the first 'n+1' bin counts are valid. The CMTS MUST report zero for Bin'*X*'PktCount for values of '*X*' greater than n+1.

7.2.2.6.11 SfCongestionStats

This object defines counters for CCAP downstream service flows. The CCAP MUST create an active instance of SfCongestionStats for every downstream Low Latency service flow. The CCAP MAY create an active instance of SfCongestionStats for other downstream service flow types. The CCAP MUST delete an instance of SfCongestionStats if the indexed service flow is deleted.

Table 426 - SfCongestionStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	Key	Interface index of the MAC Domain interface		
ServiceFlowId	UnsignedInt	Key	1.. 4294967295		
SanctionedPkts	Counter64	read-only		packets	
ArrivedEct0Pkts	Counter64	read-only		packets	
ArrivedEct1Pkts	Counter64	read-only		packets	
CeMarkedEct1Pkts	Counter64	read-only		packets	
ArrivedCePkts	Counter64	read-only		packets	

7.2.2.6.11.1 IfIndex

This key represents the interface index of the MAC Domain where the downstream Service Flow has been created.

7.2.2.6.11.2 ServiceFlowId

This key represents the downstream Service Flow to which this instance applies.

7.2.2.6.11.3 SanctionedPkts

This attribute counts the number of packets redirected from the Low Latency Service Flow to the Classic Service Flow. For other Service Flow types in the CCAP, this counter reports 0.

7.2.2.6.11.4 ArrivedEct0Pkts

This attribute reports the count of packets that arrived marked as ECT0. This attribute includes only those packets classified into the Service Flow, not those sanctioned into the Service Flow.

7.2.2.6.11.5 ArrivedEct1Pkts

This attribute reports the count of packets that arrived marked as ECT1. This attribute includes only those packets classified into the Service Flow, not those sanctioned into the Service Flow.

7.2.2.6.11.6 CeMarkedEct1Pkts

This attribute reports the count of packets that arrived marked as ECT1 and were re-marked as Congestion Experienced (CE) by the CCAP. This attribute includes only those packets classified into the Service Flow, not those sanctioned into the Service Flow.

7.2.2.6.11.7 ArrivedCePkts

This attribute reports the count of packets that arrived marked as Congestion Experienced (CE). This attribute includes only those packets classified into the Service Flow, not those sanctioned into the Service Flow.

7.2.2.6.11.8 AggregateServiceFlow

This object is defined in the QoS State Information Model. Refer to Section 7.2.1.6.4 for the definition of this object. Additional object associations are defined as follows.

Table 427 - AggregateServiceFlow Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
AggregateServiceFlowStats	Directed Association from AggregateServiceFlowStats	1	0..1	
ServiceFlow	Aggregation association to ServiceFlow	0..1	0..2	

7.2.2.6.12 ServiceFlow

This object is defined in the DOCSIS QoS State Performance Management Information Model. Refer to Section 7.2.1.6.3 for the definition of this object. Additional object associations are defined as follows.

Table 428 - ServiceFlow Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
AggregateServiceFlow	Aggregation association from AggregateServiceFlowStats	0..2	0..1	
ServiceFlowStats	Directed association from ServiceFlowStats	1	0..1	
SfCongestionStats	Directed association from SfCongestionStats	1	0..1	
CmtsIatcProfileStats	Association to CmtsIatcProfileStats	0..*	0..1	
ServiceFlowCcfStats	Association to ServiceFlowCcfStats	1	0..1	
SfLatencyStats	Directed association from SfLatencyStats	1	0..1	

7.2.2.7 SCTE-HMS-MPEG-MIB Statistics Information Model

The objects in the SCTE-HMS-MPEG-MIB: Statistics Objects are taken from [SCTE 154-4] and used with the following modifications for the CCAP.

The CcapMpegOutputProg object replaces the MpegOutputProg object from the SCTE-HMS-MPEG-MIB. It is defined in Section 7.2.1.10.5, CcapMpegOutputProg.

Reference: [SCTE 154-4]

7.2.2.8 Upstream OFDMA Status Information Model

These objects provide reporting of upstream OFDMA channel status as reported by the CCAP.

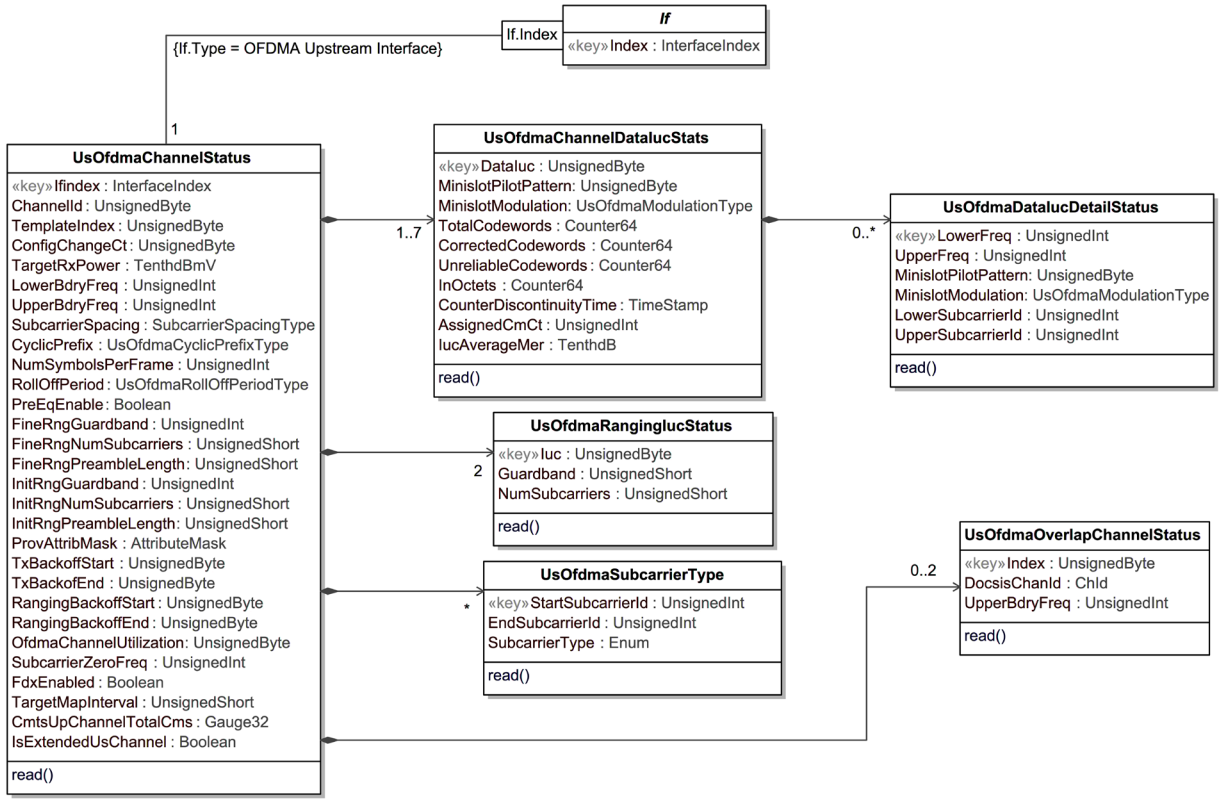


Figure 71 - Upstream OFDMA Status Information Model

7.2.2.8.1 UsOfdmaChannelStatus

The UsOfdmaChannelStatus object reports status information on the CCAP's OFDMA upstream channels. This object contains information on extended OFDMA upstream channels (FDX or FDD) and pre-DOCSIS 4.0 OFDMA upstream channels.

Table 429 - UsOfdmaChannelStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
IfIndex	InterfaceIndex	Key	Interface Index of upstream interface	
ChannelId	UnsignedByte	read-only		
TemplateIndex	UnsignedByte	read-only		
ConfigChangeCt	UnsignedByte	read-only		
TargetRxPower	TenthdBmV	read-only		dBmV
LowerBdryFreq	UnsignedInt	read-only		Hz
UpperBdryFreq	UnsignedInt	read-only		Hz
SubcarrierSpacing	SubcarrierSpacingType	read-only		
CyclicPrefix	UsOfdmaCyclicPrefixType	read-only		Samples
NumSymbolsPerFrame	UnsignedInt	read-only		
RolloffPeriod	UsOfdmaWindowingSizeType	read-only		Samples
PreEqEnable	Boolean	read-only		
FineRngGuardband	UnsignedInt	read-only		Hz

Attribute Name	Type	Access	Type Constraints	Units
FineRngNumSubcarriers	UnsignedShort	read-only		
FineRngPreambleLength	UnsignedShort	read-only		Bits
InitRngGuardband	UnsignedInt	read-only		Hz
InitRngNumSubcarriers	UnsignedShort	read-only		
InitRngPreambleLength	UnsignedShort	read-only		Bits
ProvAttribMask	AttributeMask	read-only		
TxBackoffStart	UnsignedByte	read-only		power of 2
TxBackoffEnd	UnsignedByte	read-only		power of 2
RangingBackoffStart	UnsignedByte	read-only		power of 2
RangingBackoffEnd	UnsignedByte	read-only		power of 2
OfdmaChannelUtilization	UnsignedByte	read-only		percent
SubcarrierZeroFreq	UnsignedInt	read-only		Hz
FdxEnabled	Boolean	read-only		N/A
TargetMapInterval	UnsignedShort	read-only		microseconds
CmtsUpChannelTotalCms	Gauge32	read-only		
IsExtendedUsChannel	Boolean	read-only		N/A

Table 430 - UsOfdmaChannelStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UsOfdmaChannelDataIucStats	Directed Composition		1..7	N/A
UsOfdmaRangingIucStatus	Directed Composition		2	N/A
UsOfdmaSubcarrierType	Directed Composition		*	N/A
UsOfdmaOverlapChannelStatus	Directed Composition		0..2	N/A

7.2.2.8.1.1 IfIndex

This key attribute is the unique index of the OFDMA upstream channel.

7.2.2.8.1.2 ChannelId

This attribute is the upstream channel ID signaled in the DOCSIS protocol for the OFDMA upstream channel. The ChannelId is unique within the associated MacDomain.

7.2.2.8.1.3 TemplateIndex

This attribute is the index of the UsOfdmaModulationTemplate object which the CCAP utilized when configuring this OFDMA upstream channel.

7.2.2.8.1.4 ConfigChangeCt

This attribute contains the value of the Configuration Change Count field in the Upstream Channel Descriptor (UCD) MAC Management Message corresponding to this OFDMA upstream channel.

7.2.2.8.1.5 TargetRxPower

This attribute provides the power of the expected commanded received signal in the channel, referenced to the CCAP input. The value represents the power spectral density in an equivalent 1.6 MHz spectrum.

7.2.2.8.1.6 LowerBdryFreq

This attribute provides the lower frequency for the OFDMA upstream channel.

7.2.2.8.1.7 UpperBdryFreq

This attribute provides the upper frequency for the OFDMA upstream channel.

7.2.2.8.1.8 SubcarrierSpacing

This attribute is the subcarrier spacing for the OFDMA upstream channel.

7.2.2.8.1.9 CyclicPrefix

This attribute is the allowed values for applying cyclic prefix for mitigating interference due to microreflections.

7.2.2.8.1.10 NumSymbolsPerFrame

This attribute represents the number of symbols per frame.

7.2.2.8.1.11 RolloffPeriod

This attribute provides the allowed values for applying windowing to maximize the capacity of the OFDMA upstream channel.

Reference: [PHYv4.0] Minislot Structure.

7.2.2.8.1.12 PreEqEnable

This attribute indicates pre-equalization is enabled on the OFDMA upstream channel when its value is true or disabled when its value is false.

7.2.2.8.1.13 FineRngGuardband

This attribute is the sum of the upper and lower guard bands for fine ranging in Hz.

7.2.2.8.1.14 FineRngNumSubcarriers

This attribute defines maximum number of subcarriers for fine ranging.

7.2.2.8.1.15 FineRngPreambleLength

This attribute defines the length of the OFDMA fine ranging IUC preamble.

7.2.2.8.1.16 InitRngGuardband

This attribute is the sum of the upper and lower guard bands for initial ranging in Hz.

7.2.2.8.1.17 InitRngNumSubcarriers

This attribute provides the maximum number of subcarriers for initial ranging. This is the maximum number of subcarriers for initial ranging, not including the guard band.

7.2.2.8.1.18 InitRngPreambleLength

This attribute provides the configured preamble sequence size for initial ranging in number of bits.

7.2.2.8.1.19 ProvAttribMask

This attribute provides the Provisioned Attribute Mask for the OFDMA upstream channel.

7.2.2.8.1.20 TxBackoffStart

This attribute provides the initial random back-off window to use when retrying transmissions. Expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

7.2.2.8.1.21 TxBackoffEnd

This attribute provides the final random back-off window to use when retrying transmissions. Expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

7.2.2.8.1.22 RangingBackoffStart

This attribute provides the initial random back-off window to use when retrying Ranging Requests. It is expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

7.2.2.8.1.23 RangingBackoffEnd

This attribute represents the final random back-off window to use when retrying Ranging Requests. It is expressed as a power of 2. A configured value of 16 indicates that a proprietary adaptive retry mechanism is to be used.

7.2.2.8.1.24 OfdmaChannelUtilization

The requirement to implement OFDMA upstream channels in DOCSIS 4.0 poses a scheduling and accounting problem for the CCAP. DOCSIS 4.0 requires support for simultaneous Time and Frequency Division Multiplexing (TaFDM) between SC-QAM and OFDMA channels. This implies both:

- OFDMA and SC-QAM can simultaneously operate on separate frequencies
- OFDMA and SC-QAM can also operate on the same frequencies, divided in time.

TaFDM scheduling is explained in the Upstream Time and Frequency Multiplexing section of [MULPIv4.0].

When calculating utilization for OFDMA and SC-QAM channels on overlapping frequencies, the CMTS MUST uniquely account spectrum represented by minislots to either an SC-QAM channel or an OFDMA channel.

This is required to avoid a situation where available spectrum can be mistakenly accounted as available on both overlapping channels.

This attribute indicates the calculated and truncated utilization for this OFDMA upstream channel, accurate as of the most recent utilization interval.

The upstream channel utilization is expressed as a percentage of minislots utilized on the physical channel, regardless of burst type.

The utilization index calculation can be expressed by the following equation:

Utilization = MinislotsUtilized/MinislotsAllocated *100%

For an Initial Maintenance region, the minislots for the complete region are considered utilized if the CMTS received an upstream burst within the region from any CM on the physical channel. For contention REQ and REQ/DATA regions, the minislots for a transmission opportunity within the region are considered utilized if the CMTS received an upstream burst within the opportunity from any CM on the physical channel. For all other regions, utilized minislots are those in which the CMTS granted bandwidth to any unicast SID on the physical channel.

For an upstream interface that has multiple logical upstream channels enabled, the utilization index is a weighted sum of utilization indices for the logical channels. The weight for each utilization index is the percentage of upstream minislots allocated for the corresponding logical channel.

Example:

> If 75% of bandwidth is allocated to the first logical channel and 25% to the second, and the utilization indices for each are 60 and 40, respectively, the utilization index for the upstream physical channel is (60 * 0.75) + (40 * 0.25) = 55. This figure applies to the most recent utilization interval.

A DOCSIS 4.0 CMTS can operate with upstream OFDMA and SC-QAM channels located on overlapping frequencies. Such scheduling mode is known as Time and Frequency Division Multiplexing (TaFDM). When operating in such mode, the CMTS uniquely allocates minislots to either an SC-QAM channel or an OFDMA channel.

The utilization index for an OFDMA channel is computed by excluding from the calculation those minislots which are effectively allocated to overlapping SC-QAM channels. OFDMA channel minislots dedicated to guard bands and for probes in OFDMA channel are considered utilized. When a SC-QAM channel overlaps in spectrum with an OFDMA channel, its minislots effectively allocated to OFDMA channels are excluded from channel utilization index calculation.

7.2.2.8.1.25 SubcarrierZeroFreq

This attribute specifies the center frequency of the subcarrier 0 of the OFDMA upstream channel. Note that since subcarrier 0 is always excluded, it will actually be below the allowed upstream spectrum band. This is the frequency of subcarrier X(0) in the definition of the IDFT.

7.2.2.8.1.26 FdxEnabled

This attribute reports if the OFDMA upstream channel is enabled for FDX as indicated by the OFDMA upstream channel's spectrum being configured in the FDX allocated spectrum.

A value of 'true' indicates the OFDMA upstream channel is an FDX Extended Upstream Channel. In this case, the IsExtendedUsChannel attribute also reports a value of 'true'.

A value of 'false' indicates the OFDMA upstream channel is not an FDX Extended Upstream Channel.

7.2.2.8.1.27 TargetMapInterval

This attribute reports the target MAP interval for the selected OFDMA upstream channel.

7.2.2.8.1.28 CmtsUpChannelTotalCms

This attribute reports the total number of CMs with OFDMA upstream channels in the CM Transmit Channel Set (TCS) and where each CM's CmtsCmRegStatus::Value has reached a state of 'registrationComplete', 'operational', 'bpiInit', or 'forwardingDisabled'.

7.2.2.8.1.29 IsExtendedUsChannel

This attribute reports whether the OFDMA upstream channel is an Extended Upstream Channel.

A value of 'true' indicates the OFDMA upstream channel is an Extended Upstream Channel. If the attribute FdxEnabled reports a value of 'true', the OFDMA upstream channel is an FDX Extended Upstream Channel. Otherwise, the OFDMA upstream channel is an FDD Extended Upstream Channel.

A value of 'false' indicates the OFDMA upstream channel is Non-extended Upstream Channel. For Non-extended Upstream Channels, the CCAP could report 'false' or not report an instance.

7.2.2.8.2 UsOfdmaSubcarrierType

This object specifies the subcarrier type for a group of subcarriers in the active spectrum of this OFDMA upstream channel. Groups of subcarriers of the same type are presented together; non-data subcarriers in these ranges are ignored.

Table 431 - UsOfdmaSubcarrierType Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
StartSubcarrierId	UnsignedInt	Key			
EndSubcarrierId	UnsignedInt	read-only			
SubcarrierType	Enum	read-only	data(1), excluded(2), unused(3)		

7.2.2.8.2.1 StartSubcarrierId

This attribute is a key defined to provide an index into the table and represents the subcarrier number of the first subcarrier in the group.

7.2.2.8.2.2 EndSubcarrierId

This attribute is the subcarrier number of the last subcarrier in the group.

7.2.2.8.2.3 SubcarrierType

This attribute specifies which type of subcarrier is represented in this group.

7.2.2.8.3 UsOfdmaChannelDataIucStats

This object provides information on the upstream Profile Data IUCs for an OFDMA upstream channel.

Attributes TotalCodewords, CorrectedCodewords, and UnreliableCodewords return upstream Forward Error Correction (FEC) statistics per IUC values. These attributes provide operators with Proactive Network Maintenance data by means of a query of the UsOfdmaChannelDataIucStats object.

Table 432 - UsOfdmaChannelDataIucStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
DataIuc	UnsignedByte	Key	5|6|9|10|11|12|13	N/A
MinislotPilotPattern	UnsignedByte	read-only		
MinislotModulation	UsOfdmaModulationType	read-only		
TotalCodewords	Counter64	read-only		codewords
CorrectedCodewords	Counter64	read-only		codewords
UnreliableCodewords	Counter64	read-only		codewords
InOctets	Counter64	read-only		bytes
CounterDiscontinuityTime	TimeStamp	read-only		secs
AssignedCmCt	UnsignedInt	read-only		
IucAverageMer	TenthdB	read-only		dB

Table 433 - UsOfdmaChannelDataIucStats Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
UsOfdmaDataIucDetailStatus	Directed Composition		0..*	N/A

7.2.2.8.3.1 DataIuc

This attribute represents the OFDMA Data IUC that these statistics correspond to.

7.2.2.8.3.2 MinislotPilotPattern

This attribute represents the pilot pattern for the frequency range. All minislots in the frequency range have this pilot pattern.

7.2.2.8.3.3 MinislotModulation

This attribute represents the modulation for the frequency range. All minislots in the frequency range have this modulation.

7.2.2.8.3.4 TotalCodewords

This attribute contains the count of the total number of FEC codewords received on this channel using this Data IUC.

7.2.2.8.3.5 CorrectedCodewords

This attribute contains the count of codewords received on this channel using this Data IUC that failed the pre-decoding syndrome check but passed the post-decoding syndrome check.

7.2.2.8.3.6 UnreliableCodewords

This attribute contains the count of codewords received on this channel using this Data IUC that failed the post-decoding syndrome check.

7.2.2.8.3.7 InOctets

This attribute is the count of MAC-layer octets received by the CCAP on this Data IUC. This value is the size of all unicast, multicast or broadcast frames (including all MAC-layer framing) and CCF PMD overhead (segment headers and stuffing bytes) delivered from the PHY to the MAC - this includes user data, DOCSIS MAC Management Messages, etc.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of CounterDiscontinuityTime.

7.2.2.8.3.8 CounterDiscontinuityTime

This attribute is the value of sysUpTime on the most recent occasion at which any one or more of this entry's counters suffered a discontinuity. If no such discontinuities have occurred since the last re-initialization of the local management subsystem, then this attribute contains a zero value.

7.2.2.8.3.9 AssignedCmCt

This attribute is the count of CMs currently assigned to this Data IUC.

7.2.2.8.3.10 IucAverageMer

This attribute reports the average MER value for the selected Data IUC.

7.2.2.8.4 UsOfdmaDatalucDetailStatus

This object provides information about the current minislot settings for the selected data IUC. The information is provided in the form of a set of ranges of minislots. Each range groups consecutive minislots with the same pilot pattern and modulation order.

Table 434 - UsOfdmaDatalucDetailStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
LowerFreq	UnsignedInt	Key		Hz
UpperFreq	UnsignedInt	read-only		Hz
MinislotPilotPattern	UnsignedByte	read-only	1..14	
MinislotModulation	UsOfdmaModulationType	read-only		
LowerSubcarrierId	UnsignedInt	read-only		
UpperSubcarrierId	UnsignedInt	read-only		

7.2.2.8.4.1 LowerFreq

This attribute represents the lower frequency where the minislots will use the pilot pattern and modulation.

7.2.2.8.4.2 UpperFreq

This attribute represents the upper frequency where the minislots will use the pilot pattern and modulation.

7.2.2.8.4.3 MinislotPilotPattern

This attribute represents the pilot pattern for the frequency range. All minislots in the frequency range have this pilot pattern.

7.2.2.8.4.4 MinislotModulation

This attribute represents the modulation for the frequency range. All minislots in the frequency range have this modulation.

7.2.2.8.4.5 LowerSubcarrierId

This attribute indicates the subcarrier number of the lowest-frequency subcarrier of the minislot using the pilot pattern and modulation.

7.2.2.8.4.6 UpperSubcarrierId

This attribute indicates the subcarrier number of the highest-frequency subcarrier of the minislot using the pilot pattern and modulation.

7.2.2.8.5 UsOfdmaRangingIucStatus

Table 435 - UsOfdmaRangingIucStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Iuc	UnsignedByte	Key		
Guardband	UnsignedShort	read-only		Hz
NumSubcarriers	UnsignedShort	read-only		

7.2.2.8.5.1 Iuc

This key attribute provides the Ranging IUC that this row applies to.

7.2.2.8.5.2 Guardband

This attribute is the sum of the upper and lower guardbands, expressed in Hz, for fine or initial ranging depending on the value specified for key Iuc.

7.2.2.8.5.3 NumSubcarriers

This attribute reports the number of subcarriers in the selected data ranging IUC.

7.2.2.8.6 UsOfdmaOverlapChannelStatus

This object reports the existence and status of Overlap channels configured for a specified Physical OFDMA channel.

Reference: [MULPIv4.0] Overlapping OFDMA Channels section

Table 436 - UsOfdmaOverlapChannelStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Index	UnsignedByte	Key		
DocsisChanId	ChId	read-only		

Attribute Name	Type	Access	Type Constraints	Units
UpperBdryFreq	UnsignedInt	read-only		Hz

7.2.2.8.6.1 Index

This key attribute selects an instance of non-Base Overlap Channel for a specific physical OFDMA channel.

7.2.2.8.6.2 DocsisChanId

This attribute reports the upstream channel ID assigned to this OFDMA Overlap Channel instance.

7.2.2.8.6.3 UpperBdryFreq

This attribute reports the upper boundary frequency of this OFDMA Overlap Channel instance. The upper boundary frequency value is constrained to be less than or equal to the UpperBdryFreq value configured for the associated physical OFDMA channel and to at least a minimum distance above the LowerBdryFreq value defined for the physical OFDMA channel as specified in [PHYv4.0].

7.2.2.9 Downstream OFDM Status Information Model

In order for operators to measure the data forwarding performance of their DOCSIS 4.0 DS Channels and make informed DOCSIS capacity planning decisions, the CCAP implements the following management objects.

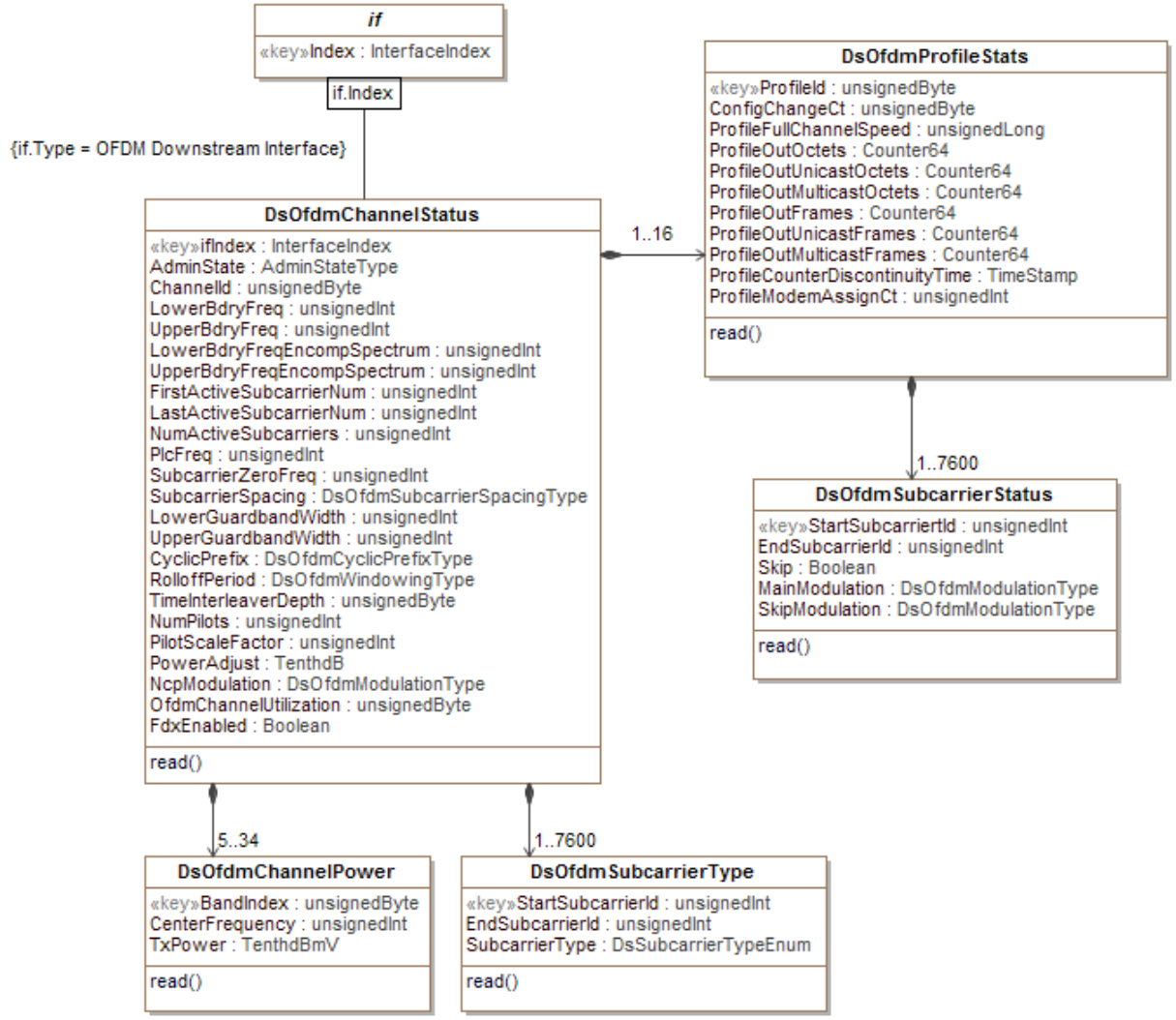


Figure 72 - Downstream OFDM Status Information Model

7.2.2.9.1 DsOfdmChannelStatus

The DsOfdmChannelStatus object reports the status of downstream OFDM downstream channels. There is a 1-to-1 relationship with the OFDM channel CFG object.

Table 437 - DsOfdmChannelStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Ifindex	InterfaceIndex	Key	Interface Index of downstream interface	
AdminState	AdminStateType	read-only		
ChannelId	UnsignedByte	read-only		
LowerBdryFreq	UnsignedInt	read-only		Hz
UpperBdryFreq	UnsignedInt	read-only		Hz
LowerBdryFreqEncomp Spectrum	UnsignedInt	read-only		Hz

Attribute Name	Type	Access	Type Constraints	Units
UpperBdryFreqEncomp Spectrum	UnsignedInt	read-only		Hz
FirstActiveSubcarrierNum	UnsignedInt	read-only		
LastActiveSubcarrierNum	UnsignedInt	read-only		
NumActiveSubcarriers	UnsignedInt	read-only		
PlcFreq	UnsignedInt	read-only		Hz
SubcarrierZeroFreq	UnsignedInt	read-only		Hz
SubcarrierSpacing	DsOfdmSubcarrierSpacingType	read-only		Hz
LowerGuardbandWidth	UnsignedInt	read-only		Hz
UpperGuardbandWidth	UnsignedInt	read-only		Hz
CyclicPrefix	DsOfdmCyclicPrefixType	read-only		samples
RolloffPeriod	DsOfdmWindowingType	read-only		samples
TimeInterleaverDepth	UnsignedByte	read-only		samples
NumPilots	UnsignedInt	read-only		
PilotScaleFactor	UnsignedInt	read-only		
NcpModulation	DsOfdmModulationType	read-only	qpsk(3)|qam16(4)|qam64(5)	
OfdmChannelUtilization	UnsignedByte	read-only		%
PowerAdjust	Short	read-only		TenthdB
FdxEnabled	Boolean	read-only		N/A

Table 438 - DsOfdmChannelStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsOfdmProfileStats	Directed Composition		1..16	N/A
DsOfdmChannelPower	Directed Composition		5..34	N/A
DsOfdmSubcarrierType	Directed Composition		1..7600	N/A

7.2.2.9.1.1 IfIndex

This key attribute is the unique index of the OFDM downstream channel.

7.2.2.9.1.2 AdminState

This attribute is the admin state for the OFDM downstream channel.

7.2.2.9.1.3 ChannelId

This attribute is the CMTS identification of the OFDM downstream channel within this particular MAC interface.

7.2.2.9.1.4 LowerBdryFreq

This attribute represents either the lower boundary frequency of the lower guard band or (if no guard band is defined) the lower boundary frequency of the lowest active subcarrier of the OFDM downstream channel. It is intended to be aligned with the boundaries of the SC-QAM channels on defined channel frequency HFC plants.

7.2.2.9.1.5 UpperBdryFreq

This attribute represents either the upper boundary frequency of the upper guard band or (if no guard band is defined) the upper boundary frequency of the highest active subcarrier of the OFDM downstream channel. It is intended to be aligned with the boundaries of the SC-QAM channels on defined channel frequency HFC plants.

7.2.2.9.1.6 LowerBdryFreqEncompSpectrum

This attribute represents the lower boundary frequency of the encompassed spectrum.

7.2.2.9.1.7 UpperBdryFreqEncompSpectrum

This attribute represents the upper boundary frequency of the encompassed spectrum.

7.2.2.9.1.8 PlcFreq

This attribute is the PHY Link Channel (PLC) frequency. It is the center frequency of the lowest subcarrier of the 6 MHz encompassed spectrum containing the PLC at its center. The frequency of this subcarrier is required to be located on a 1 MHz grid. The aim of the PLC is for the CMTS to convey to the CM the physical properties of the OFDM downstream channel.

7.2.2.9.1.9 FirstActiveSubcarrierNum

This attribute corresponds to the number of the first non-excluded subcarrier.

7.2.2.9.1.10 LastActiveSubcarrierNum

This attribute corresponds to the number of the last non-excluded subcarrier.

7.2.2.9.1.11 NumActiveSubcarriers

This attribute defines the number of active subcarriers within the OFDM downstream channel. For 4K FFT mode, the maximum number of contiguous active subcarriers cannot exceed 3800 and for 8K FFT mode, this number cannot be greater than 7600.

Note: this excludes continuous pilots and the PLC.

7.2.2.9.1.12 SubcarrierZeroFreq

This attribute specifies the center frequency of subcarrier 0 of the OFDM downstream channel. This is the frequency of subcarrier X(0) in the definition of the Discrete Fourier Transform.

7.2.2.9.1.13 SubcarrierSpacing

This attribute is the subcarrier spacing in use on the OFDM downstream channel.

7.2.2.9.1.14 LowerGuardbandWidth

This optional attribute defines the width in Hertz of the lower guard band of the OFDM downstream channel. If omitted, the width of the lower guard band will be automatically configured by the CCAP.

7.2.2.9.1.15 UpperGuardbandWidth

This optional attribute defines the width in Hertz of the upper guard band of the OFDM downstream channel. If omitted, the width of the upper guard band will be automatically configured by the CCAP.

7.2.2.9.1.16 CyclicPrefix

This attribute specifies the cyclic prefix, which enables the receiver to overcome the effects of inter-symbol-interference and intercarrier-interference caused by micro-reflections in the channel. There are five possible values for the length of the CP and the choice depends on the delay spread of the channel - a longer delay spread requires a longer cyclic prefix. The cyclic prefix (in µs) are converted into samples using the sample rate of 204.8 Msamples/s and is an integer multiple of: 1/64 * 20 µs.

7.2.2.9.1.17 RolloffPeriod

This attribute specifies the roll off period or windowing, which maximizes channel capacity by sharpening the edges of the spectrum of the OFDM signal. For windowing purposes another segment at the start of the IDFT output is

appended to the end of the IDFT output -the roll-off postfix (RP). There are five possible values for the (RP), and the choice depends on the bandwidth of the channel and the number of exclusion bands within the channel. A larger RP provides sharper edges in the spectrum of the OFDM signal; however, there is a time vs. frequency trade-off. Larger RP values reduce the efficiency of transmission in the time domain, but because the spectral edges are sharper, more useful subcarriers appear in the frequency domain. There is an optimum value for the RP that maximizes capacity for a given bandwidth and/or exclusion band scenario.

7.2.2.9.1.18 TimeInterleaverDepth

This attribute specifies the number of samples for the OFDM Downstream channel. This is limited to 16 samples for and 32 samples for 50 kHz and 25 kHz Subcarrier Spacing, respectively.

7.2.2.9.1.19 NumPilots

This attribute is the number of continuous pilots for the OFDM downstream channel.

7.2.2.9.1.20 PilotScaleFactor

This attribute represents the scale factor for calculating the number of continuous pilots.

7.2.2.9.1.21 NcpModulation

This attribute represents the modulation of all subcarriers in the NCP subcarriers.

7.2.2.9.1.22 OfdmChannelUtilization

This attribute is the OFDM downstream channel utilization measured by the CCAP across all profiles over the configured utilization interval.

The CCAP MUST report DS utilization metric of the channel that conforms to the following requirements:

- The CCAP MUST report a value for OfdmChannelUtilization <= 1% when no user traffic is forwarded on the channel and MMM traffic is known to be less than 1% of the channel capacity.
- The CCAP MUST report a value for OfdmChannelUtilization >= 99% when forwarded traffic completely saturates the channel.
- The CCAP MUST report a value for OfdmChannelUtilization which increases linearly with traffic volume increase and is accurate within 1% of the channel capacity for any given traffic mix (ratio of packets for a given OFDM profiles, packet size, traffic pattern, etc.), which results in nearly all full codewords as the maximum channel capacity is reached.
  Note: The channel capacity is defined as the largest ProfileFullChannelSpeed value for this channel.

The following algorithm is the reference algorithm for calculating OfdmChannelUtilization:

```
chanWeightedByteTotal = 0;
//ProfileFullChannelSpeed is defined in Section 7.2.2.9.4.3
mostEffProfileSpeed = max(ProfileFullChannelSpeed across all profiles);
//ProfileOutOctets is the number of octets sent on a given profile during
//the utilization interval. This implies a delta calc on a continuous ctr.
//utilInterval is the duration of the utilization interval in seconds.
for (i = 0; i < numProfiles; i++)
{
       profileMultiplier = mostEffProfileSpeed / ProfileFullChannelSpeed[i];
       chanWeightedByteTotal += profileMultiplier * ProfileOutOctets[i];
}
OfdmChannelUtilization = (8 * chanWeightedByteTotal) /
                    (mostEffProfileSpeed * utilInterval);
```

The reference algorithm is expected to give an excellent (within a fraction of 1%) representation of actual channel capacity and utilization under most real-world operating conditions. However, it should be recognized that the accuracy of this approach might be compromised in the event of one or more of the following:

- Large number of profiles in the system relative to total channel capacity
- Aggressive latency targets
- Imbalance in traffic loading across profiles (i.e., many very-lightly-loaded profiles and few more heavily loaded profiles)

These conditions could force the codeword builder to shorten codewords in order to serve all active profiles within the limited time/bandwidth dictated by the latency targets and channel capacity. The resulting additional overhead represents a loss of total capacity not accounted for in the reference algorithm, meaning that the actual utilization will be slightly higher than the utilization reported by the reference algorithm.

The Codeword Builder Latency table of [MULPIv4.0] offers guidance regarding the relationship between number of profiles, channel bandwidth, and latency targets. In a system configured at the edges of these bounds, the error of the reference algorithm is expected to be no more than 2-3% under worst-case conditions of traffic imbalance; the effects of averaging over the utilization interval will typically reduce this error significantly.

Codeword builder algorithms, including codeword-shortening decisions, are vendor-specific. A vendor might choose to incorporate proprietary information about the codeword builder algorithm into the calculation of OfdmChannelUtilization in order to account for some or all of the capacity loss described above.

In a simplified case of a single profile with moderate-to-heavy loading, codeword builder implementations are expected to provide capacity and report utilization values which are extremely close to those given by the reference algorithm.

7.2.2.9.1.23 PowerAdjust

This attribute specifies the power level adjustment for this OFDM downstream channel from the value specified by BaseChanPower.

7.2.2.9.1.24 FdxEnabled

This attribute reports if the OFDM downstream channel is enabled for FDX as indicated by the channel's spectrum being configured in the FDX allocated spectrum.

A value of 'true' indicates the OFDM downstream channel is an FDX downstream channel contained within a full duplex sub-band.

A value of 'false' indicates the OFDM downstream channel is not an FDX downstream channel.

7.2.2.9.2 DsOfdmChannelPower

The DsOfdmChannelPower object provides the attributes to measure the OFDM downstream channel power in 6 MHz-wide bands at the output of the CCAP.

Table 439 - DsOfdmChannelPower Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
BandIndex	UnsignedByte	Key	0..33		
CenterFrequency	UnsignedLong	R/O	111000000..1791000000	Hz	0
TxPower	TenthdBmV	R/O		dBmV	

7.2.2.9.2.1 BandIndex

This attribute is a unique index used by the CCAP to identify each of the 6 MHz bands of a given OFDM downstream channel (from the lowest 6 MHz band of the Occupied Bandwidth to the highest 6 MHz band of the Occupied Bandwidth). The CCAP MUST assign indices in frequency order from the OFDM downstream channel's lowest to highest 6 MHz frequency band for each of the 6 MHz bands of the channel, using an index of 1 to represent the lowest frequency band of the Occupied Bandwidth. Thus, an index of 33 represents the highest

possible 6 MHz frequency band of the Occupied Bandwidth of an OFDM downstream channel. The CCAP MUST also provide the power of the PLC channel and utilize a value of 0 to represent the PLC channel in this table.

7.2.2.9.2.2 CenterFrequency

This attribute corresponds to the center frequency of the 6 MHz band where the CCAP measured the average channel power. The 6 MHz measurement band is defined as any 6 MHz band with a center frequency of 111 + 6 (n-1) MHz for n = 1,2...281 (i.e., 111,117,...1791 MHz).

The CCAP MUST use a center frequency with a value of 0 for the 6 MHz encompassed spectrum containing the PLC at its center.

The CCAP MUST provide the center frequency for the 6 MHz channel, other than the one encompassing the PLC channel, per the following formula: centerfreq = 111 + 6(n-1), such that (centerfreq - 111) / 6, and will be a whole number.

The OFDM downstream channel center frequency range depends on the mode of operation to which DOCSIS equipment is configured to operate. Refer to [PHYv3.1] *Downstream CM Spectrum* section, for the downstream OFDM boundary frequency limits when equipment is configured to be compliant with the DOCSIS 3.1 and (non-FDX and non-FDD extended spectrum) DOCSIS 4.0 frequency plans. Refer to [PHYv4.0] *Downstream FDX CM Spectrum* section for the downstream OFDM boundary frequency limits when equipment is configured to be compliant with FDX mode. Refer to [PHYv4.0] *Upstream and Downstream Frequency Plan for FDD Operation* section for the downstream OFDM boundary frequency limits when the equipment is configured to be compliant with FDD mode.

7.2.2.9.2.3 TxPower

This attribute provides an estimate of the average power measured at the output of the CCAP in the OFDM downstream channel set for any 6 MHz bandwidth with the Center Frequency of 111 + 6(n-1) MHz for n =1,2,...281 (i.e., 111,117,...1791 MHz).

If the BandIndex is 0, then this attribute provides an estimate of the average power measured at the output of the CCAP for a 6 MHz encompassed spectrum containing the DOCSIS 4.0 PLC at its center.

7.2.2.9.3 DsOfdmSubcarrierType

This object specifies the subcarrier type for a group of subcarriers in the active spectrum of this OFDM channel. Groups of subcarriers of the same type are presented together; non-data subcarriers in these ranges are ignored.

Table 440 - DsOfdmSubcarrierType Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
StartSubcarrierId	UnsignedInt	Key			
EndSubcarrierId	UnsignedInt	read-only			
SubcarrierType	enum	read-only	data(1), plc(2), continuousPilot(3), excluded(4)		

7.2.2.9.3.1 StartSubcarrierId

This attribute is a key defined to provide an index into the table and represents the subcarrier number of the first subcarrier in the group.

7.2.2.9.3.2 EndSubcarrierId

This attribute is the subcarrier number of the last subcarrier in the group.

7.2.2.9.3.3 SubcarrierType

This attribute specifies which type of subcarrier is represented in this group.

7.2.2.9.4 DsOfdmProfileStats

This object defines the downstream OFDM Profile usage object.

All attributes in this object count MAC-layer octets and frames delivered from the MAC to the Phy. The octet counters include all MAC-layer overhead (e.g., DOCSIS and Ethernet MAC framing as well as DOCSIS MAC Management Messages), but not Physical-layer overhead (e.g., FEC overhead, NCP overhead, etc.). These counters vary by the destination MAC address of the frame. Unicast counters only include frames with a unicast MAC destination address (but include both unicast data frames and unicast MMMs). Multicast counters only include frames with a multicast MAC destination address (including multicast data frames and multicast MMMs, but excluding any frames sent to a broadcast MAC address). The broadcast octet count can be calculated by subtracting unicast octets and multicast octets from the total octets. The broadcast frame count can be calculated similarly.

Table 441 - DsOfdmProfileStats Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
ProfileId	UnsignedByte	Key	0..15	N/A
ConfigChangeCt	UnsignedByte	read-only		
ProfileFullChannelSpeed	UnsignedLong	read-only		bps
ProfileOutOctets	Counter64	read-only		bytes
ProfileOutUnicastOctets	Counter64	read-only		bytes
ProfileOutMulticastOctets	Counter64	read-only		bytes
ProfileOutFrames	Counter64	read-only		frames
ProfileOutUnicastFrames	Counter64	read-only		frames
ProfileOutMulticastFrames	Counter64	read-only		frames
ProfileCounterDiscontinuityTime	TimeStamp	read-only		secs
ProfileAssignedCmCt	UnsignedInt	read-only		

Table 442 - DsOfdmProfileStats Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsOfdmSubcarrierStatus	Directed Composition		1..7600	N/A
DsOfdmChannelStatus	Directed Composition	1..16		

7.2.2.9.4.1 ProfileId

This attribute is a unique index and is the identifier of the downstream profile associated with the OFDM downstream channel. The value of this key attribute is zero-based due to constraints of the definition of ProfileId.

Reference: [MULPIv4.0] Downstream Profile Descriptor (DPD) section

7.2.2.9.4.2 ConfigChangeCt

This attribute contains the value of the Configuration Change Count field in the Downstream Profile Descriptor (DPD) MAC Management Message corresponding to this profile.

7.2.2.9.4.3 ProfileFullChannelSpeed

This attribute is the speed of the associated channel in bps if this were the only profile and 100% of data-capable subcarriers were utilized to transmit MAC frames in full codewords. ProfileFullChannelSpeed is intended to approximate the maximum speed available to the MAC layer; thus, this attribute subtracts out FEC and NCP overhead from the maximum theoretical speed. The maximum ProfileFullChannelSpeed for a given channel differs from the ifSpeed for the channel by the amount of this FEC and NCP overhead. The CCAP SHOULD calculate ProfileFullChannelSpeed such that the result is equal to that calculated by the following algorithm or its equivalent:

```
def profileFullChanSpeed(encompSpec, subcarSpac, contPilots, cycPref, excBW,
                         avgBitLoad, ncpBitLoad):
    #encompSpec -- encompassed spectrum in MHz
    #subcarSpac -- subcarrier spacing in KHz; 25 or 50 are valid for DOCSIS 4.0
    #contPilots -- number of continuous pilots
    #cycPref -- cyclic prefix in usec
    #excBW -- exclusion bandwidth in MHz
    #avgBitLoad -- average bits/subcarrier/symbol for all data subcarriers
    #ncpBitLoad -- bits/subcarrier/symbol for NCP subcarriers

    if subcarSpac == 25:
        plcSC = 16
    elif subcarSpac == 50:
        plcSC = 8
    else:
        return error

    symbolSize = 1.0 / (subcarSpac * 1000.0)
    totSymDuration = symbolSize + (cycPref / 1000000.0)
    symbolRate = 1.0 / totSymDuration

    numSC = (encompSpec * 1000000.0) * symbolSize
    excSC = ceil(excBW * 1000 / subcarSpac)
    usableSC = numSC - plcSC - contPilots - excSC

    rawBitsPerSym = usableSC * avgBitLoad
    scatPilotFactor = 127.0/128.0 #constant (approximation)
    preNcpBitsPerSym = rawBitsPerSym * scatPilotFactor

    bitsPerFullCw = 16200 #constant
    firstPassFullCwPerSym = preNcpBitsPerSym / bitsPerFullCw

    ncpScCeil  = (48/ncpBitLoad) * (ceil(firstPassFullCwPerSym) + 1)
    ncpScFloor = (48/ncpBitLoad) * max(2, floor(firstPassFullCwPerSym) + 1)
    fpFullCwPerSymFrac = firstPassFullCwPerSym - floor(firstPassFullCwPerSym)
    interpAvgNcpSC = ncpScFloor + (ncpScCeil - ncpScFloor) * fpFullCwPerSymFrac

    postNcpAvgNumDataSC = usableSC - interpAvgNcpSC
    postNcpAvgBitsPerSym = postNcpAvgNumDataSC * avgBitLoad * scatPilotFactor

    #MAC-layer bits per full codeword / full codeword total bits (constant)
    fecEfficiencyMacData = 14216.0 / 16200.0 #~87.75%
    macLayerAvgBitsPerSym = postNcpAvgBitsPerSym * fecEfficiencyMacData

    profFullChanSpeed = macLayerAvgBitsPerSym * symbolRate

return profFullChanSpeed
```

7.2.2.9.4.4 ProfileOutOctets

This attribute is the count of MAC-layer octets transmitted by the CCAP using this profile. This value is the size of all unicast, multicast or broadcast frames (including all MAC-layer framing) delivered from the MAC to the PHY - this includes user data, DOCSIS MAC Management Messages, etc.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ProfileCounterDiscontinuityTime.

7.2.2.9.4.5 ProfileOutUnicastOctets

This attribute is the count of MAC-layer Unicast octets transmitted by the CCAP using this profile. This value is the size of all unicast frames (including all MAC-layer framing) delivered from the MAC to the PHY - this includes user data, DOCSIS MAC Management Messages, etc.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ProfileCounterDiscontinuityTime.

7.2.2.9.4.6 ProfileOutMulticastOctets

This attribute is the count of MAC-layer Multicast and broadcast octets transmitted by the CCAP using this profile. This value is the size of all frames (including all MAC-layer framing) delivered from the MAC to the PHY and addressed to a multicast MAC address - this includes user data, DOCSIS MAC Management Messages, etc.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ProfileCounterDiscontinuityTime.

7.2.2.9.4.7 ProfileOutFrames

This attribute is the count of frames transmitted by the CCAP using this profile. This value is the count of all unicast, multicast or broadcast frames delivered from the MAC to the PHY - this includes user data, DOCSIS MAC Management Messages, etc.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ProfileCounterDiscontinuityTime.

7.2.2.9.4.8 ProfileOutUnicastFrames

This attribute is the count of unicast frames transmitted by the CCAP using this profile. This value is the count of all frames delivered from the MAC to the PHY and addressed to a unicast MAC address - this includes user data, DOCSIS MAC Management Messages, etc.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ProfileCounterDiscontinuityTime.

7.2.2.9.4.9 ProfileOutMulticastFrames

This attribute is the count of multicast frames transmitted by the CCAP using this profile. This value is the count of all frames delivered from the MAC to the PHY and addressed to a multicast MAC address - this includes user data, DOCSIS MAC Management Messages, etc., but excludes frames sent to a broadcast address.

Discontinuities in the value of this counter can occur at reinitialization of the managed system, and at other times as indicated by the value of ProfileCounterDiscontinuityTime.

7.2.2.9.4.10 ProfileCounterDiscontinuityTime

This attribute is the value of sysUpTime on the most recent occasion at which any one or more of this entry's counters suffered a discontinuity. If no such discontinuities have occurred since the last re-initialization of the local management subsystem, then this attribute contains a zero value.

7.2.2.9.4.11 ProfileAssignedCmCt

This attribute is the count of CMs currently assigned to this profile.

7.2.2.9.5 DsOfdmSubcarrierStatus

This object represents a consecutive range of active subcarriers with the same modulation for the parent profile and OFDM channel.

Table 443 - DsOfdmSubcarrierStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
StartSubcarrierId	UnsignedInt	Key		
EndSubcarrierId	UnsignedInt	read-only		
Skip	Boolean	read-only		
MainModulation	DsOfdmModulationType	read-only		
SkipModulation	DsOfdmModulationType	read-only		

7.2.2.9.5.1 StartSubcarrierId

This attribute is a key defined to provide an index into the table and represents an identifier for the first subcarrier in the range of active subcarriers with the same modulation.

7.2.2.9.5.2 EndSubcarrierId

This attribute is the subcarrier number of the last subcarrier in the group.

7.2.2.9.5.3 Skip

This attribute indicates whether the skip modulation method is used. If true, the modulation order of the subcarriers in the range is alternating between the MainModulation and SkipModulation.

7.2.2.9.5.4 MainModulation

This attribute indicates the main modulation order of the subcarriers in the range. In case of skip modulation enabled, the MainModulation is the modulation order of the first, the third, the fifth, etc., subcarriers in the range.

7.2.2.9.5.5 SkipModulation

This attribute indicates the modulation order for every other subcarrier in the range.

7.2.2.10 DOCS-IF3-MIB Statistical Performance Management Information Model

The objects in the DOCS-IF3-MIB statistical performance management class diagram are taken from the following DOCSIS MIBs and are used without modification for the CCAP:

Object	MIB
SignalQualityExt	DOCS-IF3-MIB

Reference: [OSSIv3.0], [DOCS-IF3-MIB]

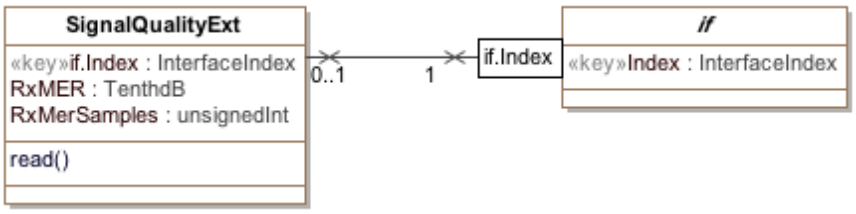


Figure 73 - DOCS-IF3-MIB Statistical Performance Management Information Model

7.2.2.10.1 SignalQualityExt

This object provides an in-channel received modulation error ratio metric for the CMTS and CCAP.

Table 444 - SignalQualityExt Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IfIndex	InterfaceIndex	key	Interface Index of logical upstream channel		
RxMER	TenthdB	read-only	-2147483648..2147483647	dB	
RxMerSamples	UnsignedInt	read-only			

7.2.2.10.1.1 IfIndex

This key represents the interface index of the logical upstream channel for the CMTS to which this instance applies.

7.2.2.10.1.2 RxMER

RxMER provides an in-channel received Modulation Error Ratio (MER). RxMER is defined as an estimate, provided by the demodulator, of the ratio:

(average constellation energy with equally likely symbols) / (average squared magnitude of error vector)

RxMER is measured just prior to FEC (trellis/Reed-Solomon) decoding. RxMER includes the effects of the HFC channel as well as implementation effects of the modulator and demodulator. Error vector estimation may vary among demodulator implementations. The CMTS RxMER is averaged over a given number of bursts at the burst receiver, which may correspond to transmissions from multiple users. In the case of S-CDMA mode, RxMER is measured on the de-spread signal.

7.2.2.10.1.3 RxMerSamples

RxMerSamples is a statistically significant number of bursts for the CMTS, processed to arrive at the RxMER value. For the CMTS, the MER measurement includes only valid bursts that are not in contention regions.

7.3 Proactive Network Maintenance Information Model

7.3.1 Overview

This section defines the CCAP information models supporting Proactive Network Maintenance (PNM). CCAP and cable modem features and capabilities can be leveraged to enable measurement and reporting of network conditions such that undesired impacts such as plant equipment and cable faults, interference from other systems and ingress can be detected and measured. With this information cable network operations personnel can make modifications necessary to improve conditions and monitor network trends to detect when network improvements are needed.

DOCSIS 4.0 PNM capability assumes the existence of a PNM server that initiates PNM tests and receives data output from the CM and/or from the CCAP. While most tests defined in this section will complete in a short time frame, some tests will collect data over extended periods. There are also tests that can be triggered on the CM that do not require any CCAP interaction. It is possible that while a test is in progress, the CCAP could command the CM to be load balanced. In these cases, the test will abort on the CM. On the CCAP, if a test (like the DS Symbol Capture) is running for a given CM, the CCAP SHOULD prevent load balancing or other DS channel changes for that CM. Operators that wish to collect long term tests on a given modem can place the modem in the Load Balance exception table to prevent future load balance attempts on that CM which might cause the testing to abort.

Any discontinuities in the channel (channel is reset or the channel is administratively taken down or removed from service) will result in any tests associated with that interface to be concluded or aborted.

7.3.2 Data Type Definitions

This section defines the management model for the PNM Downstream Parameters Information model. This information is contained in [PHYv4.0]: "Proactive Network Maintenance".

Table 445 - Data Types

Data Type Name	Base Type	Permitted Values	Reference
ComplexData	HexBinary		
MeasStatusType	enum	other(1) inactive(2) busy(3) sampleReady(4) error(5) resourceUnavailable(6) sampleTruncated(7) interfaceModification(8)	
ExclSubCarrierType	HexBinary		
ImpulseNoiseEventType	HexBinary		
RxMERData	HexBinary		

7.3.2.1 ComplexDataType

This data type uses 16-bit fixed-point, fractional, two's-complement notation to represent each of the I (real) and Q (imaginary) components of a complex number. When viewed as a 32-bit number in a file, the I component is the most significant 16 bits and the Q component is the least significant 16 bits. Positive or negative input values exceeding the number format are clipped on I and Q independently (no rollover).

The fixed-point format uses "sm.n" notation to indicate the location of the binary point in the I and Q components. Reading from left to right there is a sign bit, m integer bits, the assumed location of the binary point, and n fractional bits. If the I or Q components have less than 16 available bits of input data, the binary point of the input data is adjusted to match the sm.n specification in the 16-bit field, with the MSBs sign-filled if required, and the LSBs zero-filled if required.

Examples of sm.n notation: With s1.14 format, the numerical value "1" corresponds to hex pattern 0x4000. With s2.13 format, the numerical value "1" corresponds to 0x2000. With s3.12 format, the numerical value "1" corresponds to 0x1000.

Example of a complex number with s2.13 format on I and Q components: 0x2400F800 represents the complex number 1.125 - 0.25 j, where "j" is the square root of -1; that is, I = 1.125 and Q = -0.25.

7.3.2.2 MeasStatusType

This data type is used to determine the state of a measurement. The MeasStatusType values are interpreted as follows:

- 'other' - Indicates any state not described below
- 'inactive' - Indicates that a test is not started or in progress
- 'busy' - Indicates that a test has been started and is in progress

  'sampleReady' - Indicates that a test has completed and that the measurement data is ready
- 'error' - Indicates that there was an error starting or during the test and any test data, if available, may not be valid
- 'resourceUnavailable' - Indicates that the test could not be started due to lack of test platform resources
- 'sampleTruncated' - Indicates that the size of the requested data exceeded file size supported
- 'interfaceModification' - Indicates that the interface numbering is changed due to DBC message or when Primary backup is changed

7.3.2.3 ExclSubCarrierType

This data type is used to represent subcarriers which are excluded. The length in bytes of this data type is equal to the FFT size divided by 8. Each bit corresponds to a subcarrier. If a bit is set, then the subcarrier is excluded. The left most bit of the first byte corresponds to the lowest frequency subcarrier. The right most bit of the last byte corresponds to highest frequency subcarrier.

7.3.2.4 ImpulseNoiseEventType

This data type is used to represent Impulse Noise events. The length in bytes of this data type is 14 bytes structured as follows:

Table 446 - Format for ImpulseNoiseEventType

Element	Type	Units	Size
TImestamp	UnsignedLong		8 bytes
Event Duration	UnsignedInt	ns	4 bytes
EventAveragePower	Short	dBmV	2 bytes

7.3.2.4.1 Timestamp

Timestamp is the 64-bit Extended Timestamp. If the CMTS is not using the 64-bit Extended Timestamp, then the 8-byte value is constructed from the 32-bit DOCSIS 3.0 Timestamp as follows:

Bits 63 through 41 = 0

Bits 40 through 9 = 32-bit DOCSIS 3.0 Timestamp

Bits 8 through 0 = 0

7.3.2.4.2 EventDuration

The event duration is the period of time during which the signal level exceeded the StartTriggerLevel and until the signal level fell below the EndTriggerLevel. If the capture is done using a FreeRunDuration, then the EventDuration corresponds to the interval during which the capture was performed. The EventDuration is recorded in units of ns.

7.3.2.4.3 EventAveragePower

The EventAveragePower is the average power of the event recorded in units of dBmV using 16-bit fixed point, fractional, two's complement notation encoded using the S6.9 format.

7.3.2.5 RxMerData

This data type represents a sequence of received modulation error ratio (RxMER) values for an upstream OFDMA channel at the CM. The data is expressed as a series of RxMerDataValues - one RxMerDataValue for each subcarrier (active or excluded) from the lowest-frequency active subcarrier to the highest-frequency active subcarrier with no gaps.

7.3.2.5.1 RxMerDataValue

This data type is used to express RxMER and is defined below:

- A single byte value with units of QuarterdB (e.g., a value of 23.75 dB = 0x5F)
- Range 0 to 63.5 dB in ¼ dB steps
- The value 0xFF is used to indicate no measurement is available for a given subcarrier
- Any value over 63.5 dB is reported as 63.5 dB
- Any value below 0 dB is reported as 0 dB

7.3.3 PNM Common Information Model

This section defines the common Proactive Network Maintenance information model applicable to both the PNM Downstream Information Model described in Section 7.3.4 and the PNM Upstream Information Model described in Section 7.3.5.

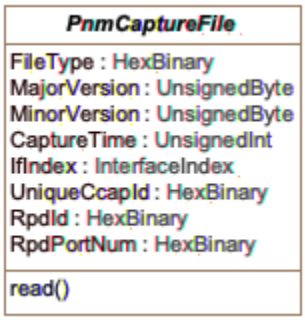


Figure 74 - PNM Common Information Model

7.3.3.1 PnmCaptureFile

The DOCSIS 4.0 PHY specification [PHYv4.0] defines requirements for 17 Proactive Network Maintenance tests or features enabling the cable operator to measure and report conditions of the network to detect and measure undesired impacts to the network, such as cable faults and ingress noise. Some of these PNM tests generate files to report measurements or test results. The results file includes header information that is common to all types of PNM tests and fields, and data that are specific to the type of PNM test. The abstract PnmCaptureFile object defines the attributes and format of the header information common to all PNM test files. File header fields are right-justified within the field and left-padded with zero values if necessary.

Determination of maximum size of the PNM Capture File is left to vendor implementation.

Table 442 shows the format of the PNM capture file header, applied to any data file created by a PNM test.

Table 447 - PnmCaptureFile Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
FileType	HexBinary	R/O	SIZE (4)	N/A	N/A
MajorVersion	UnsignedByte	R/O	SIZE (1)	N/A	N/A
MinorVersion	UnsignedByte	R/O	SIZE (1)	N/A	N/A
CaptureTime	UnsignedInt	R/O	SIZE (4)	N/A	N/A
IfIndex	InterfaceIndex	R/O	SIZE (4)	N/A	N/A
UniqueCcapId	HexBinary	R/O	SIZE (256)	N/A	N/A
RpdId	HexBinary	R/O	SIZE (6)	N/A	N/A
RpdPortNum	HexBinary	R/O	SIZE (1)	N/A	N/A

7.3.3.1.1 FileType

A four-byte hexadecimal identifier specific to the type of PNM test that generated the data file. Refer to the [CANN] DOCSIS PNM Registry for defined File Types. Filetypes prefixed by PNM (i.e., 504E4D) do not contain the Major Version and Minor Version header elements. Filetypes prefixed with PNN (i.e., 504E4E) contain the Major Version and Minor Version header elements.

7.3.3.1.2 MajorVersion

This attribute represents the file header version. This value is incremented by one when the header format is modified by this specification.

7.3.3.1.3 MinorVersion

This attribute is reserved for vendor-specific and vendor-defined version information.

7.3.3.1.4 CaptureTime

This attribute represents the epoch time (also known as 'unix time') which is the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), Thursday, 1 January 1970.

When the CCAP creates capture file with multiple result sets, the value of CaptureTime attribute corresponds to the first result set in the capture file.

7.3.3.1.5 IfIndex

This attribute represents the ifIndex of the upstream RF port sampled.

7.3.3.1.6 UniqueCcapId

A 256-byte hexadecimal field representing a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN). The value is a null-terminated string.

7.3.3.1.7 RpdId

A 6-byte hexadecimal field representing the unique RPD identifier or null string if the capture was performed on I-CCAP.

7.3.3.1.8 RpdPortNum

A 1-byte hexadecimal field representing the RPD's downstream or upstream port number or null string if the capture was performed on I-CCAP.

7.3.4 PNM Downstream Information Model

There are two downstream Proactive Network Maintenance tests that are coordinated between the CCAP and CM. The related objects are defined in this section.

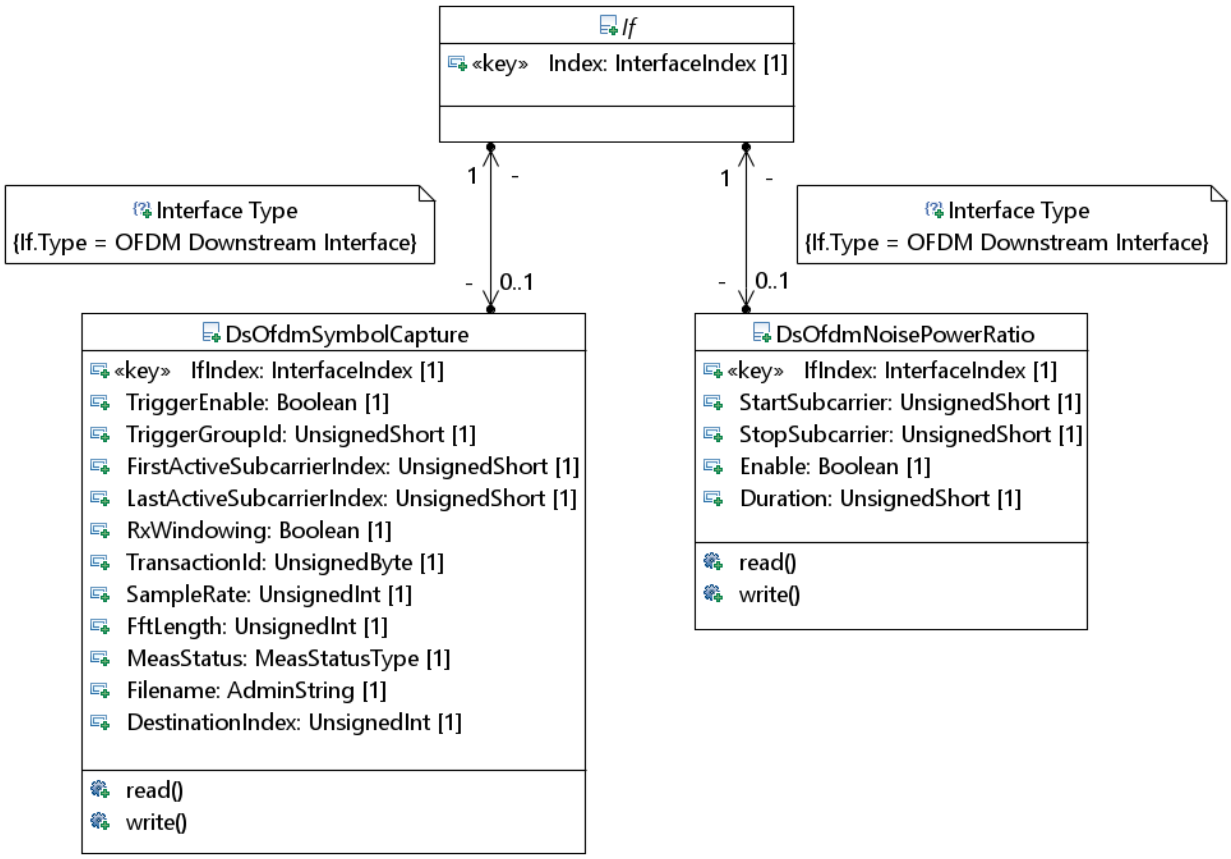


Figure 75 - PNM Downstream Information Model

7.3.4.1 DsOfdmSymbolCapture

Downstream OFDM Symbol Capture is a PNM Test described in [PHYv3.1] Downstream Symbol Capture section. The DsOfdmSymbolCapture object defines the management interface for the operator to configure, execute, and monitor the Downstream OFDM Symbol Capture test.

The DsOfdmSymbolCapture object provides partial functionality of a network analyzer to analyze the response of the cable plant.

At the CCAP, the transmitted frequency-domain modulation values of one full OFDM symbol before the IFFT are captured and made available for analysis. The frequency domain samples are expressed as 16-bit two's complement numbers using s3.12 format. This includes the I and Q modulation values of all subcarriers in the active bandwidth of the OFDM channel, including data subcarriers, pilots, PLC preamble symbols and excluded subcarriers. This capture will result in a number of samples that depends on the OFDM channel width, per [PHYv4.0] Downstream Transmitter Inverse Discrete Fourier Transform.

As examples, for 50 kHz subcarrier spacing in a 192 MHz channel with 204.8 MHz sampling rate, 3800 samples will be captured; for 25 kHz subcarrier spacing in a 192 MHz channel with 204.8 MHz sampling rate, 7600 samples will be captured; for 50 kHz subcarrier spacing in a 24 MHz channel with a reduced sampling rate of 25.6 MHz, 475 samples would be captured. Note: Excluded subcarriers in the 1 MHz guard band on either side of the encompassed spectrum are not captured.

Capturing the input and output of the cable plant is equivalent to a wideband sweep of the channel, which permits full characterization of the linear and nonlinear response of the downstream plant. The MAC provides signaling via the PLC Trigger Message to ensure that the same symbol is captured at the CCAP and CM.

The CCAP MUST create an instance of the DsOfdmSymbolCapture object for each IfIndex of a downstream channel.

The CCAP MAY support simultaneous Downstream Symbol Capture tests on more than one OFDM channel at a time.

The CCAP MUST reject configuring a value for the DestinationIndex of the DsOfdmSymbolCapture object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 448 - DsOfdmSymbolCapture Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
TriggerEnable	Boolean	R/W	Binary	Flag	False
TriggerGroupId	UnsignedShort	R/W	N/A	N/A	0
FirstActiveSubcarrierIndex	UnsignedShort	R/O	N/A	N/A	N/A
LastActiveSubcarrierIndex	UnsignedShort	R/O	N/A	N/A	N/A
RxWindowing	Boolean	R/O	N/A	N/A	N/A
TransactionId	UnsignedByte	R/O	N/A	N/A	N/A
SampleRate	UnsignedInt	R/O	N/A	Hz	N/A
FftLength	UnsignedInt	R/O	512 | 1024 |2048 |4096 | 8192	N/A	N/A
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A
Filename	AdminString	R/W	SIZE (0..255)	N/A	""
DestinationIndex	UnsignedInt	R/W	N/A	N/A	

7.3.4.1.1 IfIndex

This attribute is the interface index of an OFDM Downstream Channel and is a key to provide an index into the table.

7.3.4.1.2 TriggerEnable

This attribute is used to instruct the CCAP to insert a Trigger Message Block in the PLC with a Group ID matching the CM's TriggerGroupID. The CCAP captures the Symbol that it designated in the Trigger Message Block. The TriggerEnable is a one-shot enable and the attribute is disabled when the CCAP has completed the acquisition of the designated Symbol.

Setting this attribute to a value of 'true' will change the value of the MeasStatus attribute to 'busy'.

7.3.4.1.3 TriggerGroupId

This attribute is used by the CCAP to be inserted in the PLC Trigger MB to identify a CM or a group of CMs expected to perform Symbol Capture measurements for the designated symbol.

7.3.4.1.4 FirstActiveSubcarrierIndex

This attribute is used to denote the subcarrier index of the lowest frequency of the Encompassed Spectrum for the OFDM channel.

7.3.4.1.5 LastActiveSubcarrierIndex

This attribute is used to denote the subcarrier index of the highest frequency of the Encompassed Spectrum for the OFDM channel.

7.3.4.1.6 RxWindowing

This attribute is a flag indicating if vendor proprietary Windowing was enabled during the capture.

7.3.4.1.7 TransactionId

This attribute is the Transaction ID sent by the CCAP in the Trigger MB. Prior to completion of a measurement this attribute has no meaning.

7.3.4.1.8 SampleRate

This attribute is the FFT sample rate in use by the CM for the channel; typically, the sample rate for the downstream channel will be 204.8 MHz.

7.3.4.1.9 FftLength

This attribute is the FFT length in use by the CM for the channel; typically, this value is 4096 or 8192 for the Downstream Channel.

7.3.4.1.10 MeasStatus

This attribute is used to determine the status of the measurement. The PNM server will query the Status value to determine when the measurement is complete.

7.3.4.1.11 Filename

This attribute contains the name of the file with the captured symbol data at the CCAP that is to be downloaded using TFTP to the PNM server.

This value can only be changed while a test is not in progress. An attempt to set this value while the value of MeasStatus is 'busy' will return 'inconsistentValue'.

If the value of this attribute is an empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and the ifIndex of the interface on which the test runs. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapSymCap_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example: PNMCcapSymCap_ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

The data file is composed of a header plus the Symbol Capture Data. The header is composed of ordered fixed-length fields. Unless otherwise specified, the header fields contain hex values that are right-justified within the field. If necessary, the field is left-padded with zero values.

Syntax of the file is as follows:

Table 449 - CCAP Symbol Capture File Format

Element	Size
File type (value = 504E4E65)	4 bytes
Major Version (value = 2)	1 byte
Minor Version	1 byte
Capture Time	4 bytes

Element	Size
IfIndex	4 bytes
Unique CCAP ID	256 bytes
RPD ID	6 bytes
RPD Port Number	1 byte
Subcarrier zero Frequency in Hz	4 bytes
Subcarrier Spacing in kHz	1 byte
FirstActiveSubcarrierIndex	2 bytes
LastActiveSubcarrierIndex	2 bytes
TriggerGroupId	2 bytes
Transaction ID	1 byte
Length (in bytes) of Capture Data	4 bytes
Capture Data	ComplexData

7.3.4.1.11.1 Major Version

The current file header version assigned the “value”. The version is incremented by one when the file header format is modified by specification. The file header change causing the major version to increment from 1 to 2 is the addition of RPD ID and RPD Port Number fields.

7.3.4.1.11.2 Minor Version

The vendor-specified version information. The default value is zero if no vendor version is assigned.

7.3.4.1.11.3 Capture Time

The epoch time (also known as 'unix time') is defined as the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), Thursday, 1 January 1970.

7.3.4.1.11.4 IfIndex

The ifIndex of the OFDM Downstream Channel

7.3.4.1.11.5 Unique CCAP ID

A unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN). Value is a null terminated string

7.3.4.1.11.6 RPD ID

In cases where the channel being tested is instantiated on the RPD, this field will be the unique RPD identifier. In the case where the channel has been instantiated on an integrated CCAP, this field is left as the default 0.

7.3.4.1.11.7 RPD Port Number

In cases where the channel being tested is instantiated on the RPD, this field will be the RPD downstream port number. In the case where the channel has been instantiated on an integrated CCAP, this field is left as the default 0.

7.3.4.1.11.8 Subcarrier zero Frequency in Hz

The center frequency of subcarrier zero of the OFDM channel.

7.3.4.1.11.9 Subcarrier Spacing in kHz

This element represents the subcarrier spacing in kHz.

7.3.4.1.11.10 FirstActiveSubcarrierIndex

This element is a copy of the FirstActiveSubcarrier attribute.

7.3.4.1.11.11 LastActiveSubcarrierIndex

This element is a copy of the LastActiveSubcarrier attribute.

7.3.4.1.11.12 TriggerGroup ID

This element is a copy of the TriggerGroupId attribute.

7.3.4.1.11.13 Transaction ID

This element is a copy of the TransactionId attribute.

7.3.4.1.11.14 Length (in bytes) of Captured Data

This element indicates the size of the complexData which follows.

7.3.4.1.11.15 Capture Data

This element refers to the complexData values of the CMTS Symbol Capture. The data is expressed in s2.13 fixed point notation. Note: the average power of a given QAM constellation (not including pilots) = 1[PHYv4.0].

7.3.4.1.11.16 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

7.3.4.2 DsOfdmNoisePowerRatio

Downstream OFDM Noise Power Ratio is a PNM Test described in [PHYv3.1] Downstream Noise Power Ratio (NPR) Measurement section. The DsOfdmNoisePowerRatio object defines the management interface for the operator to configure and execute the Downstream OFDM Noise Power Ratio test.

The purpose of downstream NPR measurement is to view the noise, interference and intermodulation products underlying a portion of the OFDM signal. As an out-of-service test, the CCAP can define an exclusion band of zero-valued subcarriers which forms a spectral notch in the downstream OFDM signal for all profiles of a given downstream channel. The CM provides its normal spectral capture measurements per [PHYv4.0], or symbol capture per [PHYv4.0], which permit analysis of the notch depth. A possible use case is to observe LTE interference occurring within an OFDM band; another is to observe intermodulation products resulting from signal-level alignment issues. Since the introduction and removal of a notch affects all profiles, causing possible link downtime, this feature is intended for infrequent maintenance.

The CCAP MUST create a row in the DsOfdmNoisePowerRatio table for each IfIndex of a downstream channel.

The CCAP MAY support simultaneous Downstream NPR Measurement tests on more than one OFDM channel at a time.

Table 450 - DsOfdmNoisePowerRatio Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	
StartSubcarrier	UnsignedShort	R/W	0..8191	N/A	
StopSubcarrier	UnsignedShort	R/W	0..8191	N/A	
Enable	Boolean	R/W	N/A	N/A	False

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Duration	UnsignedShort	R/W	N/A	seconds	600

7.3.4.2.1 IfIndex

This attribute is the interface index of an OFDM Downstream Channel and is a key to provide an index into the table.

7.3.4.2.2 StartSubcarrier

This attribute is Subcarrier index corresponding to the frequency at the start of the spectral notch.

7.3.4.2.3 StopSubcarrier

This attribute is Subcarrier index corresponding to the frequency at the upper end of the spectral notch.

7.3.4.2.4 Enable

This attribute is used to enable the CCAP to create the spectral notch. The CCAP MAY require the interface to have an ifAdminStatus of 'down' before allowing the Enable value to be successfully set to 'true' for this test.

If the CCAP is unable to create the excluded subcarrier notch while executing a Downstream OFDM Noise Power Ratio test, it MUST reject the test and respond with a failure notification.

The CCAP MUST set the value of DsOfdmNoisePowerRatio::Enable to 'false' when the Downstream OFDM Noise Power Ratio operation is complete.

7.3.4.2.5 Duration

This attribute indicates the length of time in seconds that the spectral notch is to be maintained. The CCAP MAY make the excluded subcarriers active after the expiration of the Duration attribute. There is no expectation that CCAP will re-activate the excluded subcarriers immediately after the expiration of the timer. It is recommended that the CCAP use the OCD message to create the spectral notch. The CCAP MUST only allow the value of DsOfdmNoisePowerRatio::Duration to be changed while the value of DsOfdmNoisePowerRatio::Enable is 'false'.

7.3.5 PNM Upstream Information Model

There are a number of upstream Proactive Network Maintenance tests that are conducted on the CCAP. The related objects are defined in this section.

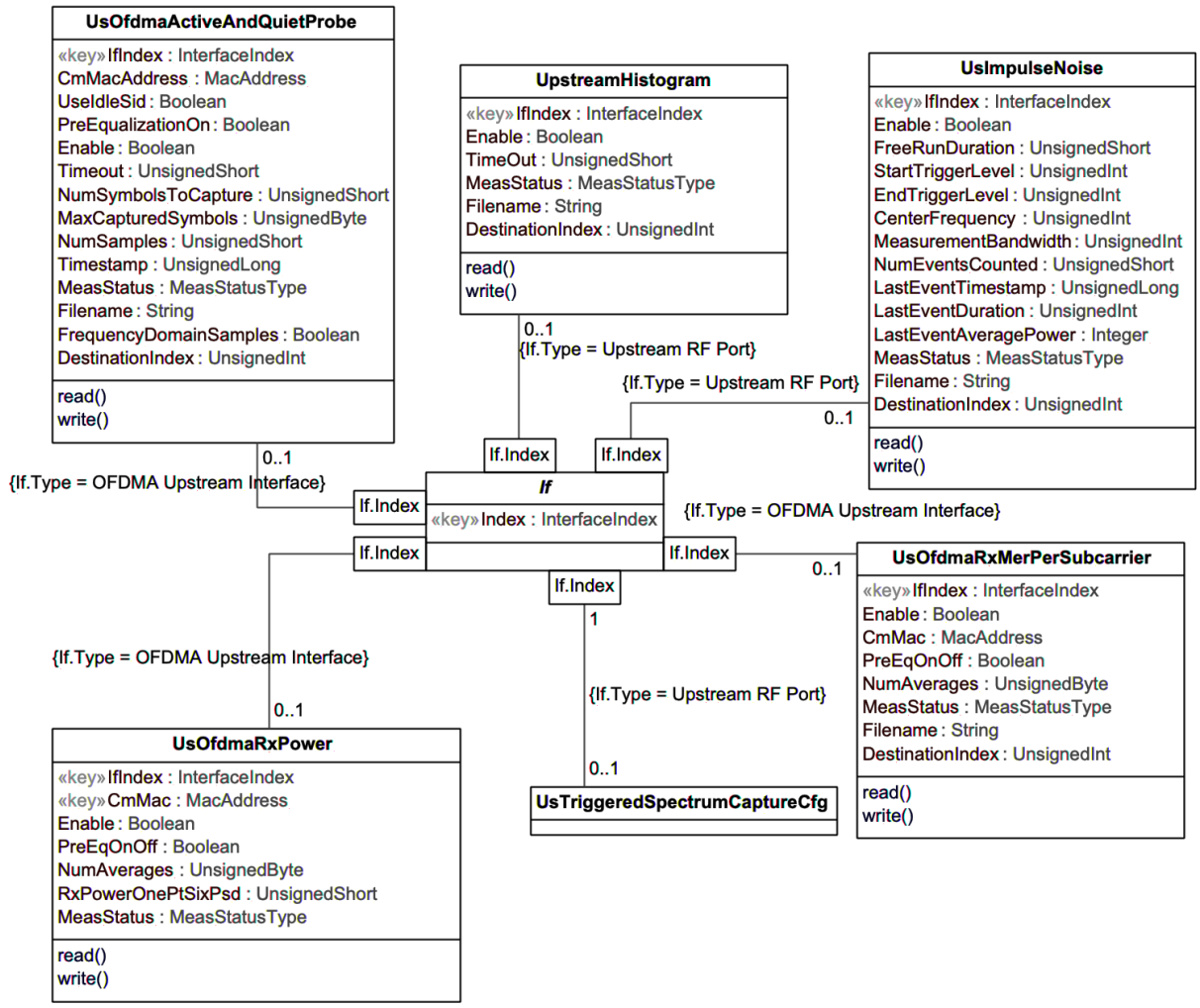


Figure 76 - PNM Upstream Information Model

7.3.5.1 UsOfdmaActiveAndQuietProbe

Upstream OFDMA Active and Quiet Probe is a PNM Test described in [PHYv3.1] Upstream Capture for Active and Quiet Probe section. The UsOfdmaActiveAndQuietProbe object defines the management interface for the operator to configure, execute, and monitor the Upstream OFDMA Active and Quiet Probe test.

The purpose of upstream capture is to measure plant response and view the underlying noise floor, by capturing at least one OFDMA symbol during a scheduled active or quiet probe. An active probe provides the partial functionality of a network analyzer, since the input is known and the output is captured. This permits full characterization of the linear and nonlinear response of the upstream cable plant. A quiet probe provides an opportunity to view the underlying noise and ingress while no traffic is being transmitted in the OFDMA band being measured.

The PNM server selects an active CM to analyze by specifying its MAC address or requests a quiet probe measurement. When enabled to perform the capture, the CCAP selects a specified transmitting CM, or quiet period when no CMs are transmitting, for the capture. The CCAP sets up the capture as described in [MULPIv4.0], selecting either an active SID corresponding to the specified MAC address or the idle SID, and defining an active or quiet probe. The active probe symbol for this capture normally includes all non-excluded subcarriers across the upstream OFDMA channel, with pre-equalization on or off as specified in the MIB. The quiet probe symbol normally includes all subcarriers, that is, during the quiet probe time there are no transmissions in the given

upstream OFDMA channel. For the quiet probe, the CCAP captures samples of at least one full OFDMA symbol including the guard interval. The CCAP begins the capture with the first symbol of the specified probe. The sample rate is the FFT sample rate (102.4 Msps).

The CCAP reports the list of excluded subcarriers, the cyclic prefix length, and the transmit window rolloff period in order to fully define the transmitted waveform. The CCAP also reports the index of the starting sample used by the receiver for its FFT. For possible comparison with other events, the CCAP reports the timestamp corresponding to the beginning of the probe. In the case where the P-MAPs for the OFDMA upstream being analyzed are being sent in an OFDM downstream, the timestamp reported is the extended timestamp, while in a case with OFDMA upstream channels but no OFDM downstream channels, the reported timestamp is the D3.0 timestamp. For an active probe, the CCAP reports the contents of the Probe Information Element (P-IE) message describing that probe.

The CCAP MUST create a row in the CmtsUsOfdmaActiveAndQuietProbe table for each IfIndex of an upstream channel.

The CCAP MAY support simultaneous Upstream Capture for Active and Quiet Probe tests on more than one OFDMA channel at a time.

The CCAP MUST reject configuring a value for the DestinationIndex of the UsOfdmaActiveAndQuietProbe object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 451 - UsOfdmaActiveAndQuietProbe Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
CmMacAddress	MacAddress	R/W	N/A	N/A	0x000000000000
UseIdleSid	Boolean	R/W	N/A	N/A	False
PreEqualizationOn	Boolean	R/W	N/A	N/A	True
Enable	Boolean	R/W	N/A	N/A	False
Timeout	UnsignedShort	R/W	N/A	Seconds	1800
NumSymbolsToCapture	UnsignedShort	R/W	N/A	Symbols	1
MaxCapturedSymbols	UnsignedShort	R/O	N/A	Symbols	N/A
NumSamples	UnsignedShort	R/O	N/A	Samples	N/A
Timestamp	UnsignedLong	R/O	N/A	N/A	N/A
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A
Filename	String	R/W	N/A	N/A	""
FrequencyDomainSamples	Boolean	R/W	N/A	N/A	True
DestinationIndex	UnsignedInt	R/W	N/A	N/A	

7.3.5.1.1 IfIndex

This attribute is the interface index of an OFDMA upstream channel and is a key to provide an index into the table.

7.3.5.1.2 CmMacAddress

This attribute represents the MAC address of the CM transmitting the probe to be measured.

7.3.5.1.3 UseIdleSid

This attribute when enabled causes the CCAP to measure the channel during a quiet period when no CM is transmitting.

7.3.5.1.4 PreEqualizationOn

This attribute when enabled causes the CCAP to enable pre-equalization in the Probe Information Element for the CM transmitting the probe to be measured.

7.3.5.1.5 Enable

When set to 'true', this attribute causes the CCAP to begin a test of a probe for the CM whose MAC address is specified in the CmMacAddress attribute or for a quiet period if the UseIdleSid attribute is enabled. The Enable attribute is set to 'false' internally by the CCAP when the test has been completed, if the Timeout value has expired, of if the CCAP encounters a test failure. If the value of Enable is 'true' the CCAP is actively measuring the I/Q values of the probe under the specified PNM test, and under this condition if Enable is set to 'false', the CCAP will abort the test.

7.3.5.1.6 Timeout

This attribute provides a timeout for the measurement if the CCAP is unable to perform the measurement for some reason. A value of zero for the Timeout attribute means that the measurement continues to be active until the measurement is complete or until the Enable attribute is cleared.

7.3.5.1.7 NumSymbolsToCapture

This attribute represents the number of symbols the CCAP is to capture for the modem whose probe is being measured or the number of symbol times to measure for the idle Sid.

7.3.5.1.8 MaxCapturedSymbols

This attribute represents the number of symbols the CCAP can capture for one measurement and is reported based on the channel's configuration. Typically, for 50 kHz Subcarrier Spacing, the CCAP can capture two symbols, and for 25 kHz, the CCAP can capture one symbol. In order to capture more than one symbol, the CCAP would need to schedule multiple probe opportunities for the CM whose probe is being measured.

7.3.5.1.9 NumSamples

For FrequencyDomainSamples set to True, this attribute represents the number of FFT samples present in the probe capture data. This corresponds to the Encompassed Spectrum of the OFDMA channel divided by the subcarrier spacing. For FrequencyDomainSamples set to False, this attribute represents the number of time-domain input samples (i.e. prior to the FFT engine) present in the probe capture data and includes the cyclic prefix, if configured. This is calculated as the sample rate (102.4 E6) divided by the subcarrier spacing plus the number of samples for the cyclic prefix (if enabled for the measurement). See [PHYv3.1]. For example, with 50 kHz subcarrier spacing this is 2048 samples plus 640 samples for the cyclic prefix (assuming the cyclic prefix is configured for 6.25 µs).

7.3.5.1.10 Timestamp

This attribute represents the timestamp corresponding to the time when measurement was performed. In the case in which the Primary Downstream is an OFDM channel this is the 64-bit timestamp. In the case in which the Primary Downstream is an SC-QAM channel this is the 32-bit timestamp. If the 32-bit timestamp is used, the 32 most significant bits of the timestamp are set to zero.

7.3.5.1.11 MeasStatus

This attribute is used to determine the status of the command. When the Status = SampleReady, the CCAP has completed the measurement and the Enable attribute has been cleared.

7.3.5.1.12 Filename

This attribute is the name of the file with the captured probe data at the CCAP that is to be downloaded using TFTP to the PNM server.

This value can only be changed while a test is not in progress. An attempt to set this value while the value of 'MeasStatus' is 'busy' will return 'inconsistentValue'.

If the value of this attribute is the empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and

will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and the ifIndex of the interface on which the test runs. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapAQProbe_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example: PNMCcapAQProbe _ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

The data file is composed of a header plus the Probe Capture Data. The header is composed of ordered fixed-length fields. Unless otherwise specified, the header fields contain hex values that are right-justified within the field. If necessary, the field is left-padded with zero values.

Syntax of the file is as follows:

Table 452 - Active and Quiet Probe File Format

Element	Size
File type (value = 504E4E66)	4 bytes
Major Version (value = 3)	1 byte
Minor Version (value = 0)	1 byte
Capture Time	4 bytes
IfIndex	4 bytes
Unique CCAP ID	256 bytes
RPD ID	6 bytes
RPD Port Number	1 byte
CM MAC Address	6 bytes
Subcarrier zero frequency in Hz	4 bytes
Subcarrier Spacing in kHz	1 byte
Length in bytes of the Excluded Subcarrier Data	4 bytes
Excluded Subcarrier Data	ExclSubCarrierType
Length in bytes of the Probe Capture Data	4 bytes
PreEq On or Off	1 byte
Length	2 bytes
Rolloff	1 byte
FirstSampleIndex	2 bytes
FrequencyDomainSamples	1 byte
Probe Information Element (P-IE)	4 bytes
Timestamp	8 bytes
Probe Capture Data	ComplexData

7.3.5.1.12.1 Major Version

The current file header version assigned the “value”. The version is incremented by one when the file header format is modified by specification. The file header changes causing the major version updates are listed below:

1 to 2: Replacement of CyclicPrefixLength field with Length field

2 to 3: Addition of RPD Port Number field

7.3.5.1.12.2 Minor Version

The vendor-specified version information. The default value is zero if no vendor version is assigned.

7.3.5.1.12.3 Capture Time

The epoch time (also known as 'unix time') is defined as the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), Thursday, 1 January 1970.

7.3.5.1.12.4 IfIndex

The ifIndex of the OFDMA upstream channel.

7.3.5.1.12.5 Unique CCAP ID

A unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN). Value is a null terminated string.

7.3.5.1.12.6 RPD ID

In cases where the channel being tested is instantiated on the RPD, this field will be the unique RPD identifier. In the case where the OFDMA channel has been instantiated on an integrated CCAP, this field is left as the default 00:00:00:00:00.

7.3.5.1.12.7 RPD Port Number

In cases where the channel being tested is instantiated on the RPD, this field will be the RPD upstream port number. In the case where the OFDMA channel has been instantiated on an integrated CCAP, this field is left as the default 0.

7.3.5.1.12.8 CM MAC Address

This attribute identifies the CM MAC address.

7.3.5.1.12.9 Subcarrier zero frequency in Hz

The center frequency of subcarrier zero of the OFDM channel.

7.3.5.1.12.10 Subcarrier spacing in kHz

This element represents the subcarrier spacing for the OFDM channel.

7.3.5.1.12.11 Length in bytes of the Excluded Subcarrier Data

This element represents the length of the excluded subcarrier data which follows.

7.3.5.1.12.12 Excluded Subcarrier Data

This element contains the excluded subcarrier data as ExclSubCarType.

7.3.5.1.12.13 Length in bytes of the Probe Capture Data

This element represents the length of the probe capture data which follows.

7.3.5.1.12.14 PreEq On or Off

This file header attribute indicates if the test was conducted with pre-equalization enabled or disabled. It is included in the header of the file to fully define the transmitted waveform.

7.3.5.1.12.15 CyclicPrefixLength

This attribute provides the currently configured cyclic prefix length configured for this OFDMA channel. It is included in the header of the file to fully define the transmitted waveform.

7.3.5.1.12.16 Rolloff

This attribute provides the currently configured rolloff period configured for this OFDMA channel. It is included in the header of the file to fully define the transmitted waveform.

7.3.5.1.12.17 FirstSampleIndex

This attribute represents the first active subcarrier used in the probe capture.

7.3.5.1.12.18 FrequencyDomainSamples

This attribute indicates if the output samples are to be in the time domain or in the frequency domain. True means the samples are in the frequency domain. False means they are in the time domain.

7.3.5.1.12.19 Probe Information Element (P-IE)

This attribute is a copy of the Probe Information Element (P-IE) sent in the P-MAP describing the Active or Quiet Probe that was captured.

7.3.5.1.12.20 Timestamp

This attribute is a copy of the Timestamp corresponding to the time when the Active or Quiet Probe was captured. If the Downstream Channel used for the P-MAP is an OFDM channel, then the Timestamp will be the 64-bit Extended Timestamp. If the Downstream Channel used for the P-MAP is an SC-QAM channel, then the Timestamp will be the 32-bit DOCSIS Timestamp and the 32 Most Significant Bits are set to zero.

7.3.5.1.12.21 Probe Capture Data

This element refers to the I/Q values of the Probe Capture Data. The data is expressed in as 16-bit signed values in s.15 notation.

7.3.5.1.13 FrequencyDomainSamples

This Boolean attribute configures the collection of output samples in the time domain or in the frequency domain. True means the samples are in the frequency domain. False means they are in the time domain.

7.3.5.1.14 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

7.3.5.2 UsImpulseNoise

Upstream Impulse Noise is a PNM Test described in [PHYv3.1] Upstream Impulse Noise Statistics section. Additional information is available in [CM-GL-PNM-3.1] Upstream Impulse Noise Statistics section. The UsImpulseNoise object defines the management interface for the operator to configure, execute, and monitor the Upstream Impulse Noise test.

The UsImpulseNoise object provides statistics of burst/impulse noise occurring in a selected narrow band. A bandpass filter is positioned in an unoccupied upstream band. A threshold is set, energy exceeding the threshold triggers the measurement of an event, and energy falling below the threshold ends the event. An optional feature allows the threshold to be set to zero, in which case the average power in the band will be measured. The measurement is time-stamped using the DOCSIS 3.0 field of the 64-bit extended timestamp (bits 9-40, where bit 0 is the LSB), which provides a resolution of 98 ns and a range of 7 minutes.

The CCAP provides the capability to capture the following statistics in a selected band up to 5.12 MHz wide:

- Timestamp of event

- Duration of event
- Average power of event

The CCAP provides a time history buffer of up to 1024 events. In steady state operation, a ring buffer provides the measurements of the last 1024 events that occurred while the measurement was enabled.

The CCAP MUST create an instance of the UsImpulseNoise object for each IfIndex of an upstream RF Port.

The CCAP MAY support simultaneous instances of the Measure Upstream Impulse Noise test on more than one RF port at a time.

Initiation and termination of impulse noise samples collection is controlled by configured values for UsImpulseNoise object attributes FreeRunDuration, StartTriggerLevel, and EndTriggerLevel.

The CCAP MUST collect Upstream Impulse Noise samples when UsImpulseNoise::Enable is set to 'true' and FreeRunDuration is configured for a nonzero value, regardless of the values configured for StartTriggerLevel and EndTriggerLevel. The CCAP MUST stop collecting Upstream Impulse Noise samples and terminate the Upstream Impulse Noise test when the time corresponding to the value of FreeRunDuration expires.

If the configured value of FreeRunDuration is nonzero, the CCAP will capture at most one impulse noise event.

The CCAP MUST collect Upstream Impulse Noise samples when UsImpulseNoise::Enable is set to 'true', FreeRunDuration is configured with zero, StartTriggerLevel is configured with a nonzero value, and the burst noise on the upstream RF port exceeds the value configured for StartTriggerLevel. The CCAP MUST stop collection of Upstream Impulse Noise samples for a burst noise event when FreeRunDuration is configured with zero, StartTriggerLevel and EndTriggerLevel are configured with a nonzero value, and the burst noise on the upstream RF port falls below the configured value for EndTriggerLevel.

If the configured value of FreeRunDuration is zero, the configured value of StartTriggerLevel is nonzero, and the configured value of EndTriggerLevel is nonzero, the CCAP could capture multiple burst noise events before the sample capture is terminated when UsImpulseNoise::Enable is set to 'false'.

If the configured values of FreeRunDuration and EndTriggerLevel are zero and the configured value of StartTriggerLevel is nonzero, the CCAP will capture at most one impulse noise event before the sample capture is terminated when UsImpulseNoise::Enable is set to 'false'.

The CCAP MUST measure average power in the band when UsImpulseNoise::Enable is set to 'true' and configured values for FreeRunDuration and StartTriggerLevel are zero, and the configured value for EndTriggerLevel is zero or nonzero. The average power in the band will be measured until sample collection is terminated when UsImpulseNoise::Enable is set to 'false'.

Upstream Impulse Noise test sample collection initiation and termination conditions described above are summarized in Table 448.

Table 453 - Upstream Impulse Noise Sample Collection Control Configuration Attributes

FreeRunDuration	StartTriggerLevel	EndTriggerLevel	CCAP Sample Collection
Nonzero	Zero or nonzero	Zero or nonzero	Sample collection begins when the UsImpulseNoise::Enable attribute is set to 'true'. Sample collection ends and the test terminates when the time equal to the value of FreeRunDuration expires. StartTriggerLevel and EndTriggerLevel are ignored. Sample collection occurs for one event and NumEventsCounted will be reported as 1 unless the test is aborted. If sample collection is terminated by the UsImpulseNoise::Enable attribute being set to 'false' before FreeRunDuration time expires, NumEventsCounted will be reported as 0 and no results will be returned.

FreeRunDuration	StartTriggerLevel	EndTriggerLevel	CCAP Sample Collection
Zero	Nonzero	Nonzero	Sample collection for an individual burst event begins when UsImpulseNoise::Enable attribute is set to 'true' and the burst noise on the upstream RF port exceeds the value configured for StartTriggerLevel. Sample collection ends for an individual burst event when the burst noise on the upstream RF port falls below the value configured for EndTriggerLevel. Sample collection may occur for multiple burst events. The test terminates when the UsImpulseNoise::Enable attribute is set to 'false'.
Zero	Nonzero	Zero	Sample collection begins when the UsImpulseNoise::Enable attribute is set to 'true' and the burst noise on the upstream RF port exceeds the value configured for StartTriggerLevel. Sample collection ends and the test terminates when the UsImpulseNoise::Enable attribute is set to 'false'. At most a single impulse noise event will be recorded.
Zero	Zero	Zero or nonzero	Sample collection begins when UsImpulseNoise::Enable attribute is set to 'true'. The average power in the band will be measured until sample collection is terminated when the UsImpulseNoise::Enable attribute is set to 'false'. A single event will be recorded.

The CCAP MUST reject configuring a value for the DestinationIndex of the UsImpulseNoise object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 454 - UsImpulseNoise Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
Enable	Boolean	R/W	N/A	N/A	False
FreeRunDuration	UnsignedShort	R/W	N/A	seconds	60
StartTriggerLevel	UnsignedInt	R/W	N/A	microvolts	300uV
EndTriggerLevel	UnsignedInt	R/W	N/A	microvolts	150uV
CenterFrequency	UnsignedInt	R/W	N/A	Hz	7000000
MeasurementBandwidth	UnsignedInt	R/W	160 | 320 | 640 | 1280 | 2560 | 5120	kHz	2560
NumEventsCounted	UnsignedShort	R/O	N/A	N/A	N/A
LastEventTimestamp	UnsignedLong	R/O	N/A	N/A	N/A
LastEventDuration	UnsignedInt	R/O	N/A	nanoseconds	N/A
LastEventAveragePower	Short	R/O	N/A	dBmV	N/A
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A
Filename	String	R/W	N/A	N/A	""
DestinationIndex	UnsignedInt	R/W	N/A	N/A	

7.3.5.2.1 IfIndex

This attribute is the interface index of the upstream RF port and is a key to provide an index into the table.

7.3.5.2.2 Enable

This attribute causes the CCAP to begin the collection of the configured Impulse Noise events. If the FreeRunDuration is set to a value greater than zero, the StartTriggerLevel is ignored and measurement of the signal power at the RF port begins when the Enable is set to true. The Enable attribute is cleared internally if FreeRunDuration has expired. If the FreeRunDuration is equal to zero and the Enable attribute is set to true, clearing

the Enable causes the CCAP to stop the capture and generate the file of impulse noise data. If the NumEventsCounted is zero when the Enable is cleared, no file will be created.

7.3.5.2.3 FreeRunDuration

This attribute, when configured with a nonzero value, provides length of time to perform the Upstream Impulse Noise measurement when the Enable attribute is set to true.

7.3.5.2.4 StartTriggerLevel

This attribute, when configured with a nonzero value, is the burst noise threshold which, when exceeded after the Enable attribute is set to 'true' and FreeRunDuration is configured with value zero, starts the Impulse Noise measurement. If the value of UsImpulseNoise::Enable is set to 'true' with a nonzero value configured for StartTriggerLevel and a zero value configured for FreeRunDuration, an individual burst event starts when the burst noise exceeds the StartTriggerLevel.

7.3.5.2.5 EndTriggerLevel

This attribute, when configured with a nonzero value, is the lower burst noise threshold for the Upstream Impulse Noise measurement which terminates the measurement after it is started. The Measurement of an individual burst event ends when the burst noise falls below the EndTriggerLevel. If the EndTriggerLevel and the FreeRunDuration are both set to zero and StartTriggerLevel is configured with a nonzero value, at most a single Impulse Noise Event will be recorded when triggered by a burst event exceeding the StartTriggerLevel.

7.3.5.2.6 CenterFrequency

This attribute defines the center frequency for the noise power measurement.

7.3.5.2.7 MeasurementBandwidth

This attribute defines the bandwidth for the noise power measurement. The MeasurementBandwidth is the -3 dB bandwidth; the occupied bandwidth is typically 1.25 times the measurement bandwidth.

7.3.5.2.8 NumEventsCounted

This attribute is used to indicate how many impulse noise events have been recorded since the Enable was set to true. This value will be 1024 in steady state, after the ring buffer has filled with measurements. If the StartTriggerLevel is set to zero, then the NumEventsCounted will be set to 1 when the FreeRunDuration has expired and the Enable has been internally cleared.

7.3.5.2.9 LastEventTimestamp

This attribute provides represents the timestamp corresponding to the start of the last recorded event. The measurement is time-stamped using the 64-bit extended timestamp. If the CMTS is not using the 64-bit Extended Timestamp, then the 8-byte value is constructed from the 32-bit DOCSIS 3.0 Timestamp as follows:

Bits 63 through 41 = 0

Bits 40 through 9 = 32-bit DOCSIS 3.0 Timestamp

Bits 8 through 0 = 0

7.3.5.2.10 LastEventDuration

This attribute provides represents the time corresponding to the duration of the last recorded event. The EventDuration is expressed in ns.

7.3.5.2.11 LastEventAveragePower

This attribute represents the average power measured during the last recorded event. The LastEventAveragePower is expressed in units of dBmV with 16-bit fixed point, fractional, two's complement notation encoded using the S6.9 format.

7.3.5.2.12 MeasStatus

This attribute is used to determine the status of the command. When the Status is sampleReady, the CCAP has completed the measurement and the Enable attribute has been cleared. If the StartTriggerLevel is set to a non-zero value and the Enable attribute is set to true, then collection of Impulse Noise events is in progress and the MeasStatus attribute will return a value of 'busy'. If the Enable attribute is cleared while collection of Impulse Noise events is active, the MeasStatus attribute will be set to 'sampleReady'.

7.3.5.2.13 Filename

This attribute is the name of the file with the captured impulse noise data at the CCAP that is to be downloaded using TFTP to the PNM server.

This value can only be changed while a test is not in progress. An attempt to set this value while the value of 'MeasStatus' is 'busy' will return 'inconsistentValue'.

If the value of this attribute is an empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and ifIndex of the interface on which the test runs.. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapImpNoise_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example: PNMCcapImpNoise _ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

The data file is created when the Enable is cleared by the PNM server. If the NumEventsCounted attribute is zero when the Enable is cleared, then no file will be created by the CCAP. The data file is composed of a header plus the Probe Capture Data. The header is composed of ordered fixed-length fields. Unless otherwise specified, the header fields contain hex values that are right-justified within the field. If necessary, the field is left-padded with zero values.

Syntax of the file is as follows:

Table 455 - Impulse Noise File Format

Element	Size
File type (value = 504E4E67)	4 bytes
Major Version (value = 2)	1 byte
Minor Version (value = 0)	1 byte
Capture Time	4 bytes
IfIndex	4 bytes
Unique CCAP ID	256 bytes
RPD ID	6 bytes
RPD Port Number	1 byte
Start Trigger Level	4 bytes
End Trigger Level	4 bytes

Element	Size
Number of Events Being Reported (NumEventsCounted)	4 bytes
Length (in bytes) of Impulse Event Data	4 bytes
Impulse Noise Capture Data	(NumEventsCounted) * 14

7.3.5.2.13.1 Major Version

The current file header version assigned the “value”. The version is incremented by one when the file header format is modified by specification. The file header change causing the major version to increment from 1 to 2 is the addition of RPD ID and RPD Port Number fields.

7.3.5.2.13.2 Minor Version

The vendor-specified version information. The default value is zero if no vendor version is assigned.

7.3.5.2.13.3 Capture Time

The epoch time (also known as 'unix time') is defined as the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), Thursday, 1 January 1970.

7.3.5.2.13.4 IfIndex

The ifIndex of the Upstream RF Port.

7.3.5.2.13.5 Unique CCAP ID

A unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN). Value is a null terminated string.

7.3.5.2.13.6 RPD ID

In cases where the channel being tested is instantiated on the RPD, this field will be the unique RPD identifier. In the case where the channel has been instantiated on an integrated CCAP, this field is left as the default 00:00:00:00:00.

7.3.5.2.13.7 RPD Port Number

In cases where the channel being tested is instantiated on the RPD, this field will be the RPD upstream port number. In the case where the channel has been instantiated on an integrated CCAP, this field is left as the default 0.

7.3.5.2.13.8 Start Trigger Level

This element is a copy of the StartTriggerLevel attribute.

7.3.5.2.13.9 End Trigger Level

This element is a copy of the EndTriggerLevel attribute.

7.3.5.2.13.10 Number of Events Being Reported

This element is a copy of the NumEventsCounted attribute.

7.3.5.2.13.11 Length in bytes of the Impulse Event Data

This element represents the length of the impulse event data which follows. The length is equal to NumEventsCounted * 14.

7.3.5.2.13.12 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

7.3.5.3 UpstreamHistogram

Upstream Histogram is a PNM Test described in [PHYv3.1]Upstream Histogram section. The UpstreamHistogram object defines the management interface for the operator to configure, execute, and monitor the Upstream Histogram test.

The Upstream Histogram provides a measurement of nonlinear effects in the channel such as amplifier compression and laser clipping. For example, laser clipping causes one tail of the histogram to be truncated and replaced with a spike. When the UpstreamHistogram Enable attribute is set to 'true', the CCAP will begin capturing the histogram of time domain samples at the wideband front end of the receiver (full upstream band). The histogram is two-sided; that is, it encompasses values from far-negative to far-positive values of the samples. The histogram will have a minimum of 255 or 256 equally spaced bins. These bins typically correspond to the 8 MSBs of the wideband analog-to-digital converter (ADC) for the case of 255 or 256 bins. The histogram dwell count, a 32-bit unsigned integer, is the number of samples observed while counting hits for a given bin and may have the same value for all bins. The histogram hit count, a 32-bit unsigned integer, is the number of samples falling in a given bin. The CCAP will report the dwell count per bin and the hit count per bin. When enabled, the CCAP will compute a histogram with a dwell of at least 10 million samples at each bin in 30 seconds or less. The CCAP will continue accumulating histogram samples until it is restarted, disabled or times out. If the highest dwell count approaches its 32-bit overflow value, the CCAP will save the current set of histogram values and reset the histogram, so that in a steady-state condition a complete measurement is always available.

The CCAP MUST create an instance of the UpstreamHistogram object for each IfIndex of an upstream RF port. The CCAP MAY support simultaneous Upstream Histogram tests on more than one RF port at a time.

The CCAP MUST reject configuring a value for the DestinationIndex of the UpstreamHistogram object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 456 - UpstreamHistogram Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
Enable	Boolean	R/W	N/A	N/A	False
Timeout	UnsignedShort	R/W	N/A	Seconds	1800
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A
Filename	AdminString	R/W	SIZE (0..255)	N/A	""
DestinationIndex	UnsignedInt	R/W	N/A	N/A	

7.3.5.3.1 IfIndex

This attribute is the interface index of an upstream RF Port and is a key to provide an index into the table.

7.3.5.3.2 Enable

Setting this attribute to a value of 'true' instructs the CCAP to begin collection of histogram data and when enabled, the CCAP continues producing new data at its own rate.

This value is only allowed to be set to 'true' if the value of 'MeasStatus' is a value other than 'busy'. Setting this value to 'true' will change the value of the 'MeasStatus' attribute to 'busy'.

Setting this attribute to a value of 'false' instructs the CCAP to stop the collection of histogram data and to generate the file.

This attribute returns 'true' if the CCAP is actively collecting histogram data. Otherwise it returns 'false'.

A restart may be accomplished by setting this attribute to 'false' and then back to 'true'.

7.3.5.3.3 Timeout

This attribute sets a seconds time-out timer for capturing histogram data. This attribute is used to automatically clear the Enable attribute when the timeout expires. If the value of Timeout is zero, the CCAP MUST collect data until the timeout value is changed, the test is stopped, or until any dwell counter reaches its 32-bit rollover value. When the dwell count reaches its 32-bit maximum, the CCAP MUST end the test and report counts accumulated to that point. If the Timeout attribute is re-written while Enable is 'true', the CCAP MUST restart the timeout timer with the new Timeout value and continue collecting data.

When the timeout expires, the 'Enable' object will be set to 'false' and the capture will stop. When this happens, the data collected up to this point will be saved in the file defined by the 'FileName', and the value of 'MeasStatus' will be set to 'sampleReady'.

Setting this value does not start a capture. Captures can only be started by setting the 'Enable' attribute.

If this attribute is written while the 'Enable' attribute is 'true', the timer is restarted.

This object returns the value with which it was last set.

7.3.5.3.4 MeasStatus

This attribute is used to determine the status of the command. When the Status is 'sampleReady', the CCAP is ready for the Histogram data to be read.

7.3.5.3.5 Filename

This attribute is the name of the file at the CCAP which is to be transferred to the PNM server. The data is stored as 32-bit integers for the hit and dwell count values.

This value can only be changed while a test is not in progress. An attempt to set this value while the value of MeasStatus is 'busy' will return 'inconsistentValue'.

If the value of this attribute is an empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and the ifIndex of the interface on which the test runs. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapHist_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example: PNMCcapHist_ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

The data file is composed of a header plus the Histogram Data. The header is composed of ordered fixed-length fields. Unless otherwise specified, the header fields contain hex values that are right-justified within the field. If necessary, the field is left-padded with zero values.

Syntax of the file is as follows:

Table 457 - Upstream Histogram File Format

Element	Size
File type (value = 504E4E68)	4 bytes
Major Version (value = 2)	1 byte
Minor Version (value = 0)	1 byte
Capture Time	4 bytes
IfIndex	4 bytes
Unique CCAP ID	256 bytes
RPD ID	6 bytes
RPD Port Number	1 byte
Symmetry	1 byte
Length (in bytes) of Dwell Count Values	4 bytes
DwellCount values	(1-4096) * 4 bytes
Length (in bytes) of Hit Count Values	4 bytes
HitCount values	(1-4096) * 4 bytes

7.3.5.3.5.1 Major Version

The current file header version assigned the “value”. The version is incremented by one when the file header format is modified by specification. The file header change causing the major version to increment from 1 to 2 is the addition of RPD ID and RPD Port Number fields.

7.3.5.3.5.2 Minor Version

The vendor-specified version information. The default value is zero if no vendor version is assigned.

7.3.5.3.5.3 Capture Time

The time (epoch time) that the file was written. The epoch time (also known as 'unix time') is defined as the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), Thursday, 1 January 1970

7.3.5.3.5.4 IfIndex

The ifIndex of the OFDMA Upstream RF Port.

7.3.5.3.5.5 Unique CCAP ID

A unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN). The value is a null terminated string.

7.3.5.3.5.6 RPD ID

In cases where the channel being tested is instantiated on the RPD, this field will be the unique RPD identifier. In the case where the channel has been instantiated on an integrated CCAP, this field is left as the default 00:00:00:00:00.

7.3.5.3.5.7 RPD Port Number

In cases where the channel being tested is instantiated on the RPD, this field will be the RPD upstream port number. In the case where the channel has been instantiated on an integrated CCAP, this field is left as the default 0.

7.3.5.3.5.8 Symmetry

This attribute is used to indicate whether 256 or 255 bins were used for the measurement.

Even Symmetry = 'false' (default):

The histogram has even symmetry about the origin. There is no bin center lying directly at the origin; rather, two bin centers straddle the origin at 0.5. All bins with indices 0-255 contain valid hit-count data. The histogram bin centers are offset from the corresponding 8-bit two's-complement integer values by 1/2, that is, bin center = two's complement value + 0.5.

Odd Symmetry = 'true':

The histogram has odd symmetry about the origin. There is a bin center lying at the origin. The bin with index 0 is not used and returns the value 0. The bins with indices 1 to 255 contain valid hit-count data. The histogram bin centers are located on the corresponding 8-bit two's-complement integer values.

The following table shows the defined histogram bin centers for the cases of even and odd symmetry.

Table 458 - Histogram Bin Centers

Bin Index	Bin Center Even Symmetry	Bin Center Odd Symmetry
0	-127.5	not used
1	-126.5	-127
2	-125.5	-126
...	...	...
127	-0.5	-1
128	0.5	0
129	1.5	1
...	...	...
253	125.5	125
254	126.5	126
255	127.5	127

7.3.5.3.5.9 Length in bytes of Dwell Count Values

This element represents the number of Dwell Count Values which follow in the file

7.3.5.3.5.10 Dwell Count Values

This element represents the Dwell Counts for each bin for the "Current" capture. The value is a sequence of 4-byte values. If the dwell count for all bins is the same, then only a single value is reported. The value for each bin is reported as a 32-bit value

7.3.5.3.5.11 Length in bytes of Hit Count Values

This element represents the number of Hit Count Values which follow in the file

7.3.5.3.5.12 Hit Count Values

This element represents the Hit Counts for each bin for the "Current" capture. The value represents a sequence of 4-byte values. If odd symmetry is used, then there will be 255 bins. The value for each bin is reported as a 32-bit value.

7.3.5.3.5.13 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

7.3.5.4 UsOfdmaRxPower

Upstream OFDMA Receive Power is a PNM Test described in [PHYv3.1] Upstream Channel Power section. The UsOfdmaRxPower object defines the management interface for the operator to configure, execute, and monitor the Upstream OFDMA Receive Power test.

The purpose of the upstream channel power metric is to provide an estimate of the received power in a specified OFDMA channel at the F connector input of the CCAP line card for a given user. The measurement is based on upstream probes, which are typically the same probes used for pre-equalization adjustment.

The CCAP measures the total power of the probe subcarriers received from the CM.

For channels without boosted pilots, the CCAP calculates the average power per subcarrier (Paverage) and then calculates the power normalized to1.6 MHz as a) Paverage + 10 * $\log_{10}(32)$ for 50 kHz subcarrier spacing, or as b) Paverage + 10 *$\log_{10}(64)$ for 25 kHz subcarrier spacing.

NOTE: The CCAP would also use that adjusted value for comparison with the Target Receive Power for the purposes of transmit power adjustments in the RNG-RSP. For channels with boosted pilots, the CCAP calculates the average power per subcarrier (Paverage) and then calculates the power normalized to1.6 MHz as a) Paverage + 10 * $\log_{10}(32)$ + 1 dB for 50 kHz subcarrier spacing, or as b) Paverage + 10 *$\log_{10}(64)$ + 0.5 dB for 25 kHz subcarrier spacing.

The CCAP MUST create a row in the UsOfdmaRxPower table for each IfIndex of an upstream channel.

The CCAP MAY support simultaneous Upstream OFDMA Rx Power tests on more than one OFDMA channel at a time.

When executing the Measure Upstream OFDMA Receive Power test the CCAP MUST provide probe opportunities and make measurements over the number of averages configured by attribute UsOfdmaRxPower::NumAverages.

Table 459 - UsOfdmaRxPower Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
CmMac	MacAddress	Key	N/A	N/A	N/A
Enable	Boolean	R/W	N/A	N/A	False
PreEqOnOff	Boolean	R/W	N/A	N/A	True
NumAverages	UnsignedByte	R/W	N/A	N/A	1
RxPowerOnePtSixPsd	TenthdB	R/O	N/A	dB	N/A
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A

7.3.5.4.1 IfIndex

This attribute is the interface index of an OFDMA upstream channel and is a key to provide an index into the table.

7.3.5.4.2 CmMac

This attribute represents the MAC address of the CM whose Received upstream channel power is being measured.

7.3.5.4.3 Enable

When set to 'true', this attribute causes the CCAP to begin a test of the received upstream channel power for the CM whose MAC address was specified in the CmMac attribute. The Enable attribute is set to 'false' internally by the CCAP when the Upstream OFDMA Receive Power test has been completed, or if the CCAP encounters a test failure. If this attribute returns 'true', the CCAP is actively measuring the received upstream channel power under the specified PNM test, and under this condition if Enable is set to value 'false', the CCAP will abort the test.

7.3.5.4.4 PreEqOnOff

This attribute is used by the CCAP to enable or disable pre-equalization of the probe. The pre-equalization is controlled by a bit in the Probe Information Element sent in a MAP to the CM.

7.3.5.4.5 NumAverages

This attribute configures the number of measurements over which the CCAP averages Upstream OFDMA Receive Power. The average is simply the sum of the RxUsRxOfdmaPowerOnePtSix values divided by the NumAverages.

7.3.5.4.6 RxPowerOnePtSixPsd

This attribute represents the average power of the probe measured by the CCAP, reported as the Power Spectral Density in an equivalent 1.6 MHz spectrum, for the CM whose MAC address was specified in the CmMac attribute. If the NumberOfAverages attribute was greater than one, then this attribute represents the accumulated average 1.6 MHz PSD.

7.3.5.4.7 MeasStatus

This attribute is used to determine the status of the command. When the Status = SampleReady, the CCAP is ready for the Upstream Power data to be read.

7.3.5.5 UsOfdmaRxMerPerSubcarrier

Upstream OFDMA Receive MER per Subcarrier is a PNM Test described in [PHYv3.1] Upstream Receive Modulation Error Ratio (RxMER) Per Subcarrier section. The UsOfdmaRxMerPerSubcarrier object defines the management interface for the operator to configure, execute, and monitor the Upstream OFDMA Receive MER per Subcarrier test.

This item provides measurements of the upstream receive modulation error ratio (RxMER) for each subcarrier. The CCAP measures the RxMER using an upstream probe, which is not subject to symbol errors as data subcarriers would be. The probes used for RxMER measurement are typically distinct from the probes used for pre-equalization adjustment. For the purposes of this measurement, RxMER is defined as the ratio of the average power of the ideal QAM constellation to the average error-vector power. The error vector is the difference between the equalized received probe value and the known correct probe value. If some subcarriers (such as exclusion bands) cannot be measured by the CCAP, the CCAP indicates that condition in the measurement data for those subcarriers.

The CCAP MUST create a row in the UsOfdmaRxMerPerSubcarrier table for each IfIndex of an upstream channel.

The CCAP MUST reject configuring a value for the DestinationIndex of the UsOfdmaRxMerPerSubcarrier object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

The CCAP MAY support simultaneous Upstream OFDMA RxMER per Subcarrier tests on more than one OFDMA channel at a time.

The CCAP MUST be capable of selecting a specified transmitting CM for the Upstream OFDMA RxMER per Subcarrier test.

The CCAP MUST provide probe opportunities and make measurements over the number of averages specified for the Upstream OFDMA RxMER per Subcarrier test.

Table 460 - UsOfdmaRxMerPerSubcarrier Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
Enable	Boolean	R/W	N/A	N/A	False
CmMac	MacAddress	R/W	N/A	N/A	0x000000000000
PreEqOnOff	Boolean	R/W	N/A	N/A	True
NumAverages	UnsignedByte	R/W	1..255	N/A	N/A
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Filename	String	R/W	N/A	N/A	""
DestinationIndex	UnsignedInt	R/W	N/A	N/A	

7.3.5.5.1 IfIndex

This attribute is the interface index of an OFDMA upstream channel and is a key to provide an index into the table.

7.3.5.5.2 Enable

When set to 'true', this attribute causes the CCAP to begin a test of the received MER per subcarrier for the CM whose MAC address was specified in the CmMac attribute. The Enable attribute is set to 'false' internally by the CCAP when the test has been completed, or if the CCAP encounters a test failure. If this attribute returns 'true', the CCAP is actively measuring the RxMER per subcarrier under the specified PNM test, and under this condition if a value of 'false' is set, the CCAP will abort the test.

7.3.5.5.3 CmMac

This attribute represents the MAC address of the CM whose Rx MER is being measured.

7.3.5.5.4 PreEqOnOff

This attribute is used by the CCAP to enable or disable Pre-Equalization of the probe. The Pre-Equalization is controlled by a bit in the Probe Information Element sent in a MAP to the CM.

7.3.5.5.5 NumAverages

This attribute controls the number of probes the CCAP will use to calculate the Rx MER per subcarrier. The average will be computed using the "leaky integrator" method, where reported Rx MER per subcarrier value = alpha*accumulated values + (1-alpha)*current value. Alpha is one minus the reciprocal of the number of averages. For example, if N=25, then alpha = 0.96. A value of 1 indicates no averaging. Re-writing the number of averages will restart the averaging process. If there are no accumulated values, the accumulators are made equal to the first measured bin amplitudes.

7.3.5.5.6 MeasStatus

This attribute is used to determine the status of the command. When the MeasStatus = SampleReady, the CMTS is ready for the RxMER data to be read.

7.3.5.5.7 Filename

This attribute is the name of the file with the RxMER data for a specified CM at the CCAP that is to be downloaded using TFTP to the PNM server.

This value can only be changed while a test is not in progress. An attempt to set this value while the value of 'MeasStatus' is 'busy' will return 'inconsistentValue'.

If the value of this attribute is the empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and the ifIndex of the interface on which the test runs. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapRxMER_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example: PNMCcapRxMER_ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

The data file is composed of a header plus the RxMER Data. The header is composed of ordered fixed-length fields. Unless otherwise specified, the header fields contain hex values that are right-justified within the field. If necessary, the field is left-padded with zero values.

Syntax of the file is as follows:

Table 461 - RxMER File Format

Element	Size
File type (value = 504E4E69)	4 bytes
Major Version (value = 2)	1 byte
Minor Version (value = 0)	1 byte
Capture Time	4 bytes
IfIndex	4 bytes
Unique CCAP ID	256 bytes
RPD ID	6 bytes
RPD Port Number	1 byte
CM MAC Address	6 bytes
Number of averages	2 bytes
PreEq On or Off	1 byte
Subcarrier zero center frequency	4 bytes
FirstActiveSubcarrierIndex	2 bytes
Subcarrier Spacing in kHz	1 byte
Length in bytes of RxMER data	4 bytes
Subcarrier RxMER data	RxMerData

7.3.5.5.7.1 Major Version

The current file header version assigned the “value”. The version is incremented by one when the file header format is modified by specification. The file header change causing the major version to increment from 1 to 2 is the addition of RPD ID and RPD Port Number fields.

7.3.5.5.7.2 Minor Version

The vendor-specified version information. The default value is zero if no vendor version is assigned.

7.3.5.5.7.3 Capture Time

The epoch time (also known as 'unix time') is defined as the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC),Thursday, 1 January 1970.

7.3.5.5.7.4 IfIndex

The ifIndex of the OFDMA upstream channel.

7.3.5.5.7.5 Unique CCAP ID

A unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN). Value is a null terminated string.

7.3.5.5.7.6 RPD ID

In cases where the channel being tested is instantiated on the RPD, this field will be the unique RPD identifier. In the case where the OFDMA channel has been instantiated on an integrated CCAP, this field is left as the default 00:00:00:00:00.

7.3.5.5.7.7 RPD Port Number

In cases where the channel being tested is instantiated on the RPD, this field will be the RPD upstream port number. In the case where the OFDMA channel has been instantiated on an integrated CCAP, this field is left as the default 0.

7.3.5.5.7.8 CM MAC Address

This element is a copy of the CmMac attribute.

7.3.5.5.7.9 Number of averages

This element is a copy of the NumAverages attribute.

7.3.5.5.7.10 PreEq On or Off

This element is a copy of the PreEqOnOff attribute.

7.3.5.5.7.11 Subcarrier Zero Center Frequency

This element represents the center frequency of the subcarrier zero of the OFDMA channel.

7.3.5.5.7.12 FirstActiveSubcarrierIndex

This element is the subcarrier index of the lowest subcarrier in the Encompassed Spectrum of the channel.

7.3.5.5.7.13 Subcarrier Spacing in kHz

This element is the OFDMA subcarrier spacing.

7.3.5.5.7.14 Length in bytes of the RxMer data

This element represents the number of the RxMerData which follow in the file.

7.3.5.5.7.15 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

7.3.5.6 Upstream Triggered Spectrum Capture Information Model

Upstream Triggered Spectrum Capture is a PNM Test described in [PHYv3.1] Upstream Triggered Spectrum Analysis section. The objects defined in the Upstream Triggered Spectrum Capture information model define the management interface for the operator to configure, execute, control, and monitor the Upstream Triggered Spectrum Capture test.

The upstream triggered spectrum analysis measurement provides a wideband spectrum analyzer function in the CCAP which can be triggered to examine desired upstream transmissions as well as underlying noise/interference during a quiet period. Figure 77 illustrates the information model for the CCAP Upstream Triggered Spectrum Capture function. The classes and attributes shown in the model are described below.

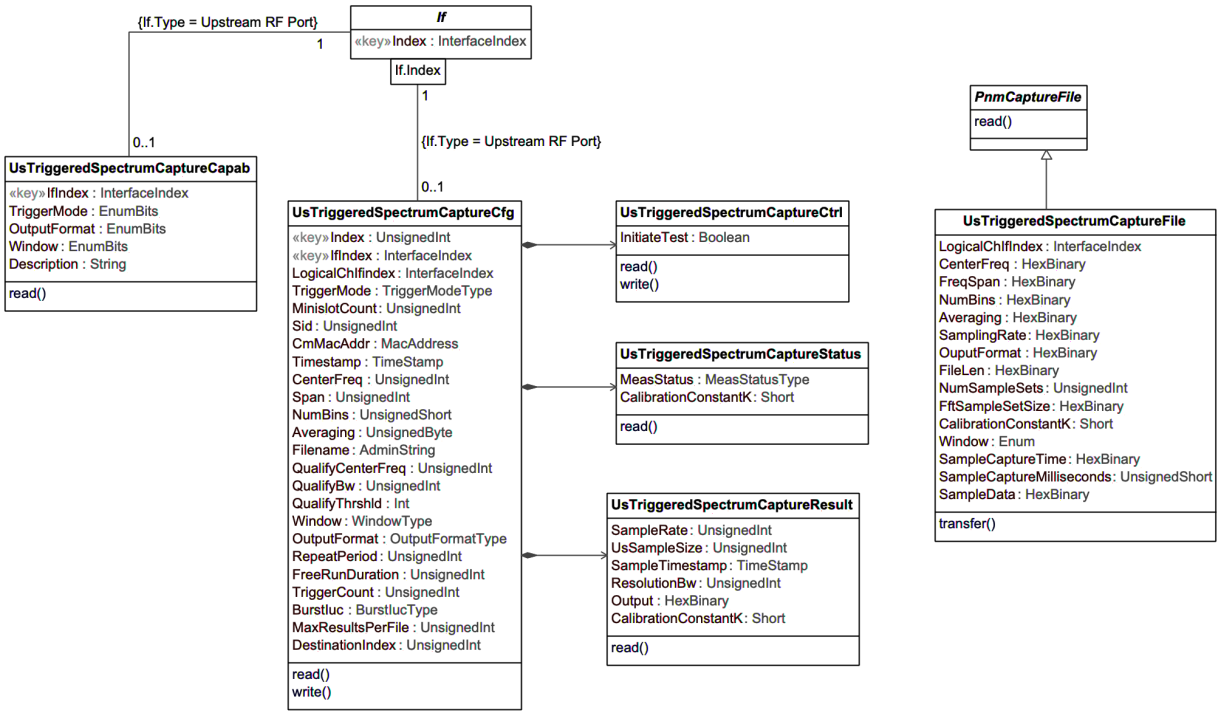


Figure 77 - Upstream Triggered Spectrum Capture Information Model

The CCAP provides wideband upstream spectrum analysis capability covering the full upstream spectrum of the cable plant. The CCAP can be made to use 100 kHz or better resolution (bin spacing) in the wideband upstream spectrum measurement.

Depending on the particular CCAP implementation, variable upstream spectrum analysis span is possible.

The CCAP is also able to provide the time-domain input samples as an alternative to the frequency-domain upstream spectrum results.

The CCAP provides the ability to trigger spectrum sample capture and perform spectrum analysis using the following modes:

- Free running
- A specified timestamp value
- Minislot Number
- A specified MAC address defining a SID, triggering at the beginning of the first minislot granted to that SID
- The idle SID, triggering at the beginning of the first minislot granted to that SID
- A specified active or quiet probe symbol, triggering at the beginning of the probe symbol

The CCAP SHOULD support creating and deleting instances of UsTriggeredSpectrumCapture. It is not required for a CCAP to support multiple simultaneous requests.

Note that upstream triggered spectrum analysis measures the power vs frequency of any input signal, including TDMA/A-TDMA, OFDMA, OOB upstream, ingress, and noise.

The Upstream Triggered Spectrum Capture function is described in four objects associated with the four fundamental functions listed below:

- Test configuration (Cfg)

- Test control (Ctrl)
- Test monitoring (Status)
- Test result reporting (Result)

The same pair of indexes are defined for the four (Cfg, Ctrl, Status and Result) Upstream Triggered Spectrum Capture objects. This links the four objects such that the same values for the pair of indexes accesses the same instance of each of the objects. Therefore, the attributes in one object indexed with Index = x and ifIndex = y correspond to the attributes in each of the other three objects indexed with Index = x and ifIndex = y. An entry created in one object with Index = x and ifIndex = y also automatically creates an entry in the other three objects with Index = x and ifIndex = y.

The CCAP is not required to retain the RF port capture configuration when the CCAP is reset.

If the CCAP supports line card failover protections, the CCAP is not required to retain the RF port capture configuration when a failover occurs.

A CCAP PNM Upstream Triggered Spectrum Capture Capabilities object is provided to allow a CCAP to advertise its US Spectrum Capture capabilities.

The Upstream Triggered Spectrum Capture feature supports eight trigger modes, and for each mode a set of attributes need to be configured to provide the CCAP with the information it needs to perform the capture. Table 457 identifies the attributes that are required to be configured for each trigger mode.

The CCAP MUST NOT initiate an Upstream Triggered Spectrum Capture test if required attributes listed in Table 462 - Attributes Required to be Configured for Each Trigger Mode for the configured trigger mode are not configured with a value. It is not required to configure Filename each time Upstream Triggered Spectrum Capture test is initiated, but this is recommended.

The CCAP MAY support creation of partial results capture files when configured with a non-zero value of the MaxResultsPerFile attribute.

For each trigger mode, the operator can optionally configure Averaging, Filename, QualifyCenterFreq, QualifyBw, QualifyThrshld, Window, OutputFormat, RepeatPeriod, or TriggerCount. Default values are used for these attributes if they are not configured.

Table 462 - Attributes Required to be Configured for Each Trigger Mode

Trigger Mode	Attributes Required to be Configured
Free Running	CenterFreq, Span, NumBins, FreeRunDuration, RepeatPeriod
Minislot Count	MinislotCount, CenterFreq, Span, NumBins, LogicalChIfIndex, FreeRunDuration, RepeatPeriod
SID	Sid, CenterFreq, Span, NumBins, LogicalChIfIndex, TriggerCount
Idle SID	CenterFreq, Span, NumBins, LogicalChIfIndex, TriggerCount
CM MAC Address	CmMacAddr, CenterFreq, Span, NumBins, LogicalChIfIndex, TriggerCount
Quiet Probe Symbol	CenterFreq, Span, NumBins, LogicalChIfIndex, TriggerCount
Burst IUC	CmMacAddr, CenterFreq, Span, ifIndex, Burstluc, NumBins, LogicalChIfIndex, TriggerCount
Timestamp	Timestamp, CenterFreq, Span, NumBins, FreeRunDuration, RepeatPeriod
Active Probe Symbol	SID,CenterFreq, Span, NumBins, LogicalChIfIndex, TriggerCount

7.3.5.6.1 UsTriggeredSpectrumCaptureCapab

The Upstream Triggered Spectrum Capture Capabilities object exposes capabilities supported by the CCAP for Upstream Triggered Spectrum Capture trigger modes, data output formats, and windowing function used when performing the discrete Fourier transform.

Table 463 - UsTriggeredSpectrumCaptureCapab Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
TriggerMode	EnumBits	R/O	other(0), freeRunning(1), miniSlotCount(2), sid(3), idleSid(4), cmMac(5), quietProbeSymbol(6), burstIuc(7), timestamp(8), activeProbeSymbol(9)	N/A	
OutputFormat	EnumBits	R/O	other(0) timeIQ(1), fftPower(2), rawAdc(3), fftIQ(4), fftAmplitude(5), fftDb(6)	N/A	
Window	EnumBits	R/O	other(0), rectangular(1), hann(2), blackmanHarris(3), hamming(4), flatTop(5), gaussian(6), chebyshev(7)	N/A	
Description	String	R/O		N/A	

7.3.5.6.1.1 TriggerMode

This attribute indicates which of the upstream triggered spectrum capture function trigger modes is supported by the CCAP. TriggerMode attribute is reported in BITS format, with value 0 for each bit definition indicating the CCAP does not support the corresponding TriggerMode, and value 1 for each bit definition indicating the CCAP supports the corresponding trigger mode. See the description of the UsTriggeredSpectrumCaptureCfg object TriggerMode attribute for more information about CCAP upstream triggered spectrum capture trigger modes. The value other(0) is provided for vendor-proprietary and future extensions.

7.3.5.6.1.2 OutputFormat

This attribute indicates which of the upstream triggered spectrum capture function data output formats are supported by the CCAP. OutputFormat attribute is reported in BITS format, with value 0 for each bit definition indicating the CCAP does not support the corresponding OutputFormat, and value 1 for each bit definition indicating the CCAP supports the corresponding output data format. See the description of the UsTriggeredSpectrumCaptureCfg object OutputFormat attribute for more information about CCAP upstream triggered spectrum capture output formats. The value other(0) is provided for vendor-proprietary and future extensions.

7.3.5.6.1.3 Window

This attribute indicates which of the upstream triggered spectrum capture function window formats are supported by the CCAP. The Window attribute is reported in BITS format, with value for each bit definition 0 indicating the CCAP does not support the corresponding Window option and value 1 for each bit definition indicating the CCAP supports the corresponding Window option. See the description of the UsTriggeredSpectrumCaptureCfg object Window attribute for more information about CCAP upstream triggered spectrum capture window options. The value other(0) is provided for vendor-proprietary and future extensions.

7.3.5.6.1.4 Description

This attribute reports a textual description of a CCAP's upstream triggered spectrum capture capabilities. The format is vendor-specific. Example content can include, but is not limited to:

- Center Frequency range and resolution
- Frequency Span range and resolution
- Sampling rate each frequency span
- Averaging range and resolution
- Averaging method
- Number of time domain IQ samples
- Number of FFT bins

7.3.5.6.2 UsTriggeredSpectrumCaptureFile

The Upstream Triggered Spectrum Capture File object defines the format for the Upstream Triggered Spectrum Capture test-specific information in the data capture file created by the CCAP when an Upstream Triggered Spectrum Capture test is executed.

When the CCAP runs an Upstream Triggered Spectrum Capture test, it MUST create one or more results file(s) composed of the PnmCaptureFile header fields as defined in Section 7.3.3.1 followed by the UsTriggeredSpectrumCaptureFile fields described further in this section. The FileType for the capture file is 504E4E6A. Capture file fields are right-justified within the field and left-padded with zero values if necessary. The implemented values of various parameters may be different from the requested values, as the spectrum analysis function will provide the implementation value closest to the requested value.

The content of the Upstream Triggered Spectrum Capture file(s) can be retrieved via SNMP or bulk file transfer. Refer to the UsTriggeredSpectrumCaptureResult object and the CCAP Bulk Data Transfer section, respectively.

In the event of insufficient memory resources to create a new capture file, the CCAP MUST overwrite the oldest stored capture file with the new capture file being created.

The UsTriggeredSpectrumCaptureFile object inherits from PnmCaptureFile object (see Figure 74 and Table 442) so the Upstream Triggered Spectrum Capture file includes PnmCaptureFile object attributes as well as those listed and described in this section.

The Upstream Triggered Spectrum Capture file type is “504E4E6A”.

The file header changes causing the major version to increment from 1 to 2 are the addition of RPD ID, RPD Port Number, LogicalChIfIndex, NumSampleSets, SampleCaptureTime, and SampleCaptureMilliseconds fields, and the field name change from FFTSampleSize to FftSampleSetSize.

Table 464 - UsTriggeredSpectrumCaptureFile Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
LogicalChIfIndex	InterfaceIndex	R/O	SIZE(4)	N/A	N/A
CenterFreq	HexBinary	R/O	SIZE (4)	Hz	
FreqSpan	HexBinary	R/O	SIZE (4)	Hz	
NumBins	HexBinary	R/O	SIZE (2)	N/A	
Averaging	HexBinary	R/O	SIZE (1)	N/A	
SamplingRate	HexBinary	R/O	SIZE (4)	Hz	
OutputFormat	HexBinary	R/O	SIZE (1)	N/A	
FileLen	HexBinary	R/O	SIZE (4)	Bytes	
NumSampleSets	UnsignedInt	R/O	SIZE(4)	N/A	
FftSampleSetSize	HexBinary	R/O	SIZE (4)	Bytes	

Attribute Name	Type	Access	Type Constraints	Units	Default Value
CalibrationConstantK	Short	R/O	SIZE (2)	HundredthsdB	
Window	Enum	R/O	other(1), rectangular(2), hann(3), blackmanHarris(4), hamming(5), flatTop(6), gaussian(7), chebyshev(8)	N/A	N/A
SampleCaptureTime	HexBinary	R/O	SIZE(11)		
SampleCaptureMilliseconds	UnsignedShort	R/O	SIZE(2)		
SampleData	HexBinary	R/O		N/A	

The group of three attributes SampleCaptureTime, SampleCaptureMilliseconds, and SampleData is present NumSampleSets times in the file.

7.3.5.6.2.1 LogicalChIfIndex

The upstream channel ifIndex of the channel being tested if a trigger mode specific to a channel is selected. In cases where the test uses a trigger not specific to a channel, this field is set to 0.

7.3.5.6.2.2 CenterFreq

A four-byte hexadecimal field containing the implemented value of the CenterFreq attribute as specified in the UsTriggeredSpectrumCaptureCfg object.

7.3.5.6.2.3 FreqSpan

A four-byte hexadecimal field containing the implemented value of the Span attribute as specified in the UsTriggeredSpectrumCaptureCfg object.

7.3.5.6.2.4 NumBins

A two-byte hexadecimal field containing the implemented value of the NumBins attribute as specified in the UsTriggeredSpectrumCaptureCfg object.

7.3.5.6.2.5 Averaging

A one-byte hexadecimal field containing the implemented value of the Averaging attribute as specified in the UsTriggeredSpectrumCaptureCfg object.

7.3.5.6.2.6 SamplingRate

A four-byte hexadecimal field containing the A/D sampling rate in Hertz. This parameter is the frequency of the sampling clock such as 102.4, 204.8 or 409.6 MHz.

7.3.5.6.2.7 OutputFormat

A one-byte hexadecimal field containing the value of the OutputFormat attribute as specified in the UsTriggeredSpectrumCaptureCfg object.

7.3.5.6.2.8 NumSampleSets

This attribute contains the number of the result sets in the capture file. Each result set includes a set of three attributes: SampleCaptureTime, SampleCaptureMilliseconds, and SampleData.

7.3.5.6.2.9 FileLen

A four-byte hexadecimal field representing the length in bytes of the upstream spectrum sample capture data which follow in the file.

7.3.5.6.2.10 FftSampleSetSize

The FftSampleSize attribute is included in the output file to provide information about the size of the FFT sample set being captured when the Upstream Capture Mode is configured to fftPower(2), fftIQ(4), fftAmplitude(5), or fftDb(6).

7.3.5.6.2.11 CalibrationConstantK

This attribute is intended to communicate the calculated Calibration Constant value K that is applied to all bins in an upstream spectrum capture.

The PNM server uses the Calibration Constant to obtain the upstream spectrum capture estimate in dBmV for each bin, at an agreed calibration point, such as the RF connector of the line card, also known as I-CMTS/CCAP Upstream Interface [PHYv4.0]. Calculation of the Calibration Constant is typically done with a 0 dBmV input signal and in that case, the Calibration Constant K is derived directly from the linear sum of the power in all bins and subsequent conversion to dB. If a different power calibration signal is desired, then the resulting power level in dBmV needs to be subtracted in the calculation of the K Calibration Constant. For instance, if a 24 MHz calibration signal uses the same power spectral density as used for a 0 dBmV 6.4 MHz SC-QAM signal, then the expected total power would be increased from 0 dBmV by $10*\log_{10}(24/6.4) = 5.74$ dB. In this scenario the total composite power of the calibration signal would be 5.74 dBmV. This number is a variable defined as dBmVTestSignalPower, which is equal to 5.74 and is used to modify K as described below.

Let P_raw = sum of the linear power (not dB) values of all FFT spectrum bins in the occupied band of the signal (e.g., 6.4 MHz or 24 MHz or other), before applying the Calibration Constant. Let P_{avg} = average value of P_raw over several (e.g., 32) spectral captures, in order to reduce noise variation in the measurement.

K is given by $K= 10* \log_{10}(P_{avg}) –$ dBmVTestSignalPower.

In the above example, $K = 10* \log_{10}(P_{avg}) – 5.74$ dBmV.

Similarly, if a higher power calibration SC-QAM signal is desired, such as +3 dBmV, then the variable dBmVTestSignalPower would be equal to 3 dBmV. In this case, $K = 10* \log_{10}(P_{avg}) –$ dBmVTestSignalPower = $10* \log_{10}(P_{avg}) – 3$ dBmV.

Details for calculating and applying a Calibration Constant follow:

1. Computing Calibration Constant

As an illustrative example, a single-carrier ATDMA QAM signal with the following characteristics can be used for calibration:

Symbol rate = 5.12 MSymbol/s

Signal is present for the entire FFT sampling interval (i.e., not captured at the edge of a burst so only part of the FFT buffer contains signal)

Signal level = 0 dBmV measured at the specified interface.

The goal is to compute the Calibration Constant such that after calibration, the sum of the linear power (not dB) values of all FFT bins in the 6.4 MHz occupied band of the above 0 dBmV test signal = 1 (i.e., 0 dBmV). This property will hold regardless of which resolution bandwidth or FFT window is selected. With this calibration, integrated power measurements (sum of linear power over a given spectral bandwidth) will give correctly calibrated results in dBmV for any collection of signals in the spectrum.

K is given by, $K= 10* \log_{10}(Pavg) –$ dBmVTestSignalPower $= 10* \log_{10}(Pavg) – 0$ dBmV.

2. Applying Calibration Constant

To apply the Calibration Constant, the PNM Server performs the following steps:

Start with the raw spectral value for a given FFT bin; let this be called D_raw (dBmV power), S_raw (linear power) or A_raw (amplitude) depending on the format of the measurement. Then the calibrated values are

P0 = $10^{\wedge(K/10)}$

D_calibrated = D_raw - K

S_calibrated = S_raw / P0

A_calibrated = A_raw / sqrt(P0)

The Calibration Constant may be affected by configuration changes or other factors. If such changes occur, resulting in implied changes in the Calibration Constant, the CCAP will take that into account when populating the Calibration Constant entry in the file header elements and also updates the CalibrationConstantK MIB value. The Calibration Constant may be different on different ports. The CCAP maintains the CalibrationConstantK and associated variable parameters which would affect the Calibration Constant across resets.

7.3.5.6.2.12 Window

This attribute specifies the windowing function that was configured when performing the discrete Fourier transform for the upstream spectrum analysis.

7.3.5.6.2.13 SampleCaptureTime

This attribute reports the time when the sample set was captured. The format of this attribute is "DateAndTime" as defined by [RFC 2579]. To get the actual sample capture time, SampleCaptureMilliseconds is added to SampleCaptureTime.

7.3.5.6.2.14 SampleCaptureMilliseconds

This attribute reports the number of milliseconds since the time reported in SampleCaptureTime attribute.

7.3.5.6.2.15 SampleData

The upstream spectrum sample capture data formatted according to the configured OutputFormat. SampleData contains one spectrum capture sample set.

7.3.5.6.3 UsTriggeredSpectrumCaptureCfg

The UsTriggeredSpectrumCaptureCfg object supports the creation and deletion of at least one instance.

The CCAP is not required to persist instances of this object across reinitializations.

The CCAP MUST reject configuring a value for the DestinationIndex of the UsTriggeredSpectrumCaptureCfg object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 465 - UsTriggeredSpectrumCaptureCfg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Index	UnsignedInt	Key	N/A	N/A	N/A
IfIndex	InterfaceIndex	Key	N/A	N/A	N/A
LogicalChIfIndex	InterfaceIndex	R/W	N/A	N/A	0

Attribute Name	Type	Access	Type Constraints	Units	Default Value
TriggerMode	Enum	R/W	other(1) freeRunning(2) miniSlotCount(3) sid(4) idleSid(5) cmMac(6) quietProbeSymbol(7) burstIuc(8) timestamp(9) activeProbeSymbol(10)	N/A	freeRunning
MinislotCount	UnsignedInt	R/W	N/A	N/A	0
Sid	UnsignedInt	R/W	N/A	N/A	0
CmMacAddr	MacAddress	R/W	N/A	N/A	'000000000000'H
Timestamp	UnsignedLong	R/W	N/A	N/A	0
CenterFreq	UnsignedInt	R/W		Hz	N/A
Span	UnsignedInt	R/W		Hz	N/A
NumBins	UnsignedShort	R/W		N/A	N/A
Averaging	UnsignedByte	R/W	0|2..255	N/A	0
Filename	AdminString	R/W	N/A	N/A	""
QualifyCenterFreq	UnsignedInt	R/W	N/A	Hz	0
QualifyBw	UnsignedInt	R/W	N/A	Hz	5120000
QualifyThrshld	TenthdB	R/W	N/A	TenthdB	-100
Window	Enum	R/W	other(1), rectangular(2), hann(3), blackmanHarris(4), hamming(5), flatTop(6), gaussian(7), chebyshev(8)	N/A	rectangular
OutputFormat	Enum	R/W	timeIQ(1), fftPower(2), rawAdc(3), fftIQ(4), fftAmplitude(5), fftDb(6)	N/A	fftPower
RepeatPeriod	UnsignedInt	R/W	N/A	usec	100000
FreeRunDuration	UnsignedInt	R/W	N/A	msec	1000
TriggerCount	UnsignedInt	R/W	N/A	N/A	0
BurstIuc	Enum	R/W	other(1), iuc1(2), iuc2(3), iuc3(4), iuc4(5), iuc5(6), iuc6(7), iuc9(8), iuc10(9), iuc11(10), iuc12(11), iuc13(12)	N/A	other(1)
MaxResultsPerFile	UnsignedInt	R/W	0 .. N	N/A	0

Attribute Name	Type	Access	Type Constraints	Units	Default Value
DestinationIndex	UnsignedInt	R/W	N/A	N/A	

7.3.5.6.3.1 Index

This key attribute is a unique identifier for a particular set of configuration settings. If the CCAP does not support multiple Upstream Triggered Spectrum Sample Capture configuration settings, the CCAP MUST only support a value of 1 for this attribute and reject any attempt to configure it to a value other than 1.

7.3.5.6.3.2 IfIndex

This key attribute is the interface index of an upstream RF port.

The CCAP MAY provide simultaneous measurements of logical upstream channels within a single upstream physical interface.

7.3.5.6.3.3 LogicalChIfIndex

For SC-QAM upstream channels, this attribute is the interface index of the logical upstream channel (ifIndex 205) to which the sample capture trigger applies, when TriggerMode is miniSlotCount, sid, idleSid, quietProbeSymbol, and burstIuc.

For OFDMA upstream channels, this attribute is the interface index of the physical OFDMA upstream channel (ifIndex 278) to which the sample capture trigger applies, when TriggerMode is miniSlotCount, sid, idleSid, quietProbeSymbol, and burstIuc.

The value 0 means the CCAP is triggering on something specific to the upstream RF port, not a specific channel.

When the value of LogicalChannelIndex is the ifIndex of a physical or logical channel and upstream triggered spectrum sample capture is initiated, the CCAP MUST trigger on the assigned trigger mode event for the physical or logical channel indicated by the value of LogicalChannelIndex.

7.3.5.6.3.4 TriggerMode

This attribute is used to control the trigger mode for the Upstream Triggered Spectrum Analysis sample capture. Values allowed for this attribute are listed and described below. Each trigger mode requires the InitiateTest attribute to be set to true as well as the proper configuration settings that are applicable to the specific trigger mode.

other: The CCAP initiates sampling the upstream spectrum as the result of a trigger condition not defined in this specification.

freeRunning: The CCAP immediately initiates a sample capture and then repeats sample captures as configured by the RepeatPeriod and FreeFunDuration. Sampling terminates when the length of time configured in FreeRunDuration has elapsed or when FFT is disabled. The interval between captures is RepeatPeriod, or the minimum period supported by the CCAP, whichever is greater. This mode can be used for the entire upstream spectrum and is independent of channel type. When the TriggerMode is "freeRunning" the UpstreamChannel Interface Index is ignored.

miniSlotCount: The CCAP performs a sample capture when the minislot number equals the value configured for attribute MinislotCount. This mode can be used for triggering a spectrum capture for either an SC-QAM or OFDMA channel. If the FreeRunDuration and RepeatPeriod are both greater than zero, the capture repeats in freeRunning mode at a rate equal to the RepeatPeriod for the FreeRunDuration. If either the RepeatPeriod or FreeRunDuration is equal to zero, then only a single capture is performed when triggered by the miniSlotCount.

sid: The CCAP performs a sample capture when triggered by a grant to the SID. If the TriggerCount is greater than one, then captures are repeated when triggered by successive grants to the SID until the number of captures equals the TriggerCount. This mode can be used for triggering a spectrum capture for either an SC-QAM or OFDMA channel.

idleSid: The CCAP performs a sample capture during an idle period when triggered by a grant to the idleSid selected by the CCAP. If the TriggerCount is greater than one, then the capture is repeated when triggered by successive grants to the idleSid until the number of captures equals the TriggerCount. This mode can be used for triggering a spectrum capture for either an SC-QAM or OFDMA channel. The SID is selected by the CMTS/CCAP.

cmMac: The CCAP performs a sample capture when triggered by a grant for any SID assigned to the cable modem whose MAC address is the value of attribute CmMac. If the TriggerCount is greater than one, then the capture is repeated when triggered by successive grants to the SID corresponding to the MAC Address until the number of captures equals the TriggerCount. This mode can be used for triggering a spectrum capture for either an SC-QAM or OFDMA channel.

quietProbeSymbol: The CCAP performs a sample capture when triggered by a grant to a SID corresponding to the configured OFDMA Quiet Probe Symbol. If the TriggerCount is greater than one, then the capture is repeated when triggered by successive grants to the IUC until the number of captures equals the TriggerCount. This mode can be used for triggering a spectrum capture for an OFDMA channel only. The Upstream Triggered Spectrum Capture test with probeSymbol trigger is different from the Upstream Capture for Active and Quiet Probes PNM feature in that the Upstream Triggered Spectrum Capture test is more general than the Upstream Capture for Active and Quiet Probes test. Upstream Triggered Spectrum Capture test can be done in any band, while the Upstream Capture for Active and Quiet Probes test is specifically for an OFDMA channel.

burstIuc: The CCAP performs a sample capture when triggered by a grant for the IUC (Interval Usage Code), issued by the CCAP. If the TriggerCount is greater than one, then the capture is repeated when triggered by successive grants to the IUC until the number of captures equals the TriggerCount. This mode can be used for triggering a spectrum capture for either an SC-QAM or OFDMA channel.

timestamp: The CCAP performs a sample capture when the configured timestamp occurs.

activeProbeSymbol: The CCAP performs a sample capture when triggered by a grant to the configured SID in a P-MAP. If the TriggerCount is greater than one, then the capture is repeated when triggered by successive grants to the SID configured for the active probe until the number of captures equals the TriggerCount. This mode can be used for triggering a spectrum capture for an OFDMA channel only

Note that if the CCAP supports only one set of Upstream Triggered Spectrum Capture configuration, then if a test is configured with timestamp trigger, it effectively blocks any other test setup and execution until it completes, since setting up the other test will overwrite the timestamp test configuration.

7.3.5.6.3.5 MinislotCount

This attribute specifies the minislot number at the beginning of which the CCAP starts the upstream spectrum sample capture. This attribute is applicable only when the TriggerMode attribute is set to MiniSlotCount and is ignored if TriggerMode is set to any other value.

7.3.5.6.3.6 Sid

This attribute specifies the SID corresponding to the CM which is granted a burst opportunity for the purpose of Upstream Triggered Spectrum Analysis.

This attribute is applicable only when the TriggerMode attribute is set to Sid and is ignored if TriggerMode is set to any other value.

7.3.5.6.3.7 CmMacAddr

This attribute specifies from which cable modem the CCAP will capture upstream transmissions.

The CCAP MUST trigger upstream spectrum sample capture on a grant for any SID assigned to the CM whose MAC address is configured in CmMacAddr and capture upstream spectrum samples when the burst corresponding to that grant is received by the CCAP. This attribute is used when the TriggerMode is cmMac and is an alternative to using Sid for the TriggerMode. This attribute is ignored if TriggerMode is set to any value other than cmMac.

7.3.5.6.3.8 Timestamp

This is the DOCSIS 4.0 timestamp defined in [MULPIv4.0]. This attribute specifies the specific time in the future when upstream spectrum sample capture is required to be initiated. If the FreeRunDuration and RepeatPeriod are both greater than zero, the capture repeats in freeRunning mode at a rate equal to the RepeatPeriod for the FreeRunDuration. If either the RepeatPeriod or FreeRunDuration is equal to zero, then only a single capture is performed when triggered by the timestamp. When the TriggerMode is "timestamp" the UpstreamChannel Interface Index is ignored. This mode can be used for the entire upstream spectrum and is independent of channel type.

If TriggerMode is set to timestamp, configuration settings have been applied, and InitiateTest is true, the CCAP MUST initiate sampling when the configured timestamp occurs. The CCAP will continue to sample the configured upstream spectrum until FFT is disabled or a new configuration is applied; however, a single capture typically is made in this mode.

7.3.5.6.3.9 CenterFreq

This attribute specifies the center frequency of the upstream spectrum to be sampled for analysis. When this attribute is read, it provides the actual center frequency, which may be different from the requested (configured) center frequency due to implementation effects.

7.3.5.6.3.10 Span

This attribute determines the frequency span of the upstream spectrum sample capture. When this attribute is read, it provides the actual span, which may be different from the requested (configured) span due to implementation effects.

7.3.5.6.3.11 NumBins

This attribute determines the number of frequency bins or samples per span when sampling the upstream spectrum. When this attribute is read, it provides the actual number of bins, which may be different from the requested (configured) number of bins due to implementation effects. The number of bins is typically less than the FFT length in use, due to filter rolloff at the edges of the analysis band. A larger number of frequency bins will result in better frequency resolution for a given frequency span.

7.3.5.6.3.12 Averaging

This attribute specifies whether the CCAP is to average spectral frequency domain sample power to remove spurious spectral peaks and troughs, and the number of samples to use to calculate the average power.

The CCAP MUST NOT calculate the average of the upstream spectrum samples when the value of Averaging is zero.

The CCAP MUST calculate the average power of upstream spectrum samples, over the number of samples specified, when the value of the Averaging attribute is non-zero.

The CCAP MUST use quantities in the linear power domain when performing time averaging over multiple spectra. Time averaging provides for a smoother resulting spectrum. In time averaging, the spectrum is captured multiple times, and each FFT bin is averaged over the successive values in that bin to provide the final spectrum value for that bin. A leaky integrator may be used to perform the averaging. Let x = x_I + j*x_Q be the vector of time domain input samples to the FFT and y = y_I + j*y_Q be the vector of complex output frequency bin values of the FFT. Then p = |y|^2 = y_I^2 + y_Q^2 is the power or squared magnitude of the bin values and r = |y| = sqrt(y_I^2 + y_Q^2) is the magnitude of the bin values. The values may be converted to dB using s = 10*log10(p) = 20*log10(r). Only values of p are used for time averaging. Magnitude values need to be squared before averaging. dB values need to be converted into linear power using p = 10^(s/10) before averaging; after averaging, the smoothed bin values may be converted back to dB.

7.3.5.6.3.13 Filename

This attribute specifies the name of the file with the upstream triggered spectrum capture data at the CCAP that is to be transferred from the CCAP using TFTP to the PNM server or other TFTP client. The content of the sample data

file transferred from the CCAP using TFTP is the same as the content returned in attribute Output of the corresponding Result object.

If the value of this attribute is an empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and the ifIndex of the interface on which the test runs. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapUsSpecAn_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example, the upstream spectrum sample capture filename format would be as shown below:

PNMCcapUsSpecAn_ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

Format of upstream triggered spectrum capture file is described in Section 7.3.5.6.2.

7.3.5.6.3.14 QualifyCenterFreq

This attribute specifies the center frequency of a band that is used to qualify a spectrum for upload. The average of the FFT linear power values in this band is computed and compared to a threshold. If the average power in the band is below the threshold, the spectrum is discarded. If the power average is greater than or equal to the threshold, the spectrum is considered qualified.

7.3.5.6.3.15 QualifyBw

This attribute specifies the bandwidth of a band that is used to qualify a spectrum for upload. The average of the FFT linear power values in this band is computed and compared to a threshold. If the average power in the band is below the threshold, the spectrum is discarded. If the power average is greater than or equal to the threshold, the spectrum is considered qualified.

7.3.5.6.3.16 QualifyThrshld

This attribute specifies the threshold applied to qualify a spectrum for upload. The average of the FFT linear power values in the specified band is computed and compared to this threshold. If the average power in the band is below the threshold, the spectrum is discarded. If the power average is greater than or equal to the threshold, the spectrum is considered qualified. If this threshold is set to -100 dB or lower, the threshold qualification feature is disabled (all spectra are then considered qualified).

7.3.5.6.3.17 Window

This attribute specifies the windowing function that will be used when performing the discrete Fourier transform for the upstream spectrum analysis. Use of "modern" windowing functions not yet defined will likely be specified as 'other'.

The CCAP MUST be capable of implementing rectangular windowing and at least one of the following other window types when performing discrete Fourier transform on upstream spectrum sample data:

- Hann windowing
- Blackman Harris windowing.

The CCAP SHOULD implement Hamming windowing for performing discrete Fourier transform on upstream spectrum sample data.

The CCAP MAY implement Flat Top windowing for performing discrete Fourier transform on upstream spectrum sample data.

The CCAP MAY implement Gaussian windowing for performing discrete Fourier transform on upstream spectrum sample data.

The CCAP MAY implement Chebyshev windowing for performing discrete Fourier transform on upstream spectrum sample data.

7.3.5.6.3.18 OutputFormat

This attribute specifies the format of the data returned in the upstream spectrum sample capture file and in the Output attribute of the Results object.

The CCAP MUST be capable of reporting upstream spectrum sample FFT input data in complex time-domain in-phase and quadrature (I/Q) format. The enumeration value for complex time-domain I/Q format is timeIQ.

The CCAP MUST use 4 bytes per upstream spectrum sample to represent the data when reporting in complex time-domain I/Q format.

The CCAP MUST be capable of reporting upstream spectrum sample FFT output data in power format. The enumeration value for power format is fftPower.

The CCAP MUST use 4 bytes per bin to represent upstream spectrum sample FFT output data when reporting upstream spectrum sample data in power format.

The CCAP MAY be capable of reporting upstream spectrum sample real FFT input data in raw analog-to-digital converter (ADC) output format. The enumeration value for raw ADC output format is rawAdc.

The CCAP MUST use 2 bytes per upstream spectrum sample to represent the data when reporting in raw ADC output format.

The CCAP MAY support reporting of upstream spectrum sample FFT output data in I/Q format. The enumeration value for I/Q format is fftIQ.

The CCAP MUST use 4 bytes per bin to represent FFT output data when reporting upstream spectrum sample data in I/Q format.

The CCAP MAY support reporting of upstream spectrum sample FFT output data in amplitude format. The enumeration value for amplitude format is fftAmplitude.

The CCAP MUST use 2 bytes per bin to represent upstream spectrum sample FFT output data when reporting upstream spectrum sample data in amplitude format.

The CCAP MAY support reporting of upstream spectrum sample FFT data in dBmV format using units of hundredths dB. The enumeration value for spectrum amplitude format is fftDb.

The CCAP MUST use 2 bytes per bin to represent upstream spectrum sample FFT output data when reporting in dB format.

The CCAP MUST reject any attempt to set OutputFormat to an optional value not supported by the CCAP.

7.3.5.6.3.19 RepeatPeriod

This attribute specifies the interval in microseconds between consecutive triggers for FFT sample capture. The CCAP is permitted to trigger at larger intervals if unable to support the requested interval. Configuring a zero value indicates the test is to run once only.

The CCAP MUST reject an attempt to set RepeatPeriod to a value greater than the current value of FreeRunDuration.

7.3.5.6.3.20 FreeRunDuration

This attribute specifies the length of time in milliseconds for which the CCAP continues to capture and return FFT results when in free running mode.

Sample captures are expected to take a few microseconds, so if FreeRunDuration is set for longer than a sample capture duration, the CCAP could potentially capture more sample data than it can store.

On initiation of the Capture Upstream Spectrum test (i.e. free run mode) the CCAP MUST start a free run duration timer as configured to bound the test duration.

The CCAP MUST reject an attempt to set FreeRunDuration to a value less than the current value of RepeatPeriod.

7.3.5.6.3.21 TriggerCount

This attribute determines the number of times to trigger upstream spectrum sample capture when InitiateTest is set to true and configured trigger conditions are met.

The CCAP MUST trigger upstream spectrum sample capture continuously when the value of TriggerCount is zero.

7.3.5.6.3.22 BurstIuc

This attribute configures the desired BurstIuc when the TriggerMode attribute is configured for burstIuc(8). IUCs that can be used include any request, station maintenance, initial maintenance, or data grant defined in [MULPIv4.0].

7.3.5.6.3.23 MaxResultsPerFile

This attribute configures the maximum number of capture result sets that the CCAP is allowed to store in a capture file. When this attribute is set to a non-zero value, the CCAP limits the number of capture result sets per file and creates partial capture result files.

During data capture, when the number of result sets stored in a file reaches the value of MaxResultsPerFile, then the CCAP stops depositing results into the current file, makes the current file with partial results available for immediate upload, and starts depositing capture results into the next file. This process iterates until the upstream triggered spectrum capture is stopped.

The format of the partial result file does not differ from the format of a file with complete results.

The value zero means that there is no administratively configured limit on the number of capture results in the capture file. The maximum supported value for this attribute is left to vendor choice.

When the filename is configured via 'Filename' attribute, in order to disambiguate multiple partial files, the CCAP appends '_' character and timestamp (with colons replaced with periods) string to the configured string resulting in the following format:

'Filename_<Timestamp>.

The format of the appended timestamp string is defined in section 7.3.4.1.11.

7.3.5.6.3.24 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

7.3.5.6.4 UsTriggeredSpectrumCaptureCtrl

The Upstream Triggered Spectrum Capture Control object provides command and control functionality for the Upstream Triggered Spectrum Capture function.

This object supports the creation and deletion of multiple instances. Instances are created and/or deleted when the corresponding UsTriggeredSpectrumCaptureCfg object instances are instantiated. The CCAP is not required to persist instances of this object across reinitializations.

Table 466 - UsTriggeredSpectrumCaptureCtrl Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
InitiateTest	Boolean	R/W	N/A	N/A	False

7.3.5.6.4.1 InitiateTest

This attribute is used to trigger an Upstream Triggered Spectrum Capture. Setting this attribute to true applies all configured upstream triggered spectrum sample capture attributes and initiates the triggered upstream spectrum sample capture and sample output conversion process.

Read-write attributes, which are used to configure the Upstream Triggered Spectrum Capture, can only be configured while a test is not in progress.

The CCAP MUST reject any attempt to modify a UsTriggeredSpectrumCaptureCfg Object attribute, or UsTriggeredSpectrumCaptureCtrl Object attribute for the same instance of InitiateTest configured to true when the triggered spectrum capture is in progress as indicated by value 'busy' for MeasStatus.

The CCAP MUST allow writable UsTriggeredSpectrumCaptureCfg Object attributes or UsTriggeredSpectrumCaptureCtrl Object attributes to be modified if the value of attribute MeasStatus for the instance is not 'busy'.

The CCAP initiates an upstream triggered spectrum sample capture only if InitiateTest is set to true and all of the UsTriggeredSpectrumCaptureCfg configuration objects are properly configured. Refer to Section 7.3.5.6 and Table 457.

While a test is in progress, this attribute returns the value true. Configuring a value of false for this attribute, while a test is in progress, will abort the currently executing test. If a test is aborted, the result data is discarded.

7.3.5.6.5 UsTriggeredSpectrumCaptureStatus

The Upstream Triggered Spectrum Capture Status object provides functionality for monitoring and reporting status of the Upstream Triggered Spectrum Capture function.

This object supports the creation and deletion of multiple instances. Instances are created and/or deleted when the corresponding UsTriggeredSpectrumCaptureCfg object instances are instantiated.

The CCAP is not required to persist instances of this object across reinitializations.

Table 467 - UsTriggeredSpectrumCaptureStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
MeasStatus	MeasStatusType	R/O	N/A	N/A	N/A
CalibrationConstantK	Short	R/O	N/A	HundredthsdB	N/A

7.3.5.6.5.1 MeasStatus

This attribute is used to report the status of the Upstream Triggered Spectrum Capture. When the value of MeasStatus is sampleReady, the CCAP has completed capturing and recording samples.

The MeasStatus attribute reports value ‘busy’ when the test is running even after CCAP creates one or more partial capture results files.

7.3.5.6.5.2 CalibrationConstantK

This attribute is used to report the current value of CalibrationConstantK for the given upstream RF Port (refer to Section 7.3.5.6.2.11). The Calibration Constant may be affected by configuration changes or other factors. If such

changes occur, resulting in implied changes in the Calibration Constant, the CCAP will take that into account when populating the Calibration Constant entry in the file header elements and also updates the CalibrationConstantK MIB value. The Calibration Constant may be different on different ports. The CCAP maintains the CalibrationConstantK and associated variable parameters that would affect the Calibration Constant across resets.

7.3.5.6.6 UsTriggeredSpectrumCaptureResult

The Upstream Triggered Spectrum Capture Result object provides functionality for reporting results of the Upstream Triggered Spectrum Capture function.

This object supports the creation and deletion of multiple instances. Instances are created and/or deleted when the corresponding UsTriggeredSpectrumCaptureCfg object instances are instantiated.

The CCAP is not required to persist instances of this object across reinitializations.

Table 468 - UsTriggeredSpectrumCaptureResult Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
SampleRate	UnsignedInt	R/O	N/A	Samples per second	N/A
UsSampleSize	UnsignedInt	R/O	N/A	Samples	N/A
SampleTimestamp	TimeStamp	R/O	N/A	TimeTicks	N/A
ResolutionBw	UnsignedInt	R/O	N/A	Hertz	N/A
Output	HexBinary	R/O	N/A	N/A	N/A
CalibrationConstantK	Short	R/O	N/A	HundredthsdB	N/A

7.3.5.6.6.1 SampleRate

This attribute reports the FFT sample rate used by the CCAP when sampling the upstream spectrum.

7.3.5.6.6.2 UsSampleSize

This attribute reports the number of samples collected for FFT. The FFT payload size will be the number of samples multiplied by the number of bytes per sample as determined by OutputFormat. The duration of the FFT sample will be the number of samples divided by the sample rate as reported in attribute SampleRate.

7.3.5.6.6.3 SampleTimestamp

This attribute reports the date and time when the FFT sample was recorded.

7.3.5.6.6.4 ResolutionBw

This attribute reports the resolution bandwidth used when samples were collected. The resolution bandwidth is the same as the bin spacing for rectangular windowing, is 1.5*bin spacing for Hanning window, etc. The resolution bandwidth used by the CCAP is needed in order to obtain an accurate power measurement for all signals when both CW and noise-like (QAM, OFDM) signals are present in the spectrum.

7.3.5.6.6.5 Output

This attribute returns the upstream spectrum sample capture data in hexadecimal format according to the output format configured in attribute OutputFormat. The format of the sample capture data returned by this attribute is as described in Section 7.3.5.6.2. This attribute provides an alternative to TFTP file transfer for reporting sample data. Due to small data sizes for upstream captures, this may be a more responsive method for screen updates than TFTP file transfer.

7.3.5.6.6.6 CalibrationConstantK

This attribute returns the calibration constant 'K' applied to all bins in an upstream spectrum capture, to allow the PNM server to obtain the upstream spectrum capture estimate in dBmV for each bin. It is the same value returned in the Upstream Triggered Spectrum Capture results file, but this attribute enables visibility to the calibration constant 'K' without having to parse a results file. See Section 7.3.5.6.2.11 for a full description of this attribute.

The Calibration Constant may be affected by configuration changes or other factors. If such changes occur, resulting in implied changes in the Calibration Constant, the CCAP will take that into account when populating the Calibration Constant entry in the file header elements and also updates the CalibrationConstantK MIB value. The Calibration Constant may be different on different ports. The CCAP maintains the CalibrationConstantK and associated variable parameters that would affect the Calibration Constant across resets.

7.3.5.6.7 SpectrumAnalysisMeas

This object is included here for reference and is defined in Section 6.6.1.2.2.

7.3.6 CCAP OPT PNM Information Model

OFDM Profile Test (OPT) is a set of functions and messages described in [MULPIv3.1] OFDM Downstream Profile Test Request (OPT-REQ) and OFDM Downstream Profile Test Response (OPT-RSP) sections and defined in the DOCSIS OSSI specifications as a PNM Test. The objects described in the OPT PNM information model define the management interface for the operator to configure, execute, and monitor the OFDM Profile Test.

To support the requirements of an external application managing DOCSIS OFDM channel profiles, a capability is needed for triggering the DOCSIS OPT message to retrieve various channel and profile related metrics and perform various tests as defined in [MULPIv4.0]. A triggering mechanism is defined to trigger the CMTS to send an OPT Request (OPT-REQ) message and then return CM metric information from the OPT Response (OPT-RSP) message. Note that the tests that return a given profile's MER per subcarrier data will be larger than a single SNMP PDU can transport in a single Ethernet frame.

The OFDM Profile Test (OPT) is performed using MAC Management Message (MMM) provided to evaluate several different parameters associated with a Downstream OFDM profile that is not currently being used by a target CM.

An OPT is requested by the CMTS through the generation of an OPT-REQ message to the CM required to perform the test. The CM performs the OPT using the parameters described in the OPT-REQ message. Upon successful completion of the test, the CM returns the OPT results in the OPT-RSP message.

The OPT message exchange is designed to support the following:

- Retrieval of the per-subcarrier MER values from the CM, which is a channel level measurement
- Compilation by the CM for codeword statistics including codeword counts, uncorrectable codeword counts, and the ability to enable codeword tagging
- Execution of NCP Profile tests, which include the NCP Field counts and NCP CRC failure counts

When the CM receives an OPT Request message it may contain one or more of the aforementioned tests. The CM will use the OPT Response message to return the tested values to the CMTS.

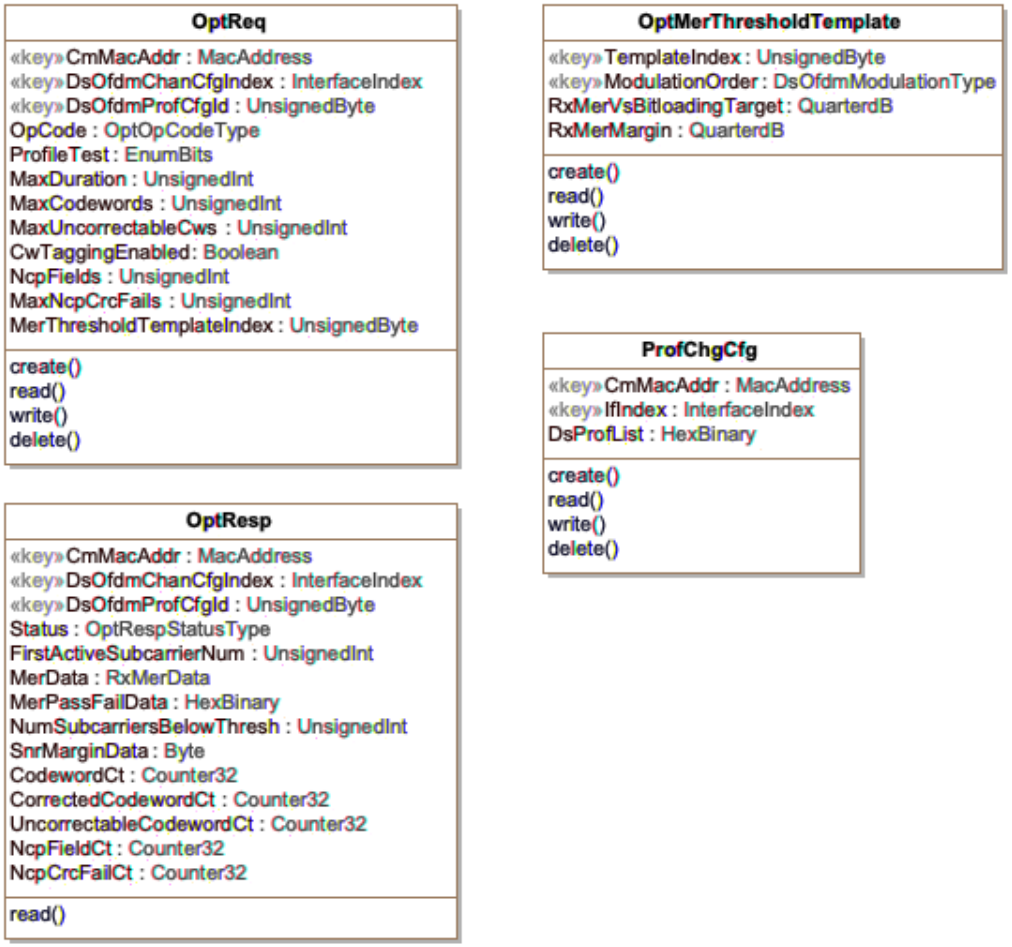


Figure 78 - CCAP OPT PNM Information Model

7.3.6.1 OptReq

The OPT Request object is used to initiate the OPT-REQ message for a given OFDM DS channel. The message and resulting tests and requirements are defined in the OPT-REQ TLV Encodings section of [MULPIv4.0]. To use the object, the Operator or PMA Application uses the CM MAC address (CmMacAddr), the downstream OFDM channel configuration index (DsOfdmChanCfgIndex), and downstream OFDM profile configuration identifier (DsOfdmProfCfgId) as the keys to initiate a test. The specific tests that are defined in MULPI are accessed with the ProfileTest attribute. This attribute is a BITS data type and will allow one or more of the OPT tests to be configured to be performed by the CM. Due to the nature of the ProfileTest attribute, one or more tests can be requested in a single message and thus different amounts of data need to be configured in order for the OPT Message to have the required TLVs. The following table depicts this.

Table 469 - Profile Tests

ProfileTest	Test Description	Required Attributes
Bit 0 - RxMER Statistics per Subcarrier	Per subcarrier MER regardless of modulation or profile	CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId
Bit 1 - RxMER per Subcarrier Threshold Comparison for Candidate Profile	When this test is selected, the CM uses MER target values for each ModOrder in the candidate Profile referenced in DsOfdmProfCfgId. Target values are configured in the OptMerThresholdTemplate with RxMerVsBitloadingTarget	CmMacAddr, DsOfdmChanIndex, DsProfCfgId Test requires that one or more instances of OptMerThresholdTemplate exist for the referenced CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId,
Bit 2 - SNR Margin for Candidate Profile	When this test is selected, the CM uses the threshold values in the OptMerThresholdTemplate object for the specified DsOfdmChanCfgIndex, DsOfdmProfCfgId, ModOrder and the RxMerVsBitloadingTarget attributes	CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId, Test requires that one or more instances of OptMerThresholdTemplate object exist for the referenced CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId, and ModOrder attributes.
Bit 3 - Codeword Statistics for Candidate Profile	When this test is selected, the CM provides Codeword Statistics for the candidate profile	CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId, MaxDuration, MaxCodewords and optionally MaxUncorrectableCws and CwTaggingEnabled
Bit 4 - Codeword Threshold Comparison for Candidate Profile	When this test is selected, the CM provides Codeword Statistics for the candidate profile	CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId, MaxDuration, MaxCodewords and optionally MaxUncorrectableCws and CwTaggingEnabled
Bit 5 - NCP Field statistics	When this test is selected, the CM provides NCP Statistics for the candidate profile	CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId, MaxDuration, NcpFields, and optionally MaxNcpCrcFails and CwTaggingEnabled
Bit 6 - NCP CRC Threshold Comparison	When this test is selected, the CM provides NCP Statistics for the candidate profile	CmMacAddr, DsOfdmChanCfgIndex, DsOfdmProfCfgId, MaxDuration, NcpFields, and optionally MaxNcpCrcFails and CwTaggingEnabled

Some of these tests perform evaluations of thresholds or margins. To facilitate these evaluations by the CM, these values are defined in the test request or the OptMerThresholdTemplate object defined later in this section.

To successfully initiate a test, the DsOfdmChanCfgIndex and an associated DsOfdmProfCfgId are required. The CCAP MUST reject a request to initiate an OPT test when the DsOfdmChanCfgIndex does not exist or is not currently in use by the CM. The CCAP MUST reject a request if the referenced DsOfdmProfCfgId is in use on the CM or the value does not exist in the profiles associated with the referenced DsOfdmChanCfgIndex. The CCAP MUST reject a request to run an OPT test on CM that is not operational.

The CCAP MUST reject starting an OPT (i.e., setting OpCode to start(2) in the OptReq object) for a unique combination of a CM, OFDM channel, and profile if there is already an OPT running (i.e., status in the OptResp object equal testing(1)) for any profile on the same CM and OFDM channel.

The CCAP MUST reject an OPT request that combines NCP tests (bit 5 or 6) with any other tests.

The CCAP MAY support simultaneous Downstream OPT tests on more than one OFDM channel at a time.

This object supports the creation and deletion of multiple instances.

Table 470 - OptReq Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
CmMacAddr	MacAddress	Key			
DsOfdmChanCfgIndex	InterfaceIndex	Key			

Attribute Name	Type	Access	Type Constraints	Units	Default Value
DsOfdmProfCfgId	UnsignedByte	Key	0..15 | 254 | 255		
OpCode	OptOpCodeType	R/W			other(1)
ProfileTest	EnumBits	R/W	rxMerSubCarrierStats(0), rxMerSubCarrierThreshComp(1), snrMarginCandidateProfile(2), codewordStats(3), codewordThreshComp(4), ncpFieldStats(5), ncpCrcThreshComp(6), reserved(7), other(8)		
MaxDuration	UnsignedInt	R/W	1..180000	milliseconds	
MaxCodewords	UnsignedInt	R/W		Number of codewords	
MaxUncorrectableCws	UnsignedInt	R/W		Number of codewords	
CwTaggingEnabled	Boolean	R/W			false(0)
NcpFields	UnsignedInt	R/W			
MaxNcpCrcFails	UnsignedInt	R/W			
MerThresholdTemplateIndex	UnsignedByte	R/W			0

7.3.6.1.1 CmMacAddr

This key represents the MAC address for the referenced CM.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.2 DsOfdmChanCfgIndex

This key is the IfIndex of a Downstream OFDM channel assigned to the modem.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.3 DsOfdmProfCfgId

This key is the targeted profile being tested with OPT for the instance of DsOfdmProfileCfg. For Data Profile testing, the ID of the profile that is being tested is used. The value 254 is used for RxMER statistics only. The value 255 is used for NCP Profile Testing.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.4 OpCode

This attribute controls the testing to be performed by the CM receiving the OPT-REQ message. This attribute is defined to mirror the OpCode field in the OPT-REQ message defined in the MULPI Spec.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.5 ProfileTest

This attribute defines which of the OPT tests are to be run by the CM. The tests are encoded as individual bits:

- rxMerSubCarrierStats(0),
- rxMerSubCarrierThreshComp(1),
- snrMarginCandidateProfile(2),
- codewordStats(3),

- codewordThreshComp(4),
- ncpFieldStats(5),
- ncpCrcThreshComp(6),
- reserved(7),
- other(8)

When a given bit is set, then that test will be performed by the CM. Note that the tests rxMerSubCarrierThreshComp(1), snrMarginCandidateProfile(2) require entries in the OptMerThreshold object for these tests to be performed.

This attribute corresponds to TLV 1 in the OPT Request message.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.6 MaxDuration

This attribute allows the tester to determine how long a test may run before returning results or aborting.

[MULPIv4.0] requires this value to be not greater than 3 minutes or 180000 milliseconds.

This attribute corresponds to TLV 4 in the OPT Request message.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.7 MaxCodewords

This attribute defines the maximum number of codewords that the CM should examine before the test is complete. When either N_c or more codewords have been received, or N_e or more codeword errors have occurred, since the start of the test, the CM will send an OPT-RSP with a Complete status.

This attribute is only present in the OPT-REQ message for Codeword tests: codewordStats(3), codewordThreshComp(4).

This attribute corresponds to TLV 5.1 in the OPT Request message.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.8 MaxUncorrectableCws

This attribute defines the maximum number of uncorrectable codewords that the CM should allow before the test is complete. When either N_c or more codewords have been received, or N_e or more codeword errors have occurred, since the start of the test, the CM will send an OPT-RSP with a Complete status.

This attribute is only present in the OPT-REQ message for Codeword tests: codewordStats(3), codewordThreshComp(4).

This attribute corresponds to TLV 5.2 in the OPT Request message.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.9 CwTaggingEnabled

This attribute indicates whether Codeword Tagging is in use for this test. This attribute is defined as a Boolean with the value 'false' meaning that codeword tagging is disabled and a value of 'true meaning that codeword tagging is enabled. When codeword tagging is enabled, The CM will report codeword counts that include only codewords received on the profile in question for the duration of the test for which the 'T' bit is set to 1 in the NCP pointing to the codeword. The location of the 'T' bit is specified in [PHYv4.0]. When codeword tagging is enabled, LFSR synthetic traffic is all that is tagged.

If codeword tagging is disabled, the CM only reports codeword counts that include all codewords received on the profile in question for the duration of the test.

This attribute is only present in the OPT-REQ message for Codeword tests: codewordStats(3), codewordThreshComp(4).

This attribute corresponds to TLV 5.3 in the OPT Request message.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.10 NcpFields

This attribute defines the maximum number of NCP fields to be examined during the test. When the CM has examined this number or more NCP fields, it returns the OPT Request with a completed test status and the collected statistical information.

This attribute is only present in the OPT-REQ message for NcpFieldTests: ncpFieldStats(5), ncpCrcThreshComp(6).

This attribute corresponds to the TLV 6.1 in the OPT-REQ.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.11 MaxNcpCrcFails

This attribute defines the maximum number of NCP fields that are allowed to fail the NCP CRC checks to be examined during the test. When the CM has examined this number or more NCP fields, it returns the OPT Request with a completed test status and the collected statistical information.

This attribute is only present in the OPT-REQ message for NcpFieldTests: ncpFieldStats(5), ncpCrcThreshComp(6).

This attribute corresponds to the TLV 6.2 in the OPT-REQ.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.1.1 MerThresholdTemplateIndex

This attribute defines the TemplateIndex of the OptMerThresholdTemplate objects for tests requiring MER thresholds. Zero means no template is assigned for the test. If ProfileTest includes bits rxMerSubCarrierThreshComp(1) or snrMarginCandidateProfile(2), the CCAP MUST reject setting opcode in the OptReq object to start(2) if MerThresholdTemplateIndex equals zero or if there are not instances of the OptMerThresholdTemplate object with a TemplateIndex matching the value MerThresholdTemplateIndex and every modulation except zero-bit-loaded in the OFDM profile being tested. Zero-bit-loaded modulations are not allowed in the threshold definition TLV (TLV 2.1) of the OPT-REQ [MULPIv4.0].

7.3.6.2 OptMerThresholdTemplate

For MER tests that require Pass/Fail criteria, it is necessary to define the parameters in a separate fashion as the OPT-REQ message needs these values on a per modulation basis. This means that for each modulation order defined in a profile, the OPT-REQ includes a TLV entry for the required MER target value for each. A single threshold template, which consists of all instances of OptMerThresholdTemplate with the same TemplateIndex, can be used in multiple OptReq objects.

This object supports the creation and deletion of multiple instances.

Table 471 - OptMerThresholdTemplate Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
TemplateIndex	UnsignedByte	Key	1..255		
ModulationOrder	DsOfdmModulationType	Key	Modulation zeroBitLoaded(2) is not valid		

Attribute Name	Type	Access	Type Constraints	Units	Default Value
RxMerVsBitloadingTarget	QuarterdB	R/W		QuarterdB	See CM Minimum CNR Performance in AWGN Channel [PHYv4.0] for default values
RxMerMargin	QuarterdB	R/W		QuarterdB	

7.3.6.2.1 TemplateIndex

This key represents the template index for all the modulations in a single template. Zero is reserved to mean no template in the OptReq object.

7.3.6.2.2 ModulationOrder

This key specifies the modulation types supported by the CCAP modulator. The modulation zeroBitLoaded is not valid for MER threshold margin calculations.

This attribute corresponds to the TLV 2.1 in the OPT-REQ.

Reference: [PHYv4.0], [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.2.3 RxMerVsBitloadingTarget

This attribute is the required value for the profile RxMER (refer to OPT-RSP) in units of 0.25dB (0xFF is 63.75dB). This is the required RxMER value that the CM uses to calculate the SNR margin for the profile. The default values for this attribute are defined in [PHYv4.0] CM Minimum CNR Performance in AWGN Channel.

This attribute corresponds to the TLV 2.2 in the OPT-REQ.

Reference: [PHYv4.0] CM Error Ratio Performance in AWGN Channel, [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.2.4 RxMerMargin

The CM reports the number of subcarriers with a measured RxMER value that is at least this value below the target RxMER in units of 0.25dB (0xFF is 63.75dB) for the bitloading of the given subcarrier in the OPT-RSP message.

This attribute corresponds to the TLV 2.3 in the OPT-REQ.

Reference: [MULPIv4.0] OPT-REQ TLV Encodings

7.3.6.3 OptResp

One of the main issues for the modeling for OPT-RSP is that all OPT responses will not be alike. Some tests will only require one test or maybe a combination of one or more tests. As a result, the information model and resulting data models need to be able to gather the needed data for each CM and provide that to the PMA. Details of this operation can be found in [MULPIv4.0] OFDM Downstream Profile Test Response (OPT-RSP**).**

MER data from the CM will be recorded as a series of hex values (0x00 to 0xFF) that will represent the MER values that the CM has measured. These values are gathered from the first active subcarrier to the last active subcarrier in the OFDM channel definition. The data from the CM will not contain pairs of values (subcarrierId and MER value) but just the subcarrier MER value. For the PMA to make sense of the data, the CCAP provides the first active subcarrier to allow the PMA to know where it should start associating the values from the CM to the individual subcarriers defined in the channel. This information will need to be learned by the PMA from the DsOfdmChannelStatus object (DsOfdmChannelStatus, FirstActiveSubcarrierNum).

Instances of this object are created when the response to an OptRequest is received by the CCAP. Instances of this object may be removed by the CCAP in a vendor-specific manner.

Table 472 - OptResp Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
CmMacAddr	MacAddress	Key			
DsOfdmChanCfgIndex	InterfaceIndex	Key			
DsOfdmProfCfgId	UnsignedByte	Key	0..15 | 254 | 255		
Status	OptRespStatusType	R/O	other(0) testing(1) profileAlreadyUnderTest(2) unavailableResources(3) maxDurationExpired(4) aborted(5) complete(6) profileAlreadyAssigned(7) dsLockLost(8)		
FirstActiveSubcarrierNum	UnsignedInt	R/O	148..7895		
MerData	RxMerData	R/O	SIZE (0..7680)		
MerPassFailData	HexBinary	R/O	SIZE (0..7680)		
NumSubcarriersBelowThresh	UnsignedInt	R/O			
SnrMarginData	Byte	R/O		QuarterdB	
CodewordCt	Counter32	R/O			
CorrectedCodewordCt	Counter32	R/O			
UncorrectableCodewordCt	Counter32	R/O			
NcpFieldCt	Counter32	R/O			
NcpCrcFailCt	Counter32	R/O			

7.3.6.3.1 CmMacAddr

This key represents the MAC address for the referenced CM.

7.3.6.3.2 DsOfdmChanCfgIndex

This key is the IfIndex of a Downstream OFDM channel assigned to the modem.

7.3.6.3.3 DsOfdmProfCfgId

This attribute is the targeted profile being tested with OPT for the instance of DsOfdmProfile Cfg. This attribute is a key for the OptResp object.

7.3.6.3.4 Status

This attribute allows the CCAP to return the status of a specific OPT test request. The value of this attribute is found in the status portion of the OPT-RSP header that is returned from the CM when the OPT-REQ is received by the CM. The values include:

- other(0) – The status is not one of the values below.
- testing(1) – The CM has initiated the requested tests.
- profileAlreadyUnderTest(2) – The CM received a request, but the profileId requested was already being used for an active test.
- unavailableResources(3) – The CM had an error with the request related to available resources to run the test collection.
- maxDurationExpired(4) – The CM has reported that for this test, the maximum duration value has expired.

- aborted(5) – The CM received an OPT-REQ request with an OpCode of abort and is aborting the tests requested.
- complete(6) – The CM has successfully completed the requested testing.
- profileAlreadyAssigned(7) – The CM is reporting that the referenced profileId is already assigned and may not be used for the requested tests.
- dsLockLost(8) – The CM is reporting that the DS lock has been lost for this DS OFDM channel.

Reference: [MULPIv4.0] OFDM Downstream Profile Test Response (OPT-RSP)

7.3.6.3.5 FirstActiveSubcarrierNum

This attribute is the subcarrier index of the lowest subcarrier in the Occupied Bandwidth of the channel.

7.3.6.3.6 MerData

This attribute contains the MER data for the active subcarriers in the instance of the DsOfdmChannelCfg object. The data represents Integer modulation error ratio measurements in 0.25 dB steps (0x00-0xFE represents 0-63.5 dB; 0xFF indicates no measurement available). These are encoded as a packed sequence of 8-bit values for N consecutive subcarriers (N≤7680) from lowest active subcarrier to the highest active subcarrier, including all the subcarriers in between. This attribute is a variable length and is dependent on the channel width and the number of active subcarriers that are available. This attribute is a channel level measurement and is independent of the profile being tested.

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.7 MerPassFailData

This attribute contains a Pass/Fail indication for each subcarrier's RxMER (1 bit for each subcarrier). A value of 1 indicates that the measured MER ≥ target value in the OPT-REQ. A value of 0 indicates that the measured MER < target value in the OPT-REQ. These are encoded as a sequence of 1-bit values for N consecutive subcarriers (N≤7680) from lowest active subcarrier.

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.8 NumSubcarriersBelowThresh

This attribute indicates the number of subcarriers (≤7680) whose RxMER is ≥ the RxMER Margin below the RxMER target for the bitloading of the given subcarrier.

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.9 SnrMarginData

This attribute indicates the SNR margin of the candidate data profile (signed integer), in units of 0.25dB, calculation is as defined in [PHYv4.0].

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.10 CodewordCt

This attribute is a count of the measured number of codewords that the CM has successfully received during the testing interval for the profile being tested - unsigned integer count of codewords that were examined during testing. If Codeword Tagging is disabled, this count includes all codewords received on the profile in question for the duration of the test. If Codeword Tagging is enabled, this count includes only codewords received on the profile in question for the duration of the test for which the 'T' bit was set in the NCP pointing to the codeword. The location of the 'T' bit is specified in [PHYv4.0].

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.11 CorrectedCodewordCt

This attribute is a count of the measured number of codewords that the CM has successfully received and was able to correct during the testing interval for the profile being tested - unsigned integer count of codewords that were examined during testing. If Codeword Tagging is disabled, this count includes all codewords received on the profile in question for the duration of the test. If Codeword Tagging is enabled, this count includes only codewords received on the profile in question for the duration of the test for which the 'T' bit was set in the NCP pointing to the codeword. The location of the 'T' bit is specified in [PHYv4.0].

7.3.6.3.12 UncorrectableCodewordCt

This attribute is a count of the measured number of uncorrectable codewords that the CM has received during the testing interval for the profile being tested - unsigned integer count of codewords that failed pre-decoding LDPC syndrome check and passed BCH decoding. If Codeword Tagging is disabled, this count includes all codewords received on the profile in question for the duration of the test. If Codeword Tagging is enabled, this count includes only codewords received on the profile in question for the duration of the test for which the 'T' bit was set in the NCP pointing to the codeword. The location of the 'T' bit is specified in [PHYv4.0].

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.13 NcpFieldCt

This attribute records the number of NCP fields that were examined by the CM during the test interval.

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.3.14 NcpCrcFailCt

This attribute records the number of NCP fields that failed the NCP CRC check.

Reference: [MULPIv4.0] OPT-RSP TLV Encodings

7.3.6.4 ProfChgCfg

This object allows the Operator to force changes in the assigned profiles on a given registered CM.

dsLockLost(8) – The CM is reporting that the DS lock has been lost for this DS OFDM channel.

Attempts to change profiles on a CM that is not currently in an operational state MUST be rejected by the CCAP. If the CCAP receives a request to change a profile on an OFDM channel that is not in the CM's RCS, the CCAP MUST reject the request. If the CCAP receives a request to change a profile on the CM and one or more profiles referenced in the DsProfList do not exist, the CCAP MUST reject the request. The CCAP MUST reject any DsProfileList that does not contain profile 0.

This object supports the creation and deletion of multiple instances. The CCAP MAY remove instances of this object when the DBC operation to update the profile list for the CM and Ds OFDM Channel has completed.

Table 473 - ProfChgCfg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
CmMacAddr	MacAddress	Key			
IfIndex	InterfaceIndex	Key			
DsProfList	HexBinary	R/W	SIZE (1..4)		

7.3.6.4.1 CmMacAddr

This key represents the MAC address for the referenced CM.

7.3.6.4.2 IfIndex

This attribute is the ifIndex of the DS OFDM channel for which the CMTS will instruct the CM to adjust its profiles.

7.3.6.4.3 DsProfList

This attribute is a list of N 1-byte downstream OFDM profile IDs assigned for the OFDM channel.

7.4 Latency Reporting

Downstream Packet Queue Latency Estimates Statistics Calculation and Reporting ("Latency Reporting") is a feature of Low Latency Services described in [MULPIv3.1] Low Latency Support section. The CmtsLatencyRpt, DsSfLatencyCfgMetaData, and SnapshotData objects described in the Latency Reporting information model define the management interface for the operator to configure, execute, and monitor the Latency Reporting test.

This section defines the CCAP information models supporting Latency Reporting. CCAP and cable modem features and capabilities can be leveraged to enable measurement and reporting of latency estimates through each of the downstream service flows. With this information operations personnel can monitor latency trends to and adjust network configurations as appropriate.

7.4.1 Latency Reporting Information Model

This section defines the model for the management interface for configuring and controlling Downstream Queue Latency Estimates and reporting for enabled service flows.

For each service flow that is enabled for Downstream Queue Latency Estimates collection (see Section 6.5.6.4.8 SfLatencyHistCfg), the CCAP will calculate a set of summary statistics and a packet queue latency estimates histogram which are reported via object SfLatencyStats (see Section 7.2.2.6.10) and object SfCongestionStats (see Section 7.2.2.6.11). The set of reported SfLatencyStats and SfCongestionStats attributes are referred to as a 'Latency Reporting Snapshot' ("Snapshot").

Latency Reporting can be enabled for a Service Flow by setting the number of packet queue latency estimates results files to create and the number of Latency Reporting Snapshots to include in each file. A packet queue latency estimates results file includes one file header, one set of metadata with the Latency Reporting Snapshot histogram configuration, and one or more separate Latency Reporting Snapshots. Each Latency Reporting Snapshot is a new and distinct set of summary statistics and histogram values collected during the snapshot time interval, and not an aggregation or running total of the packet queue latency estimates across Snapshots.

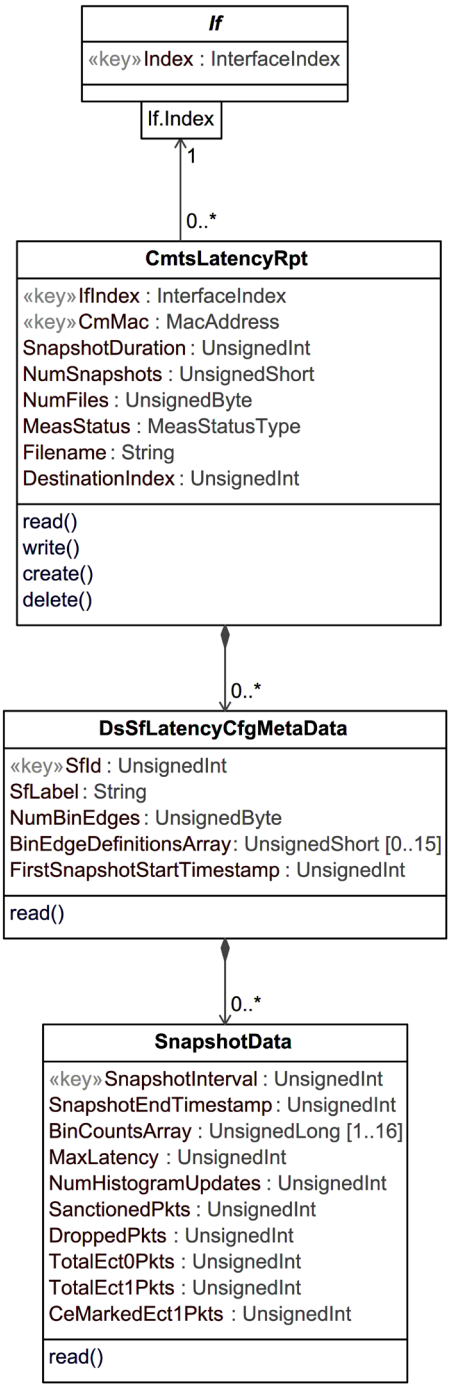


Figure 79 - Latency Reporting Information Model

7.4.1.1 CmtsLatencyRpt

The CmtsLatencyRpt object reports configuration of the CMTS downstream latency reporting, configures parameters for downstream queue latency estimate data collection and reporting, and controls initiation of the latency estimate data collection. This enables the creation of latency report files which consist of a series of latency measurements on a per Service Flow basis over a provisioned period of time.

The CCAP MUST support creation and deletion of multiple instances of the CmtsLatencyRpt object.

The CCAP MUST persist an instance of the CmtsLatencyRpt object across de-registration – registration events if the value of NumFiles for the instance is 255.

Table 474 - CmtsLatencyRpt Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
IfIndex	InterfaceIndex	Key			
CmMac	MacAddress	Key			
SnapshotDuration	UnsignedInt	read-create	1..3600	Seconds	60
NumSnapshots	Unsignedshort	read-create	1..2000		10
NumFiles	UnsignedByte	read-create	0..255	-	0
MeasStatus	MeasStatusType	R/O			
Filename	String	read-create	SIZE (0..231)		empty string
DestinationIndex	UnsignedInt	read-create	1.. 4294967295		

Table 475 - CmtsLatencyRpt Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
DsSfLatencyCfgMetaData	Directed composition association to DsSfLatencyCfgMetaData	1	0..*	

7.4.1.1.1 IfIndex

This key attribute specifies the MAC Domain in which the cable modem associated with attribute CmMac is registered.

7.4.1.1.2 CmMac

This key attribute specifies the MAC address of the CM for which the CMTS will generate downstream QueueLatency Report(s).

7.4.1.1.3 SnapshotDuration

This attribute represents the measurement duration of service flow latency estimates. One row of statistics per service flow is captured during this interval.

7.4.1.1.4 NumSnapshots

This attribute represents the number of Snapshots batched into a file. The total duration represented by the file is the product of the SnapshotDuration and NumSnapshots. Two examples follow.

- If SnapshotDuration is set to 1 second, and NumSnapshots is set to 10, when enabled, the CCAP returns the latency data samples recorded once per second over the next 10-sec period.
- If SnapshotDuration is set to 300 seconds (5 mins), and NumSnapshots is set to 288, when enabled, the CCAP returns the latency data samples recorded once per 5-minute interval over the next 24-hour period.

7.4.1.1.5 NumFiles

This attribute represents the number of file uploads performed as defined in Table 471 below.

Table 476 - NumFiles definition

NumFiles Attribute	
0	File generation disabled
1..254	Number of files to generate. Counts down from this value to zero
255	Unlimited file generation.

The CMTS MUST start generating a latency report file when this value is set to a non-zero value. The CMTS MUST close the current latency report file and decrement NumFiles by 1, when the SnapshotDuration * NumSnapshots period is complete, except when NumFiles is set to 255. The CMTS MUST preserve the NumFiles value when it is set to 255 since the value 255 means the CMTS is configured for unlimited file generation. The CMTS MUST close the current latency report file and discontinue file generation if the NumFiles attribute is set to zero or decrements to zero or if the CM deregisters.

7.4.1.1.6 MeasStatus

This attribute is used to determine the status of the measurement.

7.4.1.1.7 Filename

This attribute contains the name of the file which the CMTS creates to store latency histogram snapshots. This value can only be changed while a test is not in progress. The CMTS MUST return 'inconsistentValue' when it receives an attempt to set the CmtsLatencyRpt Filename while the value of MeasStatus is 'busy'.

If the value of this attribute is an empty string, then a default filename value will be used. Otherwise, the value set will be used as the filename. If a default filename is generated, then that value will be returned in this attribute and will represent the filename that was used for the test. All subsequent tests should set this attribute to a meaningful value or to an 'empty string' value (to generate a new default filename) before starting a new test.

If a default filename value is used, it is generated as the test name, plus a unique CCAP identifier (either a loopback address (IPv4 or IPv6) or FQDN), plus the current timestamp (with colons replaced with periods) and the ifIndex of the interface on which the test runs. The timestamp is formatted as shown below:

<Year:4d>-<Month:2d>-<Day:2d>_<Hour:2d>.<Minute:2d>.<Second:2d>.<Millisecond:3d>

Hence, the format would be:

PNMCcapDsLatencySum_<Unique CCAP Identifier>_<Timestamp>_<ifIndex>

For example: DsLatencySum_ccap1.boulder.cablelabs.com_2018-06-26_10.50.14.451_24935767

Format of CMTS Latency Report capture file is described in Section 7.4.1.3

7.4.1.1.8 DestinationIndex

This attribute is the index of the configured destination for the file upload.

7.4.1.2 DsSfLatencyCfgMetaData

This object reports the per-service flow downstream queue latency estimates calculation settings and provides the interface to modify snapshot settings.

A delay can exist between enabling Latency Calculation and measuring snapshot data, so an instance of SnapshotData might not be created when an instance of DsSfLatencyCfgMetaData is created.

Table 477 - DsSfLatencyCfgMetaData Object Attributes

Attribute Name	Type	Access	Multiplicity	Type Constraints	Units
SfId	UnsignedInt	Key	1		

Attribute Name	Type	Access	Multiplicity	Type Constraints	Units
SfLabel	String	R/O	1		
NumBinEdges	UnsignedByte	R/O	1		
BinEdgeDefinitionsArray	UnsignedShort	R/O	0..15		
FirstSnapshotStartTimestamp	UnsignedInt	R/O	1		

Table 478 - DsSfLatencyMetaCfgData Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SnapshotData	Directed composition association to SnapshotData	1	0..*	

7.4.1.2.1 SfId

This key attribute is the service flow identifier specifying the service flow for which downstream queue latency estimates were measured and reported in the CmtsLatencyRpt instance.

7.4.1.2.2 SfLabel

Refer to the attribute definition for SfLabel in Section 6.5.6.4.8 SfLatencyHistCfg.

7.4.1.2.3 NumBinEdges

This attribute reports the number of packet queue latency estimate histogram bin edges defined for the latency histogram for measurement on this service flow. The value of NumBinEdges reports the number of histogram bin edges configured in the CMTS via the configuration attribute ServiceClass::LatencyHistBinEdges, and is equal to the number of histogram bins minus one. NumBinEdges is encoded as an array of unsigned bytes. The multiplicity of NumBinEdges values can range from zero (one histogram bin) to fifteen (sixteen histogram bins).

References: Section 6.5.6.4.3.46 (ServiceClass::)*LatencyHistBinEdges*, [MULPIv4.0] *Latency Histogram Calculation* section, [MULPIv4.0] Annex C *Common TLV Encodings*, *Latency Histogram Encodings* section.

7.4.1.2.4 BinEdgeDefinitionsArray

This attribute reports the time values in tens of microseconds, for the edges or boundaries between downstream service flow queue latency estimates histogram bins, configured in the CMTS via the configuration attribute ServiceClass::LatencyHistBinEdges. BinEdgeDefinitions is encoded as an array of unsigned long integer values. The length of the array is the value of NumBinEdges. For each pair of subsequent BinEdgeDefinition values, the lower value is the lower boundary for the range of downstream service flow queue latency estimates for a histogram bin and the larger value is the upper boundary for the range of downstream service flow queue latency estimates for that histogram bin. The multiplicity of BinEdgeDefinitions values can range from zero (one histogram bin) to fifteen (sixteen histogram bins).

The resolution of the bin edge values is defined as 0.01 ms (10 microseconds). A properly formatted array specifies bin edges in monotonically increasing order, and operation is undefined otherwise.

References: Section 6.5.6.4.3.46 (ServiceClass::)*LatencyHistBinEdges*, [MULPIv4.0] *Latency Histogram Calculation* section, [MULPIv4.0] Annex C *Common TLV Encodings*, *Latency Histogram Encodings* section.

7.4.1.2.5 FirstSnapshotTimestamp

This attribute reports the start time for the first Snapshot entry for this instance. The value of this attribute is the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), Thursday, January 1, 1970.

7.4.1.3 SnapshotData

This object reports downstream queue latency estimates summary data and histogram bin data for a service flow during a Snapshot Interval. A Snapshot Interval is the length of time from when downstream queue latency estimates and histogram bin counts begin for a Snapshot, until the CMTS stops making downstream queue latency estimates and collating histogram bin counts at time CmtsLatencyRpt::SnapshotDuration after the estimates and bin counts are initiated, or until downstream queue latency estimate statistics collection is stopped by CmtsLatencyRpt::NumFiles decrementing to or being set to zero or by the CM de-registering.

Table 479 - SnapshotData Object Attributes

Attribute Name	Type	Access	Multiplicity	Type Constraints	Units
SnapshotInterval	UnsignedInt	Key	1		
SnapshotEndTimestamp	UnsignedInt	R/O	1		
BinCountsArray	UnsignedLong	R/O	1..16		
MaxLatency	UnsignedInt	R/O	1		Microseconds
NumHistogramUpdates	UnsignedInt	R/O	1		
SanctionedPkts	UnsignedInt	R/O	1		
DroppedPkts	UnsignedInt	R/O	1		
TotalEct0Pkts	UnsignedInt	R/O	1		
TotalEct1Pkts	UnsignedInt	R/O	1		
CeMarkedEct1Pkts	UnsignedInt	R/O	1		

7.4.1.3.1 SnapshotInterval

This key attribute represents the unique index for an instance of each snapshot data set.

7.4.1.3.2 SnapshotEndTimestamp

This attribute reports the time, expressed in the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC) Thursday, January 1, 1970, when this Snapshot Interval ended.

7.4.1.3.3 BinCountsArray

This attribute reports the count of queue latency estimates for this service flow, for each configured histogram bin, during the snapshot interval. This attribute is encoded as an array of unsigned long values, with each element of the array reporting the count of queue latency estimates for the corresponding bin. The number of elements in the array is equal to the value of DsSfLatencyCfgMetaData::NumBinEdges + 1, with the count for the first configured bin reported in the first element of the array. The multiplicity of BinCountsArray is 1..16.

7.4.1.3.4 MaxLatency

This attribute reports the maximum of all queue latency estimates measured by the CMTS for this service flow during the Snapshot Interval.

7.4.1.3.5 NumHistogramUpdates

This attribute reports the sum of downstream service flow queue latency estimates recorded as bin counts, in the service flow queue latency estimates histogram created during the Snapshot Interval.

7.4.1.3.6 SanctionedPkts

This attribute reports the count of packets redirected from a Downstream Low Latency Service Flow to the Classic Service Flow in the CCAP during the Snapshot Interval. For other Service Flow types in the CCAP, this counter reports 0.

7.4.1.3.7 DroppedPkts

The attribute reports the count of dropped packets on the specified service flow during the Snapshot Interval.

7.4.1.3.8 TotalEct0Pkts

This attribute reports the count of packets on the specified service flow that arrived marked as ECT0 during the Snapshot Interval.

7.4.1.3.9 TotalEct1Pkts

This attribute reports the count of packets on the specified service flow that arrived marked as ECT1 during the Snapshot Interval.

7.4.1.3.10 CeMarkedEct1Pkts

This attribute reports the count of packets that arrived on the specified Downstream Low Latency Service Flow marked as ECT1 and as Congestion Experienced (CE) by the CCAP.

7.4.1.4 Downstream Queue Latency Estimates Summary File

As specified in Section 7.4.1.1.5, NumFiles, the CCAP is required to generate files aggregating Downstream Queue Latency Estimates summaries (Downstream Latency Summary Data) when the value of CmtsLatencyRpt::NumFiles is set to a nonzero positive value. The format of the Downstream Queue Latency Estimates Summary files ("Downstream Latency Summary Data files") the CCAP is required to create is defined in this section.

A Downstream Latency Summary Data file is composed of a file header (Downstream Latency Summary File Header), per-service flow Latency Summary calculation parameters (Downstream Latency Summary Metadata), and one or more instances of Latency Snapshot Data for each service flow, for which Downstream Latency Summary Data calculation is enabled.

If bin edges for a Service Flow (ServiceClass::LatencyHistBinEdges) are changed during a Snapshot Interval, multiple instances of Downstream Latency Summary Metadata and Latency Snapshot Data will be created and included in the Downstream Latency Summary File for the same service flow.

7.4.1.4.1 Downstream Latency Summary File Header

The header of the Downstream Latency Summary File is composed of ordered fixed-length fields. Unless otherwise specified, the header fields contain hex values that are right-justified within the field. If necessary, the field is left-padded with zero values.

Syntax of the header is shown in Table 475.

Table 480 - Downstream Latency Summary Header Format

Element	Size or Data Type
File type (value = 4C4C4410)	4 bytes
Major Version (Value = 1)	1 byte
Minor Version	1 byte
CM MAC Address	6 bytes
Number of LatencySummaryData objects (n)	1 byte

- Major Version

This element represents the current file header version. The version is incremented by one when the file header format is modified by specification.

- Minor Version

The vendor-specified version information. The default value is zero if no vendor version is assigned.

- CM MAC Address

This element is a copy of the CmtsLatencyRpt::CmMac attribute.

- Number of Downstream Service Flow Latency Summary Data objects

This number indicates how many instances of the Downstream Service Flow Latency Summary Metadata and its/their associated Latency Snapshot Data instance(s) are included in the file.

The CMTS MUST include an instance of Downstream Service Flow Latency Summary Metadata and their associated Latency Snapshot Data instances for every service flow for which latency histogram calculation is turned on for any portion of the file reporting period.

When the latency histogram calculation is disabled for a service flow during a Snapshot Interval, the CMTS MUST conclude the current downstream queue latency estimate count collection for the histogram then discontinue calculating queue latency estimates histogram and summary statistics for the disabled service flow, and record the current time as the value for SnapshotData::Snapshot End Timestamp.

7.4.1.4.2 Downstream Latency Summary Metadata

Downstream Latency Summary Metadata is comprised of a set of entries of *DsSfLatencyCfgMetaData* object attributes and an entry of a *CmtsLatencyRpt* object attribute and provides context in the Downstream Summary Latency File for the service flow that downstream latency data was collected on, the structure of the downstream queue latency estimates histogram, and a time reference for the latency summary data.

The CMTS MUST include CmtsLatencyRpt::NumSnapshots instances of Latency Snapshot Data in the Downstream Latency Summary File with each instance of Downstream Latency Summary Metadata.

7.4.1.4.3 Latency Snapshot Data

The CCAP is required to include CmtsLatencyRpt::NumSnapshot instances of Latency Snapshot Data in the Downstream Latency Summary File for each histogram enabled service flow.

Each Latency Snapshot Data instance in a Downstream Latency Summary file includes values from attributes from the *SnapshotData* object, and a Reserved element (with the value 0) included for backward compatibility with a previous version of the Downstream Latency Summary Data File format.

Format of the Downstream Latency Summary Data file is shown in Table 476.

Table 481 - Downstream Latency Summary Data File Contents

Information Model Object	Element	Size
N/A	File Header	
DsSfLatencyCfgMetaData	SfId	4 bytes
	SfLabel	16 bytes
	NumBinEdges	1 byte
	BinEdgeDefinitionsArray	2 bytes* Number of Bin Edges
CmtsLatencyRpt	NumSnapshots	2 bytes
DsSfLatencyCfgMetaData	First Snapshot Start Timestamp	4 bytes
Latency Snapshot Entry (1 entry per snapshot)		
SnapshotData	- Snapshot End Timestamp	4 bytes
	- Array of Bin counts	8 bytes * (Number of Bin Edges+1)
	- MaxLatency	4 bytes
	- NumHistogramUpdates	4 bytes
	- SanctionedPkts	4 bytes
	- DroppedPkts	4 bytes
	- TotalEct0Pkts	4 bytes
N/A	- Reserved	4 bytes

Information Model Object	Element	Size
N/A	File Header	
SnapshotData	- TotalEct1Pkts	4 bytes
	- CeMarkedEct1Pkts	4 bytes

7.5 Streaming Telemetry

7.5.1 Overview

Figure 80 provides a view of the DOCSIS Streaming Telemetry management architecture, including the Telemetry components for the CCAP, as a more detailed view into the management architecture defined in Figure 5.

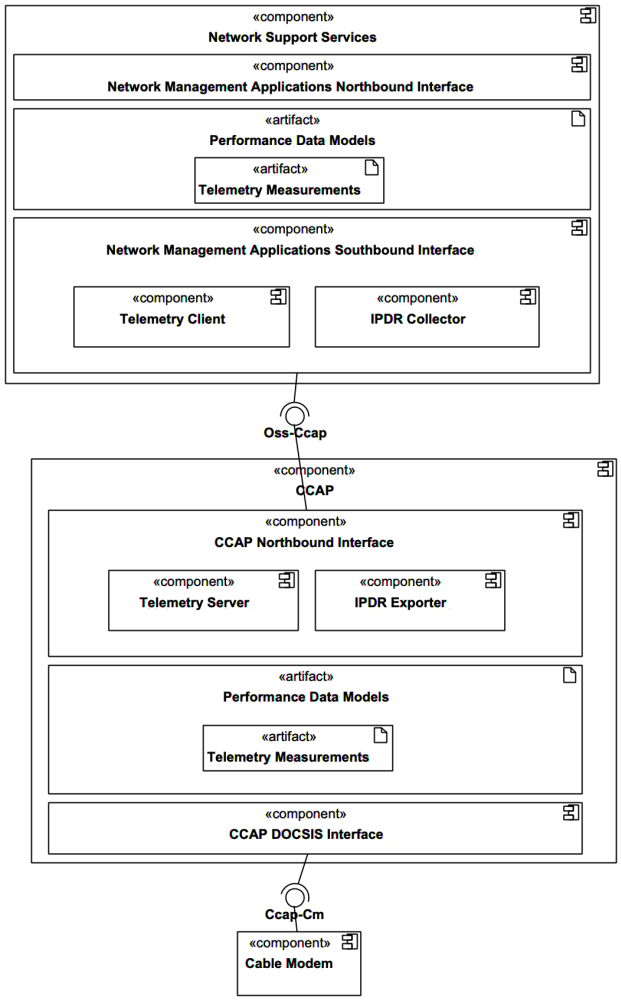


Figure 80 - CCAP Streaming Telemetry Management Architecture

The DOCSIS CCAP Streaming Telemetry management architecture components are as follows:

- Network Support Services
  Network Support Services represents the different network management applications in the operator's back office. Since Streaming Telemetry is based on subscription to the monitored data via the monitored, or target, device's data model, the Network Support Services support configuration of the Streaming Telemetry subscriptions, in addition to Streaming Telemetry operational configuration within the target

device's configuration, and a data model for the telemetry measurements streamed from the monitored devices. The Telemetry Client is responsible for subscription and collection of Telemetry data from the monitored devices. The IPDR Collector is described in Section 7.5.3, IPDR Streaming Interfaces, Protocols and Encodings.
The Telemetry Client and IPDR Collector in the Network Support Services represents only the first stage of the telemetry data processing pipeline within the operator's streaming telemetry back office system. This specification focuses on the definition of the Oss-Ccap interface and streaming of telemetry measurements from the CCAP to the Network Support Services Telemetry Client and/or IPDR Collector. Any further data processing steps after the collection such as how telemetry measurements are stored, how they are further distributed for analysis or archiving, the data analysis, the visualization, or the operational outcomes are outside of the scope of this specification.

- CCAP
  The CCAP is a monitored, or target, network element. The CCAP implements a data model for the Network Support Services to configure the Streaming Telemetry subscriptions and operation. The Telemetry Server in the CCAP Core Northbound Interface accepts subscription configuration from the Network Support Services Telemetry Client via the Oss-Ccap interface. The CCAP also streams telemetry measurements to the Network Support Services Telemetry Client via the Oss-Ccap interface. In the context of Streaming Telemetry, the Oss-Ccap interface between the Telemetry Client and Telemetry Server is realized using gNMI/gRPC/HTTP/2 protocols. Refer to Section 7.5.3, IPDR Streaming Interfaces, Protocols and Encodings for the IPDR/SP protocol operation and specifics on the IPDR Exporter function.

The Cable Modem is shown for context in Figure 80 - CCAP Streaming Telemetry Management Architecture but it does not play a direct role in CCAP Streaming Telemetry. Streaming Telemetry Use Cases are described in Section 5.5.3.6. The diagram presents a logical decomposition of the Streaming Telemetry system components and no conclusions should be drawn from it about the actual network connectivity between the sub-components.

7.5.2 DOCSIS Common Collection Framework Streaming Telemetry for PNM

DOCSIS Common Collection Framework (CCF) fits this model of pushing data to a collector that can aggregate the data and present it to an application using a REST API. Figure 81 illustrates an example where a PNM Server in the back office implements a telemetry collection function based on streaming telemetry protocols (implemented over the Oss-Ccap interface) and data encodings using YANG based PNM models for PNM test measurements. The PNM server provides a northbound interface based on REST APIs for PNM applications to easily consume the PNM measurement data, such as spectrum capture data, for data analysis and display.

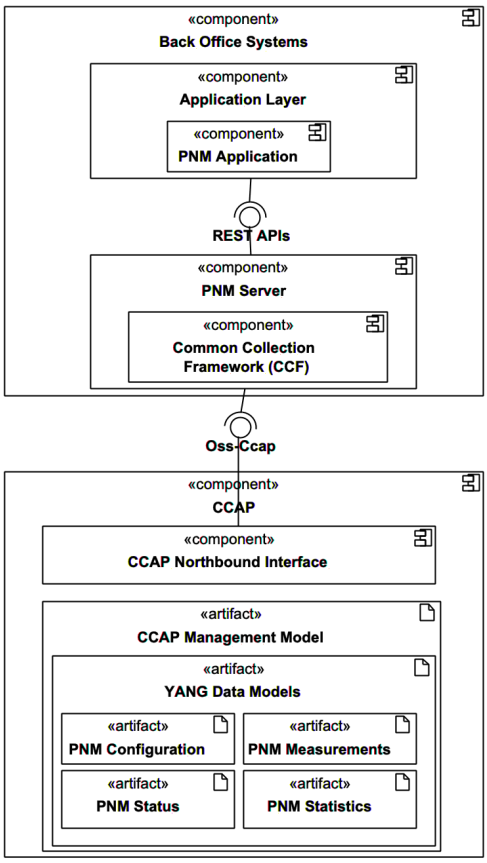


Figure 81 - DOCSIS CCF Streaming Telemetry for PNM

7.5.3 IPDR Streaming Interfaces, Protocols and Encodings

7.5.3.1 Streaming Telemetry IPDR/SP Protocol Stack

7.5.3.1.1 Introduction

This section defines the IPDR Streaming Protocol [IPDR/SP] requirements for the CCAP. Unless otherwise indicated, the term "IPDR Exporter" refers to the CCAP. A collector system is often referred to as an "IPDR Collector" and conforms to [IPDR/BSR] and in particular to [IPDR/SP] specification. IPDR collector management requirements are outside the scope of this specification. See Section 7.5.3.1.2.1, IPDR Network Model for a brief overview of the IPDR Standard.

[IPDR/SP] provides scalable solutions for the collection of high-volume management data related to performance, usage, and operational status of the cable networks. The [IPDR/SP] scalability benefits are for both the CCAP and the data collection systems. The CCAP gains in reduced computing resources, compared with other management protocols, such as SNMP, when generating comparable data sets. The collector systems benefit from [IPDR/SP] by reducing the costs associated with reliable data collection, scalable growth in number of records, and multiple types of data sets over the same collection platform. See [IPDR/SP] for additional information about the streaming protocol design considerations.

The IPDR-related standards listed in Table 477 are supported by CCAP.

Table 482 - IPDR-Related Standards

[IPDR/SP]	IPDR/SP Protocol Specification
[IPDR/BSR]	IPDR Business Solution Requirements - Network Data Management Usage (NDM-U)
[IPDR/SSDG]	IPDR Service Specification Design Guide
[IPDR/XDR]	IPDR/XDR Encoding Format
[IPDR/CAPAB]	IPDR/Capability File Format

7.5.3.1.2 IP Detail Record (IPDR) Standard

[IPDR/SSDG] defines a generic model for using XML Schema in IP Detail Recording applications. [IPDR/XDR] defines the compact binary representation of corresponding IP Detail Records. The following subsections describe the IPDR standard and its application in DOCSIS networks.

7.5.3.1.2.1 IPDR Network Model

The IPDR Network Model is given in the [IPDR/BSR] specification and is portrayed in Figure 82. In this network model, the Service Consumer (SC) is the Cable Data Service Subscriber identified by their Cable Modem MAC address, current CM IP address, and current CPE IP addresses. The Service Element (SE) is the CCAP identified by its host name, IP address, and current value of its sysUpTime object. The IPDR Recorder (IR) is the record formatter and exporter function that creates the data record compliant to [IPDR/BSR] based on the DOCSIS schemas. The IPDR Store (IS) and the IPDR Transmitter (IT) are two kinds of collector functions that receive IPDR XDR records from the IR exporter function as specified in Section 7.5.3.1.3, IPDR Streaming Model. The CCAP implements the IPDR Recorder (IR) functions and is often referred to as the "Exporter". The IT/IS collector functions receive IDPR XDR records on a collection cycle determined by the IR exporter function.

The A-interface is not specified by the [IPDR/BSR] specification because it is an internal interface between the SE and the IR exporter components. The B-interface between the IR exporter and the IT/IS collector components is specified by the IPDR Streaming Protocol [IPDR/SP]. The CCAP supports the B-interface.

NOTE: The highlighted blocks and interfaces depicted in Figure 82 are the only ones defined in this specification. The A, C, D, E, and F interfaces are beyond the scope of this specification.

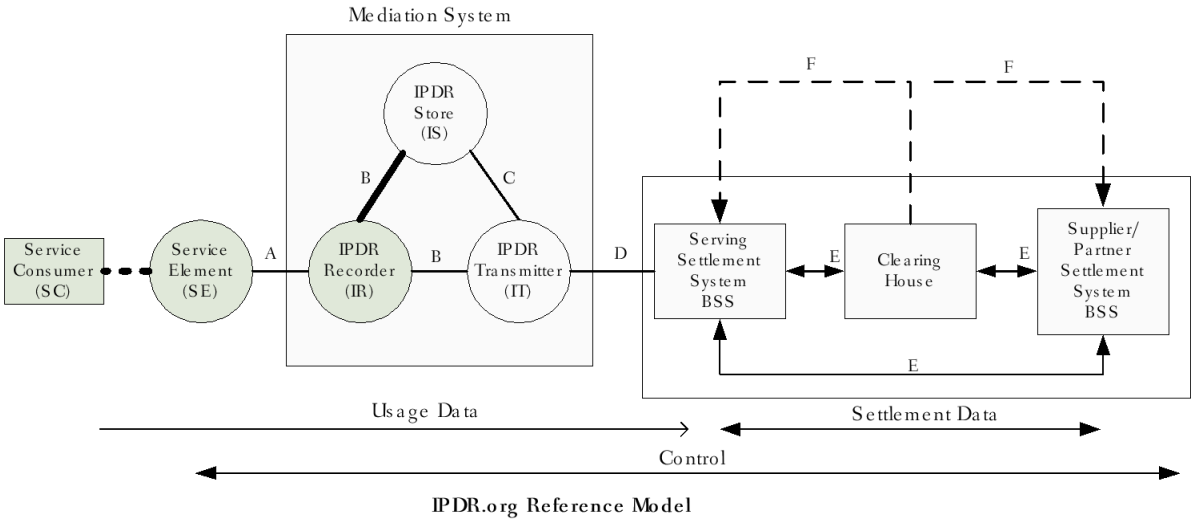


Figure 82 - Basic Network Model (IPDR/BSR)

7.5.3.1.2.2 IPDR Transport High Level Protocol Requirements

To facilitate processing of the DOCSIS IPDR Service Definitions by a large number of mediation systems, an Extensible Markup Language (XML) [W3XML1.0] format is required. Specifically, the IP Detail Record (IPDR) standard as described in [IPDR/BSR] is used to model the DOCSIS IPDR Service Definitions.

To improve the performance of storage and transmission of the BSR XML records, a compression mechanism is required. [IPDR/XDR] describes a compact encoding of IPDR Docs, based on the IETF XDR specification language [RFC 1832].

To improve the network performance of the data collection activity, a reliable high-throughput TCP stream is used to transfer data records between the record formatter and the collection system. Furthermore, at the application layer the streaming protocol [IPDR/SP] described in Section 7.5.3.1.3, IPDR Streaming Model is implemented to scale the collection of data in a reliable manner for both Exporters and Collectors.

To ensure the end-to-end privacy and integrity of the billing records, while either stored or in transit, an authentication and encryption mechanism between the record formatter and the collection system is desirable. The security model is detailed in Section 7.5.3.1.9, IPDR Streaming Protocol Security Model.

7.5.3.1.2.3 IPDR Record Structure

The Master IPDR Schema Document (IPDRDoc) [IPDR/BSR] defines the generic structure of any IPDR document regardless of application. The IPDRDoc defines the hierarchy of elements within an IPDR instance document that are supported by the CCAP as shown in Figure 83 below.

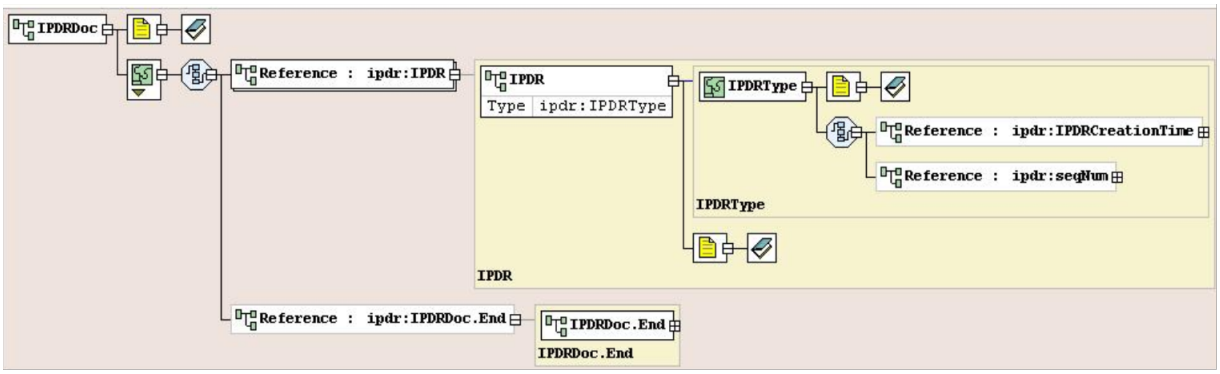


Figure 83 - IPDRDoc 3.5.1 Master Schema

7.5.3.1.2.4 Service Definition Schemas

Service definition schemas are defined based on the guidelines listed in [IPDR/SSDG]. Refer to the applicable Annex as defined in Table 480 for each service definition schema.

7.5.3.1.2.5 Service Definition Instance Documents

To complete the definition of an application-specific IPDR record structure, an application instance schema needs to be provided that imports the basic IPDRDoc master schema (see [IPDR/SSDG]). The IPDRDoc records may be constructed by the Collector for the purpose of storing. The Collector takes the data records and may use the session ID to construct a docId, it depends upon the collector storing IPDR records as IPDR documents, or simulating a docId for the purpose of acknowledging each record as part of a reliable collection process labeled with a docId (accounting of total number of records). Some ways to demark docId could be session start/stop boundaries, but it is Collector implementation specific.

1. The IPDRDoc element is the outermost element that describes the IPDR file itself. It defines the XML namespace, the identity of the XML schema document, the version of the specification, the timestamp for the file, a unique document identifier, and the identity of the IPDR recorder. An IPDRDoc is composed of multiple IPDR records.

The attributes for the IPDRDoc element are defined as follows:

a) xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"

Constant: the IPDR XML namespace identifier.

b) xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"}

Constant: the XML Schema Instance Namespace identifier. Defined by the W3C Consortium.

c) xmlns="http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr" or

xmlns= "http://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr"

Constant: the DOCSIS XML namespace identifier. Defined by CableLabs.

d) xsi:schemaLocation="*.xsd"

Constant: the name of the DOCSIS service definition schema file. Refer to Table 480 for a list of the DOCSIS service definition schema files.

e) version="<IPDR BSR version>-<DOCSIS version>.<schema major version>.<schema minor version>.<schema patch version>"

Constant: the version of the IPDR document defined by Cable Television Laboratories, Inc. This specification follows the convention of:

<IPDR BSR version>-<DOCSIS version>.<schema major version>.<schema minor version>.<schema patch version>.

<IPDR BSR version> is currently 3.7 (refer to [IPDR/BSR]).

IPDR BSR version 3.7 includes support for the new format of docId as described below.

<DOCSIS version> follows the convention defined below:

"A" for DOCSIS 3.0

"B" for DOCSIS 3.1

"C" for DOCSIS 4.0

<schema major version> is the major version number (1..N) of the corresponding service definition schema.

When the major schema version is incremented, the minor and patch version numbers reset to a value of 0 (e.g., 1.1.2 is updated to 2.0.0 with a major version number release).

<schema minor version> is the minor version number (0..N) of the corresponding service definition schema release.

<schema patch version> is the patch version number (0..N) of the corresponding service definition schema release.

The schema major, minor, and patch version number is incremented as described in Table YYY below.

NOTE: The major+minor+patch schema versioning only applies to the 3.7 IPDR BSR version (and later) and DOCSIS versions B (DOCSIS 3.1) and C (DOCSIS 4.0) and later. Existing major schema version numbers will not be reset or rolled back when updating schemas from the IPDR BSR version of 3.5.1 to 3.7. In addition, existing major schema version numbers will not be reset or rolled back when updating schemas from the old versioning scheme to the new versioning scheme. For example:

The third version of a DOCSIS Service Definition schema in compliance with version 3.5.1 of [IPDR/BSR] and DOCSIS 3.1 is defined as "3.5.1-B.3".

When updating this schema with the major+minor+patch versioning scheme and IPDR BSR version, the following versioning is used:

The third version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 3.1 is defined as "3.7-B.3.0.0".

The fourth version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 3.1 is defined as "3.7-B.4".

When updating this schema with the major+minor+patch versioning scheme, the following versioning is used:

The fourth version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 3.1 is defined as "3.7-B.4.0.0".

This major+minor+patch schema versioning does not apply to DOCSIS 3.0 service definition schemas or existing service definitions based on the 3.5.1 IPDR BSR version.

The following examples illustrate the convention used for DOCSIS 3.1 service definition releases:

The third version of a DOCSIS Service Definition schema in compliance with version 3.5.1 of [IPDR/BSR] and DOCSIS 3.0 is defined as "3.5.1-A.3".

The first version of a DOCSIS Service Definition schema in compliance with version 3.5.1 of [IPDR/BSR] and DOCSIS 3.1 is defined as "3.5.1-B.1" and the third version of a DOCSIS 3.0 schema is defined as "3.5.1-A.3".

The first version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 3.1 is defined as "3.7-B.1.0.0".

The second version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 3.1 with a patch version update is defined as "3.7-B.1.0.1".

The third version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 3.1 with a major version update is defined as "3.7-B.2.0.0".

The following examples illustrate the convention used for DOCSIS 4.0 service definition releases:

The first version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 4.0 is defined as "3.7-C.1.0.0".

The second version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 4.0 with a minor version update is defined as "3.7-C.1.1.0".

The third version of a DOCSIS Service Definition schema in compliance with version 3.7 of [IPDR/BSR] and DOCSIS 4.0 with a patch version update is defined as "3.7-C.1.1.1".

The following table illustrates the rules for version number increments.

Table 483 - IPDR Schema Version Number Increment Rules

<table>
<tr><th>IPDR BSR Version</th><th>DOCSIS Version</th><th>Major Schema Version</th><th>Minor Schema Version</th><th>Patch Schema Version</th></tr>
<tr><td><Any></td><td>A (DOCSIS 3.0)</td><td colspan="3">Legacy schema whose elements will not change, but other aspects of the schema are still subject to change. The new versioning scheme applies to all changes.</td></tr>
<tr><td>3.5.1</td><td colspan="4">Legacy schema whose elements will not change, but other aspects of the schema are still subject to change. The new versioning scheme applies to all changes</td></tr>
<tr><td>3.7</td><td>B (DOCSIS 3.1)</td><td rowspan="2">New schema
New elements or removal of elements from existing schemas
Changes to existing elements (in existing schemas)</td><td rowspan="2">Left to vendor implementation
The default value is “0”.</td><td rowspan="2">Grammatical fix
Validation error or Warning fix
No changes to schema data model</td></tr>
<tr><td>3.7</td><td>C (DOCSIS 4.0)</td></tr>
</table>

f) creationTime ="yyyy-mm-ddThh:mm:ssZ"

UTC time stamp at the time the IPDR Record is created (in ISO format). For example: creationTime="2002-06-12T21:11:21Z". Note that IPDR timestamps are always specified in UTC/GMT (Z). The compact representation of this element is the 32-bit unsignedLong value since EPOCH [IPDR/XDR].

g) docId

There are two docId formats specified, the original CableLabs defined UUID and the Version 1 UUID variant as defined in [RFC 4122]. Each format is defined as follows:

docId = "<32-bit UTC timestamp>-0000-0000-0000-<48-bit MAC address>"

The unique document identifier. The CableLabs DOCSIS docId is in a simplified format that is compatible with the Universally Unique Identifier (UUID) format required by the IPDR [IPDR/BSR] specification.

The docId attribute consists of the following:

- The 32-bit UTC timestamp contains the IPDRDoc creationTime in seconds since the epoch 1 Jan 1970 UTC formatted as eight hex digits.
- The 48-bit MAC address component is the Ethernet address of the CCAP management interface formatted as 12 hex digits.
- All other components are set to zero.

In the context of the minimum 15-minute IPDR billing file collection cycle specified in this document, this simplified UUID is guaranteed to be unique across all CCAPs and for the foreseeable future.

The CCAP MUST support the IPDR document docId CableLabs defined UUID format.

docId = Version 1 UUID variant as defined in [RFC 4122]

This field represents a unique document identifier. The docId is in a format that is compatible with the Universally Unique IDentifier (UUID) format required by the IPDR [IPDR/BSR] specification and defined in [RFC 4122].

The docId attribute consists of the following:

- Timestamp
  - The timestamp contains the IPDRDoc creationTime which supports time resolution at the millisecond level (refer to dateTimeMsec in [IPDR/BSR]. Refer to [RFC 4122] for the UUID version 1 format.
- Clock Sequence
  - For UUID version 1, the clock sequence is used to help avoid duplicates that could arise when the clock is set backwards in time or if the node ID changes.
- Node
  - For UUID version 1, the node field consists of an IEEE 802 MAC address component represented as the Ethernet address of the CCAP IPDR Exporter interface.
- All other bits are set to zero.

Refer to section 4 of [RFC 4122] for the UUID version 1 generation algorithm.

The internal representation of a UUID is a specific sequence of bits in memory, as described in section 4 of [RFC 4122]. To accurately represent a UUID as a docId, it is necessary to convert the bit sequence to a string representation. Section 3 of [RFC 4122] describes how to translate a 16 octet UUID into a URN. The docId is the namespace-specific string <NSS> of the URN. The following text from section 3 of [RFC 4122] describes the algorithm for translating the internal representation of a UUID into a string that matches the format of a Universally Unique IDentifier (UUID) format required by the IPDR [IPDR/BSR] specification:

Each field is treated as an integer and has its value printed as a zero-filled hexadecimal digit string with the most significant digit first. The hexadecimal values "a" through "f" are output a lower case characters and are case insensitive on input.

The formal definition of the UUID string representation is provided by the following ABNF:

```
UUID                   = time-low "-" time-mid "-"
    time-high-and-version "-"
    clock-seq-and-reserved
    clock-seq-low "-" node
time-low               = 4hexOctet
time-mid               = 2hexOctet
time-high-and-version  = 2hexOctet
clock-seq-and-reserved = hexOctet
clock-seq-low          = hexOctet
node                   = 6hexOctet
hexOctet               = hexDigit hexDigit
hexDigit =
    "0" / "1" / "2" / "3" / "4" / "5" / "6" / "7" / "8" / "9" /
    "a" / "b" / "c" / "d" / "e" / "f" /
    "A" / "B" / "C" / "D" / "E" / "F"
```

The CCAP SHOULD support the IPDR document docId Version 1 UUID variant [RFC 4122] format.

h) IPDRRecorderInfo="hostname.mso.com"

IPDRRecorderInfo identifies the IPDR Recorder (IR) from the network model in Figure 82. Since the CCAP includes the IPDR Recorder function, the CCAP MUST populate the IPDRRecorderInfo attribute with its fully qualified hostname. If a hostname is not available, then the CCAP MUST populate the IPDRRecorderInfo attribute with its IPv4 address formatted in dotted decimal notation.

2. An IPDR element describes a single DOCSIS service application specific record. The IPDR record is further structured into DOCSIS specific sub elements that describe the details of the CCAP, the subscriber (CM and CPE), and the service application itself. The attributes for the IPDR element are:

xsi:type="*-TYPE"

Constant: identifies the DOCSIS application specific type of the IPDR record. Examples of types based on the DOCSIS Service Definitions listed in Table 480.

In addition to the DOCSIS service specific sub-elements, the following sub-elements for the IPDR element are:

a) IPDRCreationTime

The IPDRCreationTime element identifies the time associated with the counters for this record. The IPDRCreationTime element uses the same format as the IPDRDoc creationTime attribute (see 1f. above). The CCAP MUST NOT support IPDRCreationTime element.

NOTE: This sub element is optional in the basic IPDR 3.5.1 schema and is required by previous DOCSIS specifications. This specification deprecates that requirement and prohibits usage of IPDRCreationTime.

b) seqNum

The CCAP MUST NOT support seqNum elements of the basic IPDR 3.5.1 schema.

NOTE: There is no ordering implied in DOCSIS IPDRs within an IPDRDoc.

3. IPDRDoc.End is the last element inside IPDRDoc. It defines the count of IPDRs that are contained in the file and the ending timestamp for the file creation. The attributes of IPDRDoc.End are:

   a) count="nnnn"

   Where "nnnn" is the decimal count of the number of IPDR records in this IPDRDoc.

   b) endTime ="yyyy-mm-ddThh:mm:ssZ"

   Where endTime is the UTC time stamp at the time the file is completed (see 1f. above).

   For [IPDR/SP] protocol, it is left to the collector to generate IPDRDoc.End based on SessionStop message for a specific docId, see Section 7.5.3.1.6, CCAP IPDR Specifications Support. In addition, IPDRDoc.End is an [IPDR/BSR] optional field and it is included in this section for information purposes with no requirements for CCAPS Exporter.

7.5.3.1.3 IPDR Streaming Model

DOCSIS IPDR Service records are built by the record formatter on the CCAP and are then transmitted to the collection system using the IPDR Streaming Protocol [IPDR/SP].

The [IPDR/SP] Protocol is an application running over a reliable, connection-oriented transport layer protocol such as TCP. It allows exporting high volume of Data Records from a Service Element with an efficient use of network, storage, and processing resources. There are also bi-directional control message exchanges, though they only comprise a small portion of the traffic.

The [IPDR/SP] was built upon two existing specifications, namely IPDR's [IPDR/BSR] [IPDR/XDR] file format and Common Reliable Accounting for Network Elements (CRANE) [RFC 3423].

It enables efficient and reliable delivery of any data, mainly Data Records from Service Elements (the record formatters that are denoted as the "Exporters") to any collection systems (that are denoted as the "Collectors"), such as mediation systems and BSS/OSS.

NOTE: The term "Exporter" corresponds to the CCAP, unless otherwise specified.

Since the IPDR Streaming Protocol could run over different transport layers in future versions, a transport neutral version negotiation is needed. [IPDR/SP] supports a negotiation mechanism running over UDP. Either the Exporter or the Collector could inquire about the Streaming Protocol version and transport layer support by sending a UDP packet on a configured UDP port.

7.5.3.1.4 Sessions and Collector Priorities

A Session is a logical connection between an Exporter and one or more Collectors for the purpose of delivering Data Records. For any given Session, a single active Collector will be targeted with those Data Records. Multiple Sessions may be maintained concurrently in an Exporter or Collector, in which case they are distinguished by Session IDs. For a complete specification of the Sessions, see [IPDR/SP].

A Collector is assigned a Priority value. Data Records need to be delivered to the Collector with the highest Priority value (the primary Collector) within a Session. The Collector Priority reflects the Exporter's preference regarding which Collector will receive Data Records. The assignment of the Collector Priority needs to consider factors such as geographical distance, communication cost, and Collector loading, etc. It is also possible for several Collectors to have the same priority. In this case, the selection method is vendor-specific.

7.5.3.1.5 Documents and Collection Methodologies

The IPDR/SP Protocol provides for open-ended streaming of data records as they are created, or as an option, logical boundaries may also be placed between groups of data records as well. A logical range of data records is called a document. For more information on this topic see [IPDR/SP]. Even though [IPDR/SP] supports the IPDRDoc instance documents requirements, the IPDRDoc is handled by the collector and not by the exporter. The

collector can, for example, create IPDRDoc based on sessions start/stop sequence sent by the exporter, or based on number of records received.

In this specification, an IPDR document is defined as a series of records that were generated during the interval an IPDR session lasted or during a time interval called collection interval. Each DOCSIS IPDR Service Definition has its own requirements in terms of how IPDR documents are generated. For example, [IPDR/SP] sessions are created on a schedule basis, an open-ended session or a per-request session. Below is a list of collection methodologies:

Time Interval Session: The exporter follows a schedule-based session to stream data on a periodic time interval. The collector creates the IPDRDoc within those demarcation points. Note that the Time Interval Session is managed by the exporter as being delimited by session start/stop messages. A collector-initiated flow operation is possible as well; the collector issues Flow Stop messages to stop the exporter streaming. Finally, it is possible to control the Time Interval Session at either end-points. A Time Interval Session may close immediately after the exporter streams the records or remain open until the end of the time interval in which case, the exporter stops the session and starts a new session for the next time interval.

Event Based Session: It consists of an open-ended session or a Time Interval Session. During the time the IPDR session is open the exporter can stream records at any time, thus the name "Event Based Session". In the case of an open-ended session, the collector could create documents based on size, number of records received, timestamps (to simulate Time Interval Sessions), or never creates an IPDRDoc.

Ad-hoc Session: Per request (from a Collector), the Exporter creates a session and closes it when either the data is streamed or a closing command is generated. Once Collector starts flow, CCAP Exporter SHOULD start session, stream data and stop session. The CCAP Exporter can optionally support additional management interface triggers for starting the session.

Some variations of the collection methodologies above include the possibility that an open-ended session demarcated by the collector as IPDR document by time where the records are received.

In cases where periodic records exporting applies (Time Interval Session), the DOCSIS IPDR Service Definition needs to specify the handling of records deleted in the exporter before the scheduled time for data streaming. That is accomplished either with an immediate record if exporter does not want to retain such record in memory or wait until the next periodic interval to report that data. It is also required to distinguish between the record being a periodically exported record or a final record. This specification defines a periodic record as an "interim" record and a final record as a "stop" record.

In cases where a periodic collection session is configured with IPDR records that have different requirements for collection interval, the CCAP MAY restrict the permitted value of the collection interval to match the requirements of one of the records.

7.5.3.1.5.1 Data Types and Message Format

[IPDR/SP] describes its message format using an augmented form of [RFC 1832], External Data Representation (XDR) [IPDR/XDR]. Two augmentations of XDR used by [IPDR/XDR] that enable a more concise and formal C style syntax for describing protocol message formats, are as follows:

- Support for indefinite length specification. This allows for stream-based encoding of information without knowing or calculating the entire length of a message or document in advance. The value of -1 in a length field indicates that, based on Template information, a decoder be able to determine where a message completes.
- No 32-bit alignment padding. Beginning in IPDR 3.5.1, both [IPDR/XDR] and [IPDR/SP] remove the padding constraint specified by XDR. This allows for specification to the byte level of structures. This augmentation is described in [RFC 1832], "Areas for Future Enhancement".

For a complete specification of the [IPDR/SP] message format, see the Message Format section of that specification.

The type IDs for the base types and the derived types used in the protocol, the data structure as well as the data representation are described in the Data Types section of [IPDR/SP] specification.

7.5.3.1.5.2 Templates and Service Definitions

The IPDR/SP Protocol utilizes the concept of Templates in order to eliminate the transmission of redundant information such as field identifiers and typing information on a per data record basis.

A Template is an ordered list of Field Identifiers. A Field Identifier is the specification of a Field in the Template. A Template references an IPDR Service Definition. It specifies a data item that a Service Element (e.g., CCAP) may export. Each Field specifies the Type of the Field. [IPDR/SP] specifies that Templates may be optionally negotiated upon setup of the communication between the Exporter and the Collector. This allows the Exporter to avoid sending Fields that the Collector is not interested in. Several Templates can be used concurrently (for different types of records). Fields contained in a Template could be enabled or disabled. An enabled Field implies that the outgoing data record will contain the data item specified by the key. A disabled Field implies that the outgoing record will omit the specified data item. The enabling/disabling mechanism further reduces bandwidth requirements; it could also reduce processing in Service Elements, as only needed data items are produced. For a complete specification of the IPDR streaming Templates, refer to the Templates section of [IPDR/SP].

The IPDR/SP Protocol incorporates IPDR/Service Definitions [IPDR/SSDG], based on XML-Schema, by reference.

A Template references an IPDR Service Definition document, where a more complete definition of the Template is included. IPDR Service Definitions describe in detail the properties of the various data records and their fields (see Service Specification Design Guide 3.5.1 [IPDR/SSDG].)

7.5.3.1.5.3 Flow Control and Data Reliability

Flow control mechanisms are employed to ensure that data is sent from an Exporter to a Collector only if it is ready to receive data. Four messages are employed to support flow control:

- FlowStart and FlowStop are sent by the Collector to indicate whether it is ready or not ready to receive data.
- SessionStart and SessionStop messages are sent by the Exporter to designate the associated Collector the active/inactive Collector and to provide information about the IPDR document being transmitted within the Session.

Flow control mechanisms are likewise used to indicate to the Collector whether the Exporter considers the Collector to be a primary or backup Collector. The Flow control also provides information on the data sequence numbers and document Id so that the Collectors can collectively guarantee that no Data Records are lost. For the complete specification of the IPDR flow control mechanism refer to the Flow Control section of [IPDR/SP].

To further reduce the likelihood of data loss, IPDR/SP Messages are acknowledged after they have been processed and the record information has been placed in persistent storage. Refer to the Data Transfer section of [IPDR/SP].

7.5.3.1.5.4 DOCSIS IPDR/SP Sequence Diagrams

The Sequence Diagrams in this section map to the IPDR/SP Use Cases for streaming Service Definitions defined in Section 8.3.

The Time Interval based Session Streaming can also be treated as on Ad-hoc streaming flow. Neither these diagrams nor the explanations provided in limit the ability of a Collector or Exporter (CCAP) to be fully compliant with the IPDR Streaming Protocol flow diagram [IPDR/SP]. Note that these Sequence Diagrams model a DocId boundary (established by the IPDR Streaming Session Start/Stop messages) that is used to identify the records created during a collection interval (see Section 7.5.3.1.5, Documents and Collection Methodologies). A single continuously open session/document will span a single collection interval and will be closed at the end of the interval. Figure 84 represents a complete IPDR session/document and assumes the model of periodic data streaming with Interim and Stop records. Each entity instance of the DOCSIS IPDR Service will include one or more Interim records and one Stop record when the entity in the DOCSIS IPDR service is deleted. If a Service entity instance is both created and deleted within the same collection interval, then only a single Stop record is exported.

Since the collection interval may be up to 24 hours long, it is likely that Keep Alive messages will be sent periodically to indicate that the session/document is still open but there are no Stop records to export at the moment. Later, at the end of the collection interval, the current session/document is terminated with a Session Stop message, a new DocId is created, and the next session/document is started with a Session Start message.

NOTE: The Sequence Diagrams illustrated in this section do not include the mandatory Keep Alive messages.

7.5.3.1.5.4.1 IPDR/SP Time Interval Session Sequence Diagrams

This Sequence Diagram provides example message flows for the IPDR/SP Time Interval based session streaming where the Collector initiates the connection. Refer to the Event Session Sequence Diagram for an example of a CCAP Exporter initiated connection.

The sequence of steps, as illustrated in Figure 84 - IPDR/SP Streaming Telemetry Time Interval Session Sequence Diagram, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the CCAP's IPDR/SP Exporter feature by enabling the function.
2. The back office application configures the CCAP with the IPDR/SP Collector details including the unique Collector Id, Collector IP Address and Priority set to the Primary Collector. Provisioning of the IPDR/SP Collector is not in scope of this specification.
3. The back office application configures the IPDR/SP Session details including the unique Session Id, the Collection Interval of 15 minutes, and the Session Type of 'timeInterval'. This step completes the IPDR/SP configuration in the CCAP.
4. Prior to establishing a streaming connection, the Collector can query the CCAP Exporter for Streaming protocol version and transport layer support as part of the Version Discovery Phase. Messages are sent as UDP packets on an agreed on UDP Port. This step is optional, and can also be initiated by the Exporter.
5. The CCAP Exporter responds to the UDP Version Request message by sending a UDP Version Response message indicating the supported protocol version, transport type and port number used for the specified transport.
6. The Collector initiates the TCP Connection by sending the SYN message on Port 4737 as part of the TCP Connection Establishment Phase.
7. The CCAP Exporter responds to the TCP SYN message with the SYN-ACK message.
8. The Collector sends the final TCP ACK message to complete TCP connection establishment.
9. Since the Collector initiated the TCP connection, the Collector sends the Connect message which specifies the capabilities flags and Keep Alive interval.
10. The CCAP Exporter responds to the Connect message with the Connect Response message which includes the desired Keep Alive interval and capabilities flags.
11. The Collector can send the Get Sessions message to identify the streams of records available on each stream provided by the CCAP Exporter. This is an optional step.
12. The CCAP Exporter responds to the Get Sessions message with the Get Sessions Response message which includes the list of Sessions, and their descriptions, available to the Collector. This Sessions list can be used by the Collector to issue Get Templates messages for specific Sessions of interest. In this example, the CCAP returns a Session Type of 'Time Interval(1)'.
13. The Collector sends the Flow Start message to indicate its willingness to participate in a Session for a particular stream of records. This starts the Session Initiation Phase where the Collector is now ready to start receiving data.
14. After receiving the Flow Start message and before establishment of a Session, the CCAP Exporter sends the Template Data message to initiate the Template Publish and optional Template Negotiation Phase. This message includes a flag whether Template Data is negotiable. The Template block identifies all the Templates that will be used over this Session.
15. If the Collector received a negotiable Template Data message from the CCAP, the Collector can send the Modify Template message in order to alter the set of records and their fields which will be transferred. This is an optional step.

16. The CCAP Exporter responds to the Template Data message with the Modify Template Response message. The CCAP Exporter is not obligated to recognize any of the proposed changes in the Template Data message. The Modify Template Response message indicates the set of Templates for that Session after applying any approved changes in the Modify Template message received from the Collector.
17. The Collector sends the Final Template Data Ack message to indicate it is satisfied with the received Template Data message and does not require a negotiation or to confirm that it received the Modify Template Data Response message and it is ready to begin a Session-based delivery of records. This step completes the Template Publish and optional Template Negotiation Phase.
18. When the CCAP is ready to stream data based on the collection interval 't' trigger, it sends the Session Start message indicating streamed data follows.
19. The CCAP Exporter streams the IPDR Service Definition record with a RecType of Interm and an IPDRDoc.docId of ID1 data to the Collector with the Data message. The Session Id is carried in the message header.
20. Additional Data messages are sent in the context of a Session. A sequence number does data acknowledgement on a configured window of outstanding Data messages as determined by the CCAP Exporter. The Exporter also specifies the minimal ack interval to ensure timely acknowledgements in the case where data streaming volumes are low.
21. The Collector sends a Data Acknowledge message to indicate the data has been received and handled. The CCAP Exporter no longer has to be responsible for the Data messages which were acknowledged.
22. While the CCAP Exporter has collection interval 't' data records to stream and the Session is active, it sends Data messages.
23. While the CCAP Exporter has collection interval 't' data records to stream and the Session is active, it sends Data messages.
24. The Collector continues to acknowledge the received Data records.
25. Once the CCAP Exporter finishes streaming the collection interval 't' data records, it sends a Session Stop message to terminate the active Session with the Collector with the standard IPDR/SP reason code of 'end of IPDRDoc'.
26. When the CCAP is ready to stream data based on the collection interval 't+1' trigger, it sends the Session Start message indicating streamed data follows.
27. The CCAP Exporter streams the IPDR Service Definition record with a RecType of Interm and a IPDRDoc.docId of ID2 data to the Collector with the Data message. The Session Id is carried in the message header.
28. Additional Data messages are sent in the context of a Session. A sequence number does data acknowledgement on a configured window of outstanding Data messages as determined by the CCAP Exporter. The Exporter also specifies the minimal ack interval to ensure timely acknowledgements in the case where data streaming volumes are low.
29. The Collector sends a Data Acknowledge message to indicate the data has been received and handled. The CCAP Exporter no longer has to be responsible for the Data messages which were acknowledged.
30. While the CCAP Exporter has collection interval 't+1' data records to stream and the Session is active, it sends Data messages.
31. While the CCAP Exporter has collection interval 't+1' data records to stream and the Session is active, it sends Data messages.
32. The Collector continues to acknowledge the received Data records.
33. Once the CCAP Exporter finishes streaming the collection interval 't+1' data records, it sends a Session Stop message to terminate the active Session with the Collector with the standard IPDR/SP reason code of 'end of IPDRDoc'. Steps 26 to 33 are repeated for future collection intervals 't+n'.

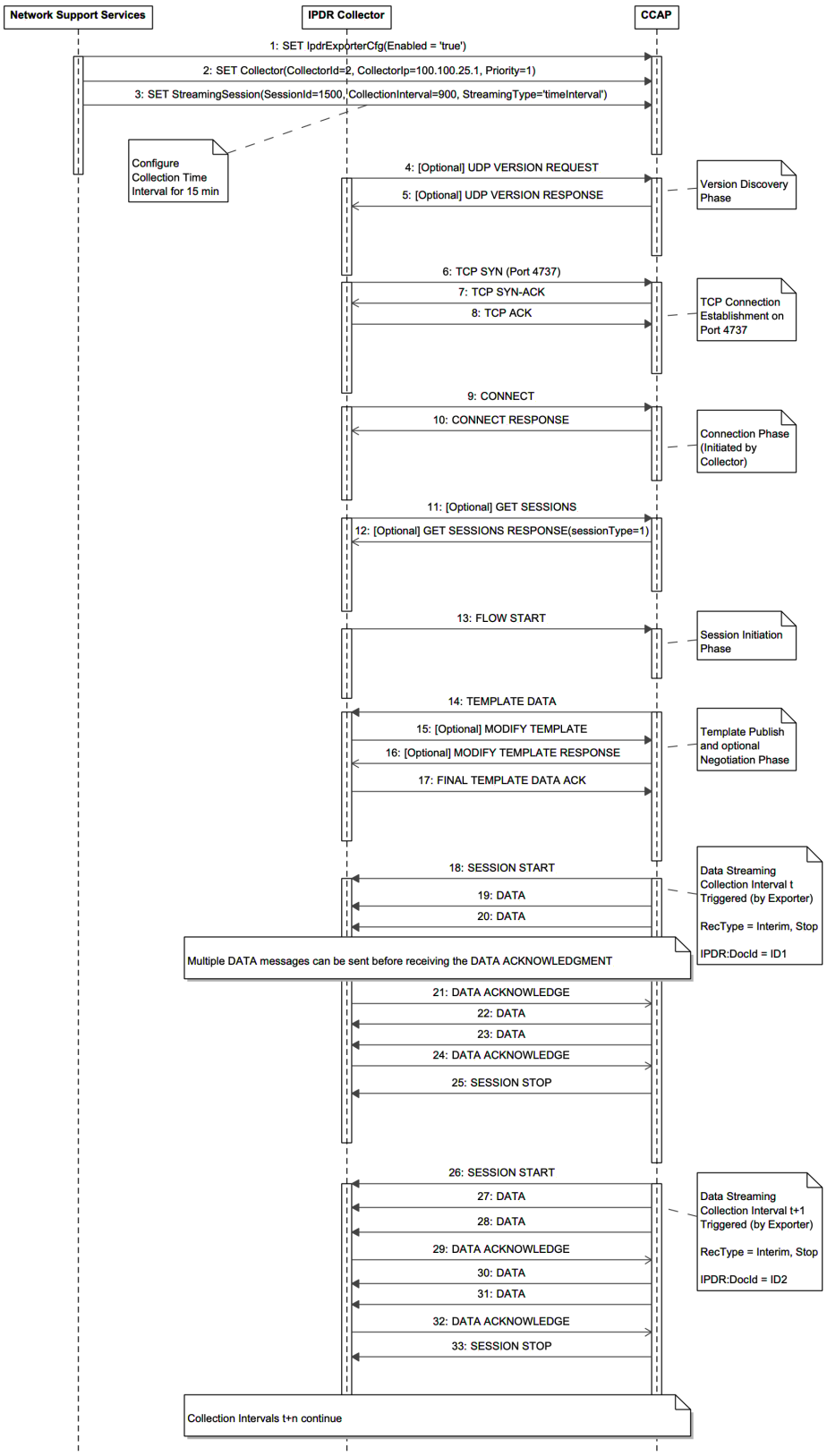


Figure 84 - IPDR/SP Streaming Telemetry Time Interval Session Sequence Diagram

7.5.3.1.5.4.2 IPDR/SP Event Session Sequence Diagram

This Sequence Diagram provides example message flows for the IPDR/SP Event based session streaming where the CCAP Exporter initiates the connection.

The sequence of steps, as illustrated in Figure 85 - IPDR/SP Streaming Telemetry Event Session Sequence Diagram, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the CCAP's IPDR/SP Exporter feature by enabling the function.
2. The back office application configures the CCAP with the IPDR/SP Collector details including the unique Collector Id, Collector IP Address and Priority set to the Primary Collector. Provisioning of the IPDR/SP Collector is not in scope of this specification.
3. The back office application configures the IPDR/SP Session details including the unique Session Id and the Session Type of 'event'. This step completes the IPDR/SP configuration in the CCAP.
4. Prior to establishing a streaming connection, the Collector can query the CCAP Exporter for Streaming protocol version and transport layer support as part of the Version Discovery Phase. Messages are sent as UDP packets on an agreed on UDP Port. This step is optional, and can also be initiated by the Exporter.
5. The CCAP Exporter responds to the UDP Version Request message by sending a UDP Version Response message indicating the supported protocol version, transport type and port number used for the specified transport.
6. The CCAP Exporter initiates the TCP Connection by sending the SYN message on Port 4737 as part of the TCP Connection Establishment Phase.
7. The Collector responds to the TCP SYN message with the SYN-ACK message.
8. The CCAP Exporter sends the final TCP ACK message to complete TCP connection establishment.
9. Since the CCAP Exporter initiated the TCP connection, the CCAP Exporter sends the Connect message which specifies the capabilities flags and Keep Alive interval.
10. The Collector responds to the Connect message with the Connect Response message which includes the desired Keep Alive interval and capabilities flags.
11. The Collector can send the Get Sessions message to identify the streams of records available on each stream provided by the CCAP Exporter. This is an optional step.
12. The CCAP Exporter responds to the Get Sessions message with the Get Sessions Response message which includes the list of Sessions, and their descriptions, available to the Collector. This Sessions list can be used by the Collector to issue Get Templates messages for specific Sessions of interest. In this example, the CCAP returns a Session Type of 'Event(3)'.
13. The Collector sends the Flow Start message to indicate its willingness to participate in a Session for a particular stream of records. This starts the Session Initiation Phase where the Collector is now ready to start receiving data.
14. After receiving the Flow Start message and before establishment of a Session, the CCAP Exporter sends the Template Data message to initiate the Template Publish and optional Template Negotiation Phase. This message includes a flag whether Template Data is negotiable. The Template block identifies all the Templates that will be used over this Session.
15. If the Collector received a negotiable Template Data message from the CCAP, the Collector can send the Modify Template message in order to alter the set of records and their fields which will be transferred. This is an optional step.
16. The CCAP Exporter responds to the Template Data message with the Modify Template Response message. The CCAP Exporter is not obligated to recognize any of the proposed changes in the Template Data message. The Modify Template Response message indicates the set of Templates for that Session after applying any approved changes in the Modify Template message received from the Collector.

17. The Collector sends the Final Template Data Ack message to indicate it is satisfied with the received Template Data message and does not require a negotiation or to confirm that it received the Modify Template Data Response message and it is ready to begin a Session-based delivery of records. This step completes the Template Publish and optional Template Negotiation Phase.
18. When the CCAP is ready to send data based on an Event-based collection trigger, it sends the Session Start message indicating streamed data follows.
19. The CCAP Exporter streams the IPDR Service Definition record data to the Collector with the Data message. The Session Id is carried in the message header.
20. Additional Data messages are sent in the context of a Session. A sequence number does data acknowledgement on a configured window of outstanding Data messages as determined by the CCAP Exporter. The Exporter also specifies the minimal ack interval to ensure timely acknowledgements in the case where data streaming volumes are low.
21. The Collector sends a Data Acknowledge message to indicate the data has been received and handled. The CCAP Exporter no longer has to be responsible for the Data messages which were acknowledged.
22. While the CCAP Exporter has data records to stream and the Session is active, it sends Data messages.
23. The Collector continues to acknowledge the received Data records.
24. When necessary, the Exporter can send a Session Stop message to terminate the active Session with the Collector. The Session Stop message contains a standard IPDR/SP reason code (e.g., end of data for Session) or vendor-specific code.

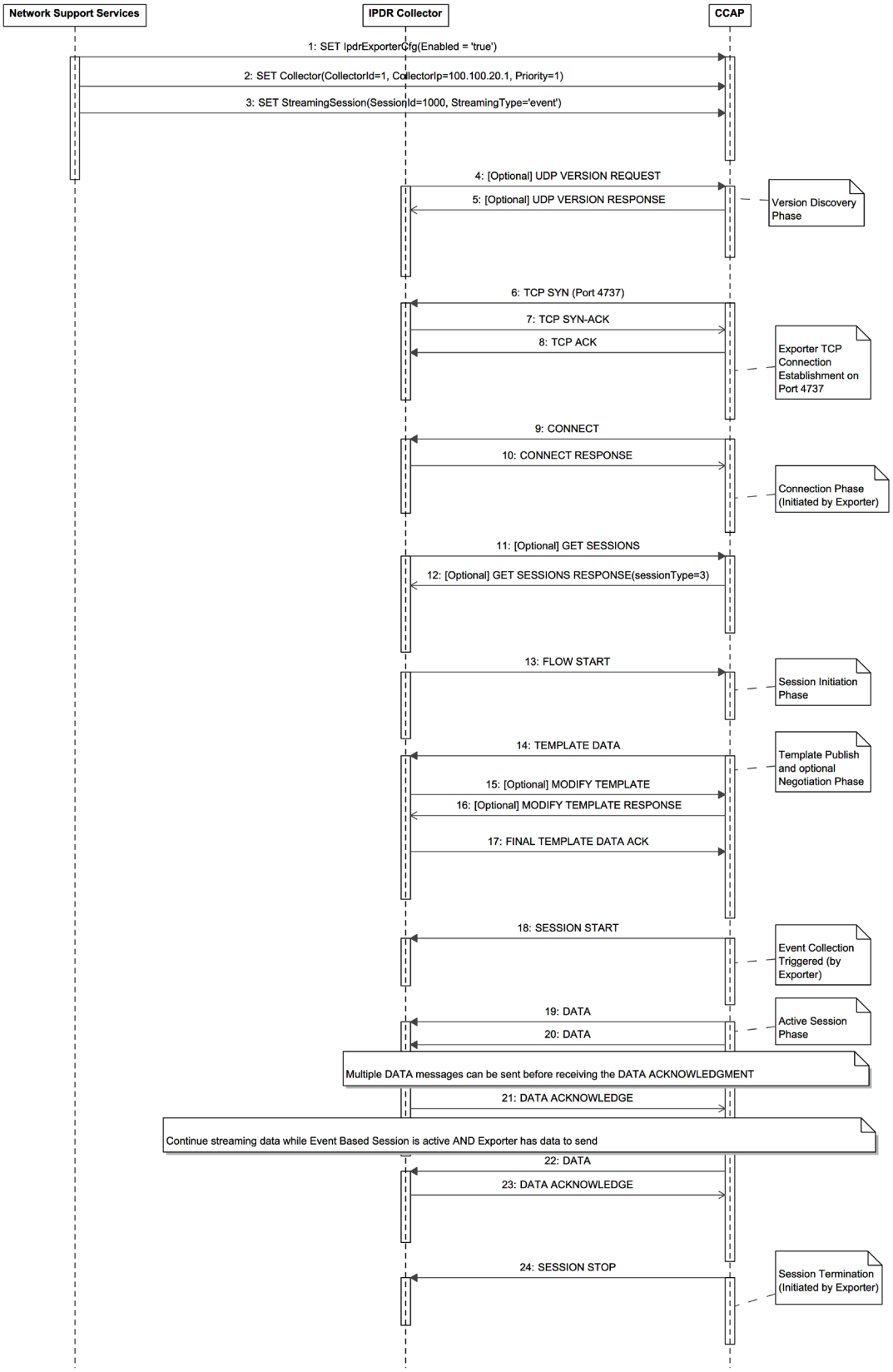


Figure 85 - IPDR/SP Streaming Telemetry Event Session Sequence Diagram

7.5.3.1.5.4.3 IPDR/SP Ad-hoc Session Sequence Diagram

This Sequence Diagram provides example message flows for the IPDR/SP Ad-hoc session streaming where the Collector initiates the connection.

The sequence of steps, as illustrated in Figure 86 - IPDR/SP Streaming Telemetry Ad-hoc Session Sequence Diagram, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the CCAP's IPDR/SP Exporter feature by enabling the function.
2. The back office application configures the CCAP with the IPDR/SP Collector details including the unique Collector Id, Collector IP Address and Priority set to the Primary Collector. Provisioning of the IPDR/SP Collector is not in scope of this specification.
3. The back office application configures the IPDR/SP Session details including the unique Session Id and the Session Type of 'adHoc'. This step completes the IPDR/SP configuration in the CCAP. Refer to the Time Interval Session Sequence Diagram for step definitions for IPDR Version Discovery and TCP Connection.
4. Since the Collector initiated the TCP connection, the Collector sends the Connect message which specifies the capabilities flags and Keep Alive interval.
5. The CCAP Exporter responds to the Connect message with the Connect Response message which includes the desired Keep Alive interval and capabilities flags.
6. The Collector can send the Get Sessions message to identify the streams of records available on each stream provided by the CCAP Exporter. This is an optional step.
7. The CCAP Exporter responds to the Get Sessions message with the Get Sessions Response message which includes the list of Sessions, and their descriptions, available to the Collector. This Sessions list can be used by the Collector to issue Get Templates messages for specific Sessions of interest. In this example, the CCAP returns a Session Type of 'Ad-hoc(2)'.
8. The Collector can send the Get Templates message to identify the available Templates for a given Session. This is an optional step.
9. The CCAP Exporter responds to the Get Templates message with the Get Templates Response message for any valid Session which the Collector is allowed to consume.
10. The Collector sends the Flow Start message to indicate its willingness to participate in a Session for a particular stream of records. This starts the Session Initiation Phase where the Collector is now ready to start receiving data.
11. After receiving the Flow Start message and before establishment of a Session, the CCAP Exporter sends the Template Data message to initiate the Template Publish Phase. This message includes a flag whether Template Data is negotiable. The Template block identifies all the Templates that will be used over this Session.
12. The Collector sends the Final Template Data Ack message to indicate it is satisfied with the received Template Data message and does not require a negotiation and it is ready to begin a Session-based delivery of records. This step completes the Template Publish Phase.
13. When the CCAP is ready to send data based on an Ad-hoc Collection N trigger, it sends the Session Start message indicating streamed data follows. For this session, the IPDRDoc contains the DocId of 'ID1'.
14. The CCAP Exporter streams the IPDR Service Definition record data to the Collector with the Data message. The Session Id is carried in the message header.
15. Additional Data messages are sent in the context of a Session. A sequence number does data acknowledgement on a configured window of outstanding Data messages as determined by the CCAP Exporter. The Exporter also specifies the minimal ack interval to ensure timely acknowledgements in the case where data streaming volumes are low.

16. The Collector sends a Data Acknowledge message to indicate the data has been received and handled. The CCAP Exporter no longer has to be responsible for the Data messages which were acknowledged.
17. While the CCAP Exporter has data records to stream and the Session is active, it sends Data messages.
18. While the CCAP Exporter has data records to stream and the Session is active, it sends Data messages.
19. The Collector continues to acknowledge the received Data records.
20. When the Exported completes the data stream for Collection N, the Exporter sends a Session Stop message to terminate the active Session with the Collector. The Session Stop message contains a standard IPDR/SP reason code (e.g., end of data for Session) or vendor-specific code. This completes the stream for IPDRDoc.DocId = ID1.
21. The Collector sends the Flow Stop message to indicate that it is no longer able to participate in the Session.
22. The Collector then closes the TCP connection.
23. For the next Collection N+1, the Collector initiates the TCP connection and sends the Connect message.
24. The CCAP Exporter responds to the Connect message with the Connect Response message. Refer to the step descriptions above for the optional Get Sessions and Get Templates message exchange.
25. The Collector sends the Flow Start message to indicate its willingness to participate in a new Session for a the Collection N+1 stream of records. This starts the Session Initiation Phase where the Collector is now ready to start receiving data.
26. After receiving the Flow Start message and before establishment of a Session, the CCAP Exporter sends the Template Data message to initiate the Template Publish Phase. This message includes a flag whether Template Data is negotiable. The Template block identifies all the Templates that will be used over this Session.
27. The Collector sends the Final Template Data Ack message to indicate it is satisfied with the received Template Data message and does not require a negotiation and it is ready to begin a Session-based delivery of records. This step completes the Template Publish Phase.
28. When the CCAP is ready to send data based on an Ad-hoc Collection N+1 trigger, it sends the Session Start message indicating streamed data follows. For this session, the IPDRDoc contains the DocId of ‘ID2’.
29. The CCAP Exporter streams the IPDR Service Definition record data to the Collector with the Data message. The Session Id is carried in the message header.
30. Additional Data messages are sent in the context of a Session. A sequence number does data acknowledgement on a configured window of outstanding Data messages as determined by the CCAP Exporter. The Exporter also specifies the minimal ack interval to ensure timely acknowledgements in the case where data streaming volumes are low.
31. The Collector sends a Data Acknowledge message to indicate the data has been received and handled. The CCAP Exporter no longer has to be responsible for the Data messages which were acknowledged.
32. While the CCAP Exporter has data records to stream and the Session is active, it sends Data messages.
33. While the CCAP Exporter has data records to stream and the Session is active, it sends Data messages.
34. The Collector continues to acknowledge the received Data records.
35. When the Exported completes the data stream for Collection N+1, the Exporter sends a Session Stop message to terminate the active Session with the Collector. The Session Stop message contains a standard IPDR/SP reason code (e.g., end of data for Session) or vendor-specific code. This completes the stream for IPDRDoc.DocId = ID2.

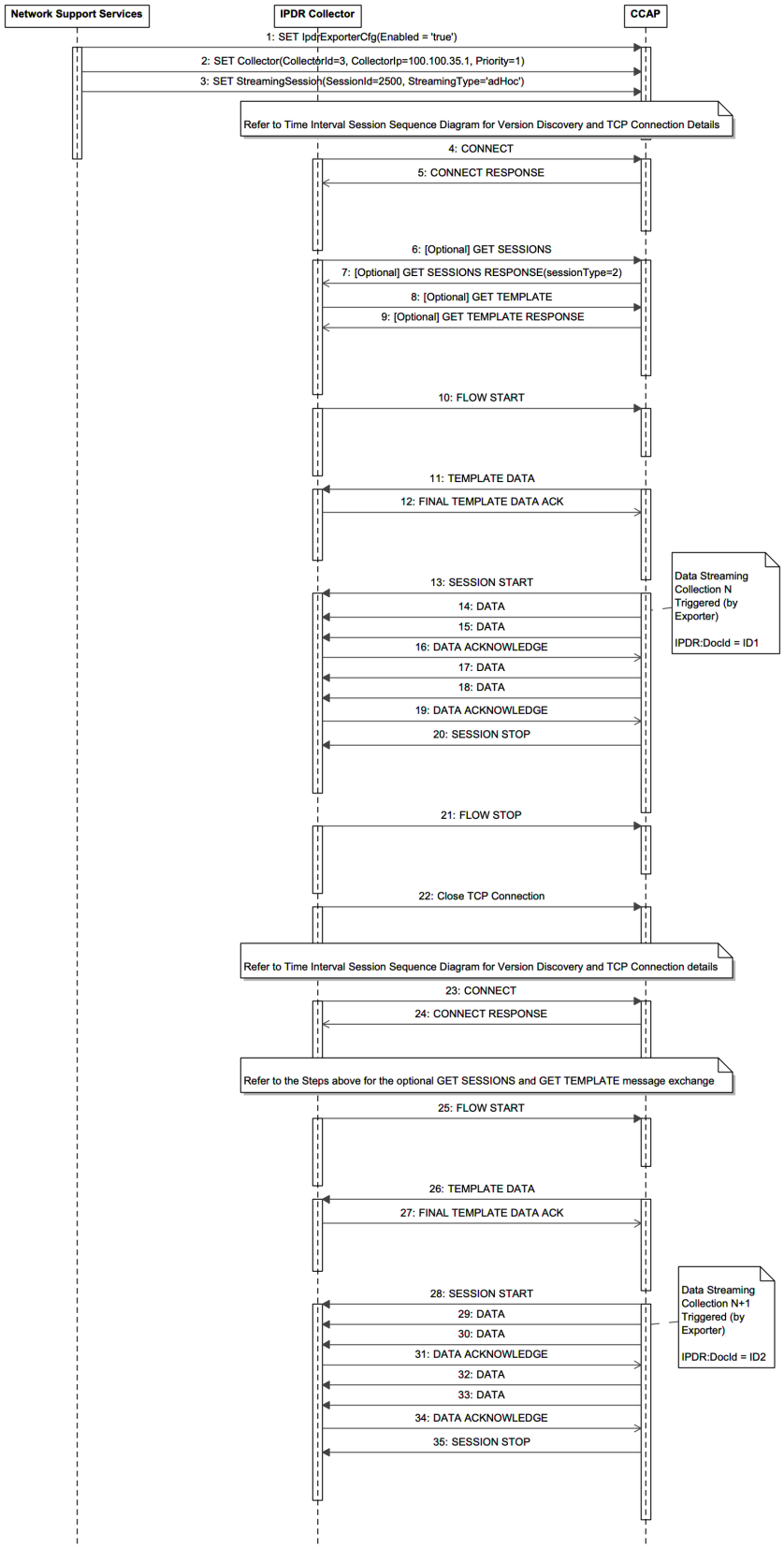


Figure 86 - IPDR/SP Streaming Telemetry Ad-hoc Session Sequence Diagram

7.5.3.1.5.4.4 IPDR/SP Multisession Streaming Sequence Diagram

Figure 87 - Sequence Diagram for a Multisession Streaming Example shows typical interaction between Collector and Exporter when multiple sessions are used. In this particular example Collector uses ad-hoc and event-based session ("Session 1" and "Session 3" respectively) to retrieve initial state and subsequent changes of CMTS-TOPOLOGY. Another time interval-based session ("Session 2") is used for SAMIS-TYPE-2 service. This example has the following assumptions:

- The event session is a time interval session
- The CCAP time interval is in sync with the wall clock. Sessions 2 and 3 have the same time interval t.
- Keep Alive, Data Ack and other messages are omitted for clarity the example.
- Each IPDR session is carried in a separated IPDR connection.

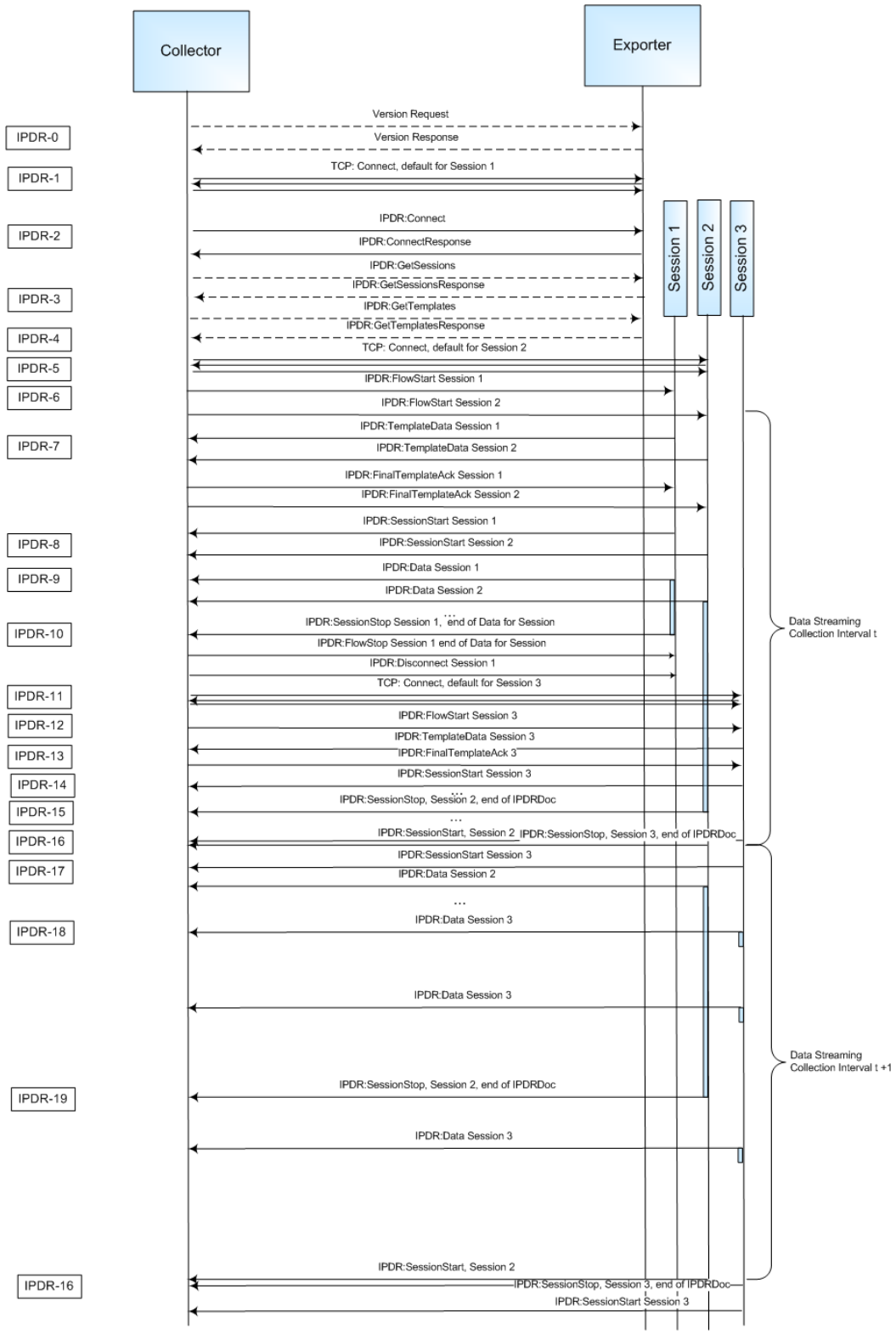


Figure 87 - Sequence Diagram for a Multisession Streaming Example

Table 484 - Multisession Streaming Example Sequence Diagram Details

Identifier	Streaming Sequence Diagram Description
IPDR-0	Prior to Streaming Connection, Collector may query Exporter (CCAP) for version request (discovery).
IPDR-1	Collector initiates the TCP connection: Port 4737. This connection will carry session 1.
IPDR-2	Collector sends IPDR Connect message, sets capabilities flags and KeepAlive value. Exporter (CCAP) replies with IPDR ConnectResponse message.
IPDR-3	Collector may request Sessions description to know what session ID and associated templates to use for streaming by GetSessions message request. Exporter (CCAP) replies with the GetSessionsResponse message.
IPDR-4	Collector requests templates to make sure they match expected configuration. Exporter (CCAP) replies with the GetTemplatesResponse message.
IPDR-5	Collector initiates the second TCP connection: Port 4737 for session 2.
IPDR-6	Collector is ready to start receiving data. Collector sends IPDR FlowStart messages for sessions 1 and 2.
IPDR-7	Exporter (CCAP) sends a TemplateData messages for sessions 1 and 2. Collector responds with FinalTemplateData message.
IPDR-8	Exporter (CCAP) starts the Sessions 1 and 2 by sending IPDR SessionStart message.
IPDR-9	Exporter (CCAP) sends data for Sessions 1 and 2.
IPDR-10	Exporter (CCAP) closes the IPDR Session 1 with a SessionStop and reasonCode 'end of data for session'. Subsequently the Exporter sends FlowStop and Disconnect message.
IPDR-11	Collector initiates the TCP connection: Port 4737 for session 3
IPDR-12	Collector previously knew the IPDR Service Definition sessions and the associated templates. Therefore, the Collector is ready to start receiving data and sends IPDR FlowStart message for session 3.
IPDR-13	Exporter (CCAP) sends a TemplateData messages for session 3. Collector responds with FinalTemplateData message.
IPDR-14	Exporter (CCAP) starts the Session 3 by sending IPDR SessionStart message.
IPDR-15	When there is no more data for the Exporter (CCAP) to send for session 2, the Exporter sends a SessionStop message with reasonCode 'end of IPDRDoc'. The Exporter maintains the connection waiting for the next time interval for Session 2.
IPDR-16	At the time of the expire of the time interval session 3 is terminated with message SessionStop and reasonCode 'end of IPDRDoc'. Around the same time new IPDR SessionStart messages for sessions 2,3 and sent by the Exporter.
IPDR-17	Exporter (CCAP) sends data for Session 2.
IPDR-18	When available, IPDR data for session 3 is sent by the Exporter (CCAP).
IPDR-19	When there is no more data for the Exporter (CCAP) to send for session 2, the Exporter sends a SessionStop message with reasonCode 'end of IPDRDoc'. The Exporter maintains the connection waiting for the next time interval for Session 2.
IPDR-20	The process continues on IPDR-16 for the closure of session data for the expiring interface and initiate the next cycle.

7.5.3.1.5.5 IPDRDoc Mapping for DOCSIS IPDR Streaming

The IPDRDoc records may be constructed by the Collector for the purpose of storing or to be communicated to other instances through the Collector's D-interface mentioned in Section 7.5.3.1.2.1, IPDR Network Model. The IPDRDoc is identified by a docId that is used to tag all of the IPDR records contained within the document. To do so, IPDRDoc in [IPDR/SP] is scoped to the IPDR/SP Session boundary as described in Section 7.5.3.1.5.4, DOCSIS IPDR/SP Sequence Diagrams and the IPDR/SP transport elements listed in Table 479 below.

Table 485 - IPDRDoc Element/Attribute Mapping

Element or Attribute of IPDRDoc	IPDR/SP Mapping
docId	IPDR:SP:SessionStart:documentId (see Section 7.5.3.1.2.5, Service Definition Instance Documents, item 1.g)
version	3.5.1-A.1; In general this field contains the version content of the schemaName of the first TemplateBlock within a negotiated Template after FinalTemplateDataAck
creationTime	IPDR:SP:SessionStartExporterBootTime
IPDRRecorderInfo	reverse DNS lookup of Exporter IP
IPDRType	Refer to the Data Type section of [IPDR/SP]
ipdr:IPDRCreationTime	Not supported (see Section 7.5.3.1.2.5, Service Definition Instance Documents)
ipdr:seqNum	Not supported (see Section 7.5.3.1.2.5, Service Definition Instance Documents) IPDR reliable transport is handled via IPDR:SP:DataSequenceNum
IPDRDoc.End (optional)	
Count	reflect number of records After closing the Session (Session Stop): IPDR:SP:DataAcknowledge:SequenceNumber - IPDR:SP:SessionStart:FirstRecordSequenceNumber
endTime	Time since epoch time when SessionStop was received

7.5.3.1.5.6 Message Detail and IDL Definition

The complete message set defined for IPDR/SP and the normative IDL specification for constructing IPDR/SP messages are defined in [IPDR/SP].

7.5.3.1.6 CCAP IPDR Specifications Support

The CCAP MUST support [IPDR/SP] as the transport mechanism for all DOCSIS Service Definitions.

The CCAP MUST support data records encoded in IPDR/XDR Encoding Format, per the [IPDR/XDR] specification.

The CCAP MAY support the UDP-based Service Discovery Protocol described in the IPDR Streaming Protocol section in [IPDR/SP].

The CCAP MAY support the advertisement upon request of IPDR capabilities as described in [IPDR/CAPAB]. The retrieval of this file is vendor-dependent. The same information is available by the Service Discovery described above.

7.5.3.1.6.1 IPDR Streaming Protocol

The CCAP MUST support the minimum conformance feature set for the IPDR Streaming Protocol as follows:

7.5.3.1.6.1.1 IPDR/SP Transport Protocol

The CCAP MUST support IPDR Streaming Protocol [IPDR/SP] over TCP.

7.5.3.1.6.1.2 IPDR/SP Service Discovery

Either the Collector or the Exporter can optionally inquire about the IPDR/SP version and transport layer support by sending UDP packets on an agreed UDP port. The VERSION REQUEST and VERSION RESPONSE IPDR/SP messages [IPDR/SP] are used to perform IPDR/SP Service Discovery before a connection is initiated.

The CCAP SHOULD support IPDR version discovery initiated by the Collector as specified in [IPDR/SP].

The CCAP SHOULD support Exporter-initiated IPDR version discovery to an IPDR Collector as specified in [IPDR/SP].

7.5.3.1.6.1.3 IPDR/SP Connection Establishment

The IPDR/SP state machine [IPDR/SP] allows either the Exporter or the Collector to initiate the IPDR TCP connection and thereby the IPDR connection itself. The creator of the underlying reliable transport (e.g., TCP) connection sends the IPDR CONNECT message.

The CCAP MUST support IPDR connections initiated by the Collector, subject to authorization access controls, as specified in [IPDR/SP].

The CCAP MUST support Exporter-initiated connections to an IPDR Collector as specified in [IPDR/SP].

7.5.3.1.6.1.4 Streaming Flow Control and Messaging

[IPDR/SP] defines three main states in its model: 1) Connection, 2) Flow and 3) Session. Connections are initiated by either Collectors or Exporters. Flows are initiated by Collectors only and Sessions are initiated by Exporters (CCAPs) only. See Table 1 *IPDR/SP Messages* of [IPDR/SP] for details on message direction.

7.5.3.1.6.1.4.1 Streaming Flow Connection and Messaging

The CCAP MUST support a minimum of two IPDR streaming connections.

IPDR streaming includes Template Negotiation allowing Collectors to adjust the data streams to include only the information that is relevant to their systems. The CCAP SHOULD support Template Negotiation for any supported Service Definition; the support of the IPDR/SP message MODIFY TEMPLATE RESPONSE is recommended.

If the CCAP implements Template Negotiation capability, then all messages within the Template Negotiation phase MUST be supported as described in the Protocol Sequence section of [IPDR/SP].

If the CCAP does not implement Template Negotiation, a Collector MODIFY TEMPLATE message MUST be replied to with a MODIFY TEMPLATE RESPONSE having a preconfigured Template Set as described in [IPDR/SP].

The CCAP MAY support IPDR Capability File Negotiation.

If the CCAP supports IPDR Capability File Negotiation, then Communication Negotiation MUST be supported. Communication Negotiation allows the Exporter and the Collector to negotiate communication parameters. The Communication Negotiation allows both the Collector and the Exporter to acknowledge that they are capable of participating in the exchange of records via IPDR Streaming as and identify their ability to support optional protocol capabilities.

7.5.3.1.6.1.4.2 Streaming Flow Sessions

The CCAP MUST support a minimum of one Data Streaming Session per connection.

The CCAP MUST handle a minimum of one Template per Session, which is transmitted to the Collector via the TEMPLATE DATA message as described in [IPDR/SP].

See Section 7.5.3.1.3. IPDR Streaming Model for the definition of the relationship between IPDR/SP Sessions, [IPDR/XDR] documents, and collection intervals.

7.5.3.1.6.1.5 Records Collection

A particular Service Definition supports ad-hoc, and event or time interval-based data collection in order for the Collector to retrieve initial state through the ad-hoc session followed by subsequent updates through the event or time interval based session.

A typical scenario is for example the IPDR Service Definition CMTS-TOPOLOGY-TYPE that supports ad-hoc and event-based sessions. The ad-hoc session allows the Collector to obtain initial topology, and the event-based session to obtain subsequent topology updates. To allow a Collector to perform timely synchronous processing of SAMIS flow records (e.g., SAMIS-TYPE-2) along with corresponding topology records, the CCAP SHOULD use the same time base and interval for both a topology event session and a SAMIS interval session. The only difference to open ended event sessions is that Exporter inserts start/stop session messages at regular time intervals while the content of data records is the same. This allows Collector to easily detect when Exporter is done sending flow information and

topology (e.g., CMTS-TOPOLOGY-TYPE, CMTS-CM-REG-STATUS-TYPE and CPE-TYPE) for specific interval.

Unless otherwise specified, for an IPDR Service Definition that supports ad-hoc, and time interval and/or event based collection mechanisms, the CCAP MUST support the streaming of the ad-hoc session along with an event based or time interval session of that IPDR Service Definition at the same time where each session could be within the same connection or in separate connections.

Due to the nature of the record streaming at the Exporter, it is up to the Collector to detect duplicate records along simultaneous collection methodologies. Possible scenarios are the following:

- Collector starts ad-hoc session first and doesn't start event session for the same service until ad-hoc session finishes and it gets initial state.
- Collector starts both ad-hoc and corresponding event sessions with the same service at the same time. Exporter doesn't send any events (changes) until is done with sending initial state and stops ad-hoc session.
- Exporter can start sending event records while the ad-hoc session has not terminated. In this case Collector will have to figure out based on the recreation time that event record it has already received is newer than ad-hoc record which represents initial state so it could discard obsolete ad-hoc record.

In the case when adHoc session is established while event session is not for the same service, the CCAP Exporter SHOULD send any events that occur while sending an adHoc "snapshot" within the adHoc session.

The CCAP Exporter SHOULD use record type interim(1) for snapshot records and record type stop(2), start(3) or event(4) for event records (record is created, destroyed or changed, respectively). Event records are sent as events occur or are detected. AdHoc session lasts as long as it is necessary to send a snapshot. If in the meantime corresponding event session is established, the CCAP Exporter SHOULD send any subsequent events using that session as it would normally do. It is up to the Collector to make sure there is always either adHoc or event session open for sending events in order to make sure no events are lost.

Refer to Table 478 - Multisession Streaming Example Sequence Diagram Details and Figure 87 - Sequence Diagram for a Multisession Streaming Example for a multisession streaming example.

7.5.3.1.7 Requirements for IPv6

The CCAP MUST support IPDR/SP transport for Collectors that have IPv4 addresses [IPDR/SP]. The CCAP SHOULD support an interoperable IPDR/SP transport mechanism for both IPv4 and IPv6 addresses [IPDR/SP].

7.5.3.1.8 Data Collection Methodologies for DOCSIS IPDR Service Definitions

This specification, as well as [IPDR/SP], defines a mechanism for the Collector and Exporter to coordinate the state control of DOCSIS IPDR Service Definitions that support multiple collection methodologies. In this case the session message provides information about the streaming methodology used for that session id. In other words, an additional session ID of the same service template is associated with a specific collection methodology (e.g., ad-hoc). This is achieved by placing special requirements in the SessionBlock.reserved attribute of the IPDR/SP GET SESSIONS RESPONSE message as follows:

The CCAP MUST define a sessionID for each collection mechanism supported for each IPDR Service Definition.

The CCAP MUST define the SessionBlock.sessionType attribute of the IPDR/SP GET SESSIONS RESPONSE as defined in [IPDR/SP]. The SessionBlock.sessionType attribution is shown below:

```
struct SessionBlock {
  char sessionId;
  char sessionType;
  UTF8String sessionName;
  UTF8String sessionDescription;
  int ackTimeInterval;
```

```
  int ackSequenceInterval;
};
```

The field description for sessionType:

Type of Session: Integer values of first three least significant bits of this field identify the following session types:

0 - Equivalent of sessionType Information Not Available

1 - Time Interval

2 - Adhoc

3 - Event

4 - Time Based Event

7.5.3.1.9 IPDR Streaming Protocol Security Model

Refer to [IPDR/SP] for the IPDR/SP Security recommendations. The IPDR/SP Security Model is out of the scope of this specification.

7.5.3.2 IPDR Service Definition Schemas

This section defines the IPDR Service Definitions required for DOCSIS 4.0. Table 480 lists the IPDR Service Definitions, corresponding schemas, applicable device and information model specification reference.

Refer to Section 7.5.3.1, Streaming Telemetry IPDR/SP Protocol Stack for an overview of the IPDR/SP protocol and Annex B for an overview of the SAMIS IPDR Service Definition. The SAMIS Service Definition schemas are defined in [DOCSIS-SAMIS-TYPE-1] and [DOCSIS-SAMIS-TYPE-2].

The CCAP MUST support IPDR reporting on all of its access network interfaces (QAM, PON, etc.).

If the CCAP supports PON interfaces, the CCAP MUST support all IPDR service definitions defined as mandatory in [DPoE OSSIv2.0].

Table 486 - IPDR Service Definitions and Schemas

Information Model Reference	Schema
[DOCSIS-SAMIS-TYPE-1] [DOCSIS-SAMIS-TYPE-2]	Subscriber Account Management Interface Specification (SAMIS) Service Definition: SAMIS-TYPE-1 Schema Definition: DOCSIS-SAMIS-TYPE-1_<version> Subscriber Account Management Interface Specification (SAMIS Optimized) Service Definition: SAMIS-TYPE-2 Schema Definition: DOCSIS-SAMIS-TYPE-2_<version>
[DOCSIS-DIAG-LOG-TYPE] [DOCSIS-DIAG-LOG-EVENT-TYPE] [DOCSIS-DIAG-LOG-DETAIL-TYPE]	Diagnostic Log Service Definition: DIAG-LOG-TYPE Schema Definition: DOCSIS-DIAG-LOG-TYPE_<version> Service Definition: DIAG-LOG-EVENT-TYPE Schema Definition: DOCSIS-DIAG-LOG-EVENT-TYPE_<version> Service Definition: DIAG-LOG-DETAIL-TYPE Schema Definition: DOCSIS-DIAG-LOG-DETAIL-TYPE_<version>
[DOCSIS-CMTS-CM-REG-STATUS-TYPE] [DOCSIS-CMTS-CM-US-STATS-TYPE]	CMTS CM Registration Status Information Service Definition: CMTS-CM-REG-STATUS-TYPE Schema Definition: DOCSIS-CMTS-CM-REG-STATUS-TYPE_<version> CMTS CM Upstream Status Information Service Definition: CMTS-CM-US-STATS-TYPE Schema Definition: DOCSIS-CMTS-CM-US-STATS-TYPE_<version>
[DOCSIS-CMTS-TOPOLOGY-TYPE]	CMTS Topology Service Definition: CMTS-TOPOLOGY-TYPE Schema Definition: DOCSIS-CMTS-TOPOLOGY-TYPE_<version>

Information Model Reference	Schema
[DOCSIS-CPE-TYPE]	CPE Service Definition: CPE-TYPE Schema Definition: DOCSIS-CPE-TYPE_<version>
[DOCSIS-CMTS-US-UTIL-STATS-TYPE] [DOCSIS-CMTS-DS-UTIL-STATS-TYPE] [DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE]	CMTS Upstream Utilization Statistics Service Definition: CMTS-US-UTIL-STATS-TYPE Schema Definition: DOCSIS-CMTS-US-UTIL-STATS-TYPE_<version> CMTS Downstream Utilization Statistics Service Definition: CMTS-DS-UTIL-STATS-TYPE Schema Definition: DOCSIS-CMTS-DS-UTIL-STATS-TYPE_<version> CMTS Service Flow Information Service Definition: CMTS-CM-SERVICE-FLOW-TYPE Schema Definition: DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE_<version>
[DOCSIS-CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE] [DOCSIS-CMTS-CM-DS-OFDM-STATUS-TYPE] [DOCSIS-CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE] [DOCSIS-CMTS-CM-US-OFDMA-STATUS-TYPE]	CMTS CM Downstream OFDM Profile Status Service Definition: DOCSIS-CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE Schema Definition: DOCSIS-CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE_<version> CMTS CM Downstream OFDM Status Service Definition: DOCSIS-CMTS-CM-DS-OFDM-STATUS-TYPE Schema Definition: DOCSIS-CMTS-CM-DS-OFDM-STATUS-TYPE_<version> CMTS CM Upstream OFDMA Profile Status Service Definition: DOCSIS-CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE Schema Definition: DOCSIS-CMTS-CM-US-OFDMA-PROFILE-STATUS TYPE_<version> CMTS CM Upstream OFDMA Status Service Definition: DOCSIS-CMTS-CM-US-OFDMA-STATUS-TYPE Schema Definition: DOCSIS-CMTS-CM-US-OFDMA-STATUS TYPE_<version>
[DOCSIS-DS-OFDM-PROFILE-STATS-TYPE] [DOCSIS-US-OFDMA-PROFILE-STATS-TYPE]	Downstream OFDM Profile Statistics Service Definition: DOCSIS-DS-OFDM-PROFILE-STATS-TYPE Schema Definition: DOCSIS-DS-OFDM-PROFILE-STATS-TYPE_<version> Upstream OFDMA Profile Statistics Service Definition: DOCSIS-US-OFDMA-PROFILE-STATS-TYPE Schema Definition: DOCSIS-US-OFDMA-PROFILE-STATS-TYPE_<version>

The DOCSIS IPDR Service Definitions are XML schemas derived from the IPDR Master Schema document (IPDRDoc). See Section 7.5.3.1.2.3, IPDR Record Structure for details of the IPDR Master Schema. This specification names DOCSIS IPDR Service Definitions in the form of DOCSIS-<SERVICE-NAME>-TYPE (e.g., DOCSIS-SAMIS-TYPE-1, DOCSIS-DIAG-LOG-TYPE).

In addition to the conventional IPDR Service Definition models, this specification defines Information model Schemas (Auxiliary Schemas) to represent network components being referenced by the Service Definitions themselves. For example, the DOCSIS-CMTS-INFO Auxiliary Schema offers Topology information at the Physical and MAC layer of the CMTS-CM arrangements. For the same example, a DOCSIS Service Definition (service aware) can include the object schema DOCSIS-CMTS-INFO to complete the CM-CMTS identification and to offer context for the statistics and parameters reported in the document records. This modular abstraction allows the definition of different schema documents for the same Service Definition at different elements of the collection infrastructure. Refer to Annex C for a list of Auxiliary Schemas defined for DOCSIS 3.1 and later DOCSIS versions.

One example is the SAMIS model that supports two different models (see detailed SAMIS requirements in Annex B):

- The Service Definition Schema DOCSIS-SAMIS-TYPE-1
  Each document record contains the information modeled by the Service Definition DOCSIS-CMTS-INFO. CMTS-CM related information is duplicated for each SAMIS record.

- The Service Definition Schema DOCSIS-SAMIS-TYPE-2
  Each document record contains a reference to the last updated DOCSIS-CMTS-INFO, reducing the amount of data sent over the network. DOCSIS-CMTS-INFO information is sent periodically (e.g., any time an update to the CMTS-CM Status is performed). The collector system is in charge of correlating the information received from records of DOCSIS-SAMIS-TYPE-2 and DOCSIS-CMTS-INFO to re-create the equivalent record obtained when using the DOCSIS-SAMIS-TYPE-1 Service Definition schema.

This section defines the minimum set of objects required to support the DOCSIS 3.0 IPDR Service Definitions. The CCAP MAY define IPDR Service Definitions which extend the DOCSIS requirements to include vendor-specific features.

7.5.3.2.1 Requirements for DOCSIS SAMIS Service Definitions

The CCAP MUST implement SAMIS-TYPE-1 as specified in Annex B.

The CCAP MUST implement SAMIS-TYPE-2 as specified in Annex B.

7.5.3.2.1.1 Records Collection

Subscriber Usage Billing Records report the absolute traffic counter values for each Service Flow that has become active during the billing collection interval as seen at the end of the interval. Normal Service Flows used by a Cable Modem or Class or Service (Subscriber) are reported. Group Service Flows are reported by Service Flow without CM association. The collection interval is defined as the time between:

- The creation of the previous billing document denoted as Tprev.
- The creation of the current billing document denoted as T_{now}.

In reference to Figure 88 below, there are two kinds of records reported for a SFID/SID in the current billing document: 1) SFIDs/SIDs that are still running at the time the billing document is created (called 'Interim' records) and 2) terminated SFIDs/SIDs that have been deleted and logged during the collection interval (called 'Stop' records). The CCAP MUST report 'Interim' records at the end of the collection interval. The CCAP MUST NOT record a provisioned or admitted state SF that was deleted before it became active in the billing document, even though it was logged by the CCAP.

The CCAP MUST report any currently running SFIDs/SIDs using T_{now} as the timestamp for its counters and identify them in the IPDR RecType element as 'Interim'. The CCAP MUST report a terminated SFIDs/SIDs only once in the current billing document. Terminated SFIDs/SIDs have a deletion time (T_{del}) later than T_{prev}. A CCAP MUST report a terminated SFID/SID using its T_{del} from the log as the timestamp for its counters and identify it in the IPDR RecType element as 'Stop'. Note that the timestamps are based on the formatter's reporting times. Since the collection cycle may vary over time, the reporting times in the billing document can be used to construct an accurate time base over sequences of billing documents.

In the example shown in Figure 88 - Billing Collection Interval Example below there are four Service Flows recorded for a Subscriber in the current billing document being created at T_{now}. SFa is a long running SF that was running during the previous collection interval (it has the same SFID in both the current and the previous billing documents). SFa was recorded as type Interim at T_{prev} in the previous billing document and is recorded again as type Interim at T_{now} in the current document. SFb is a running SF that was created during the current collection interval. SFb is recorded as type Interim for the first time at T_{now} in the current document. SFc is a terminated SF that was running during the previous collection interval but was deleted and logged during the current collection interval. SFc was recorded respectively as type Interim at T_{prev} in the previous billing document and is reported as type Stop at the logged $T_{del(c)}$ in the current document. SFd is a terminated SF that was both created and deleted during the current collection interval. SFd is reported only once as type Stop at the logged $T_{del(d)}$ in the current billing document only.

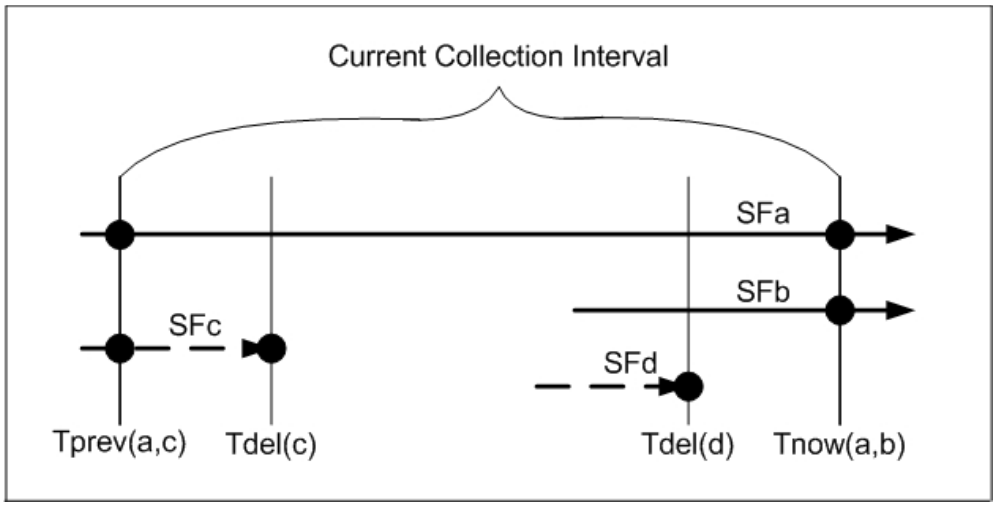


Figure 88 - Billing Collection Interval Example

The CCAP MUST support streaming of SAMIS-TYPE-1 and SAMIS-TYPE-2 record collections as a time interval session and an ad-hoc session. The CCAP MUST support a minimum collection interval of 15 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of SAMIS-TYPE-1 and SAMIS-TYPE-2 records. The CCAP SHOULD support a minimum collection interval of 5 minutes for time interval session streaming of SAMIS-TYPE-1 and SAMIS-TYPE-2.

7.5.3.2.2 Requirements for DOCSIS Diagnostic Log Service Definitions

The CCAP MUST implement DIAG-LOG-TYPE as specified in [DOCSIS-DIAG-LOG-TYPE].

The CCAP MUST implement DIAG-LOG-EVENT-TYPE as specified in [DOCSIS-DIAG-LOG-EVENT-TYPE].

The CCAP MUST implement DIAG-LOG-DETAIL-TYPE as specified in [DOCSIS-DIAG-LOG-DETAIL-TYPE].

7.5.3.2.2.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the Diagnostic Log.
- IPDR/SP is used to stream the Diagnostic Log instances.

The CCAP MUST support streaming of DIAG-LOG-TYPE record collections as an ad-hoc session.

The CCAP MUST support streaming of DIAG-LOG-EVENT-TYPE record collections as an event session.

The CCAP MUST support streaming of DIAG-LOG-DETAIL-TYPE record collections as a time interval session, an ad-hoc session and an event session.

For event-based Diagnostic Log records, the CCAP streams the record when the event is logged in the Diagnostic Log. For time interval based Diagnostic Log records, the CCAP streams a snapshot of the Diagnostic Log. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the Diagnostic Log records.

7.5.3.2.3 Requirements for DOCSIS CMTS CM Registration Status Service Definition

The CCAP MUST implement CMTS-CM-REG-STATUS-TYPE as specified in [DOCSIS-CMTS-CM-REG-STATUS-TYPE].

7.5.3.2.3.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure CMTS CM Registration Status service definition.
- IPDR/SP is used to stream CMTS CM Registration Status instances.

The CCAP MUST support streaming of CMTS-CM-REG-STATUS-TYPE record collections as a time interval session, an ad-hoc session and an event session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the CMTS-CM-REG-STATUS-TYPE records.

The following requirements apply specifically when streaming CMTS-CM-REG-STATUS-TYPE records as an event session:

- The CCAP MUST support sending of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem upon a change in its CmtsCmRegState to any of the CmRegStatusValue enumerations contained in the DOCSIS-CM auxiliary schema associated with the configured CMTS-CM-REG-STATUS-TYPE schema.
- The CCAP MUST support configuration of the specific CmRegStatusValue enumerations that will trigger the generation of CMTS-CM-REG-STATUS-TYPE records. This allows operators to configure sending of CMTS-CM-REG-STATUS-TYPE records for only those CmRegStatusValue enumerations that are of interest. For example, the operator could configure the CCAP to send a CMTS-CM-REG-STATUS-TYPE record for any Cable Modem that enters the initialRanging, registrationComplete, or operational states without receiving records for states they are not interested in. The default values are left to the discretion of the vendor.
- The CCAP MUST support sending of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem upon a change in the CmtsCmEmStats Object for that Cable Modem when the CmEnergyMgtOperStatus element is available in the selected schema and has not been disabled during Template Negotiation.
- The CCAP MUST support sending of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem upon a change in the DsProfileIdList Object for that Cable Modem when the DsProfileIdList element is available in the selected schema and has not been disabled during Template Negotiation.
- The CCAP MUST support sending of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem upon a change in the UsProfileIucList Object for that Cable Modem when the UsProfileIucList element is available in the selected schema and has not been disabled during Template Negotiation.
- The CCAP MUST support sending of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem upon a change in the PartialServiceType Object for that Cable Modem when the PartialSvcState element is available in the selected schema and has not been disabled during Template Negotiation.
- The CCAP MUST support sending of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem upon a change in the PartialChannelType Object for that Cable Modem when the PartialChanState element is available in the selected schema and has not been disabled during Template Negotiation.

The CCAP MUST support configuration of which events should trigger generation of a CMTS-CM-REG-STATUS-TYPE record for a given Cable Modem. For example, enabling all the triggers listed above could generate a significant load on either the CMTS, the collector, or both. Having the specific triggers be configurable allows the operator the ability to limit the generation of records to only those events which the operator is specifically interested in receiving.

7.5.3.2.4 Requirements for DOCSIS CMTS CM Upstream Status Service Definition

The CCAP MUST implement CMTS-CM-US-STATS-TYPE as specified in [DOCSIS-CMTS-CM-US-STATS-TYPE].

7.5.3.2.4.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure CMTS CM Upstream Status service definition.
- IPDR/SP is used to stream CMTS CM Upstream Status instances.

The CCAP MUST support streaming of CMTS-CM-US-STATS-TYPE record collections as a time interval session and an ad-hoc session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the CMTS-CM-US-STATS-TYPE records.

7.5.3.2.5 Requirements for DOCSIS CMTS Topology Service Definition

The CCAP MUST implement CMTS-TOPOLOGY-TYPE as specified in [DOCSIS-CMTS-TOPOLOGY-TYPE].

7.5.3.2.5.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the topology.
- IPDR/SP is used to stream the topology information.

The CCAP MUST support streaming of CMTS-TOPOLOGY-TYPE record collections as an ad-hoc session and event session.

7.5.3.2.6 Requirements for DOCSIS CPE Service Definition

The CCAP MUST implement CPE-TYPE as specified in [DOCSIS-CPE-TYPE].

7.5.3.2.6.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure DOCSIS CPE service definition.
- IPDR/SP is used to stream DOCSIS CPE instances.

The CCAP MUST support streaming of CPE-TYPE record collections as an ad-hoc session and event session.

7.5.3.2.7 Requirements for DOCSIS CMTS Upstream Utilization Statistics Service Definition

The CCAP MUST implement CMTS-US-UTIL-STATS-TYPE as specified in [DOCSIS-CMTS-US-UTIL-STATS-TYPE].

7.5.3.2.7.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure CMTS Upstream Utilization Statistics service definition.
- IPDR/SP is used to stream CMTS Upstream Utilization Statistics instances.

The CCAP MUST create CMTS-US-UTIL-STATS-TYPE records using the configured utilization interval. The CCAP MUST support streaming of CMTS-US-UTIL-STATS-TYPE record collections as an event-based session.

7.5.3.2.8 Requirements for DOCSIS CMTS Downstream Utilization Statistics Service Definition

The CCAP MUST implement CMTS-DS-UTIL-STATS-TYPE as specified in [DOCSIS-CMTS-DS-UTIL-STATS-TYPE].

7.5.3.2.8.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure CMTS Downstream Utilization Statistics service definition.
- IPDR/SP is used to stream CMTS Downstream Utilization Statistics instances.

The CCAP MUST create CMTS-DS-UTIL-STATS-TYPE records using the configured utilization interval. The CCAP MUST support streaming of CMTS-DS-UTIL-STATS-TYPE record collections as an event-based session.

7.5.3.2.9 Requirements for DOCSIS CMTS CM Service Flow Service Definition

The CCAP MUST implement CMTS-CM-SERVICE-FLOW-TYPE as specified in [DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE].

7.5.3.2.9.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the CMTS CM SERVICE FLOW Service Definition.
- IPDR/SP is used to stream the CMTS CM SERVICE FLOW instances.

The CCAP MUST support streaming of CMTS-CM-SERVICE-FLOW-TYPE record collections as an ad-hoc session and event session. The CCAP MUST report all Active service flows on an ad-hoc session. The CCAP MUST report all new service flows that become active on an event session.

7.5.3.2.10 Requirements for IP Multicast Statistics Service Definition

The CCAP MUST implement IP-MULTICAST-STATS-TYPE as specified in [DOCSIS-IP-MULTICAST-STATS-TYPE].

7.5.3.2.10.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the IP Multicast Statistics Service Definition.
- IPDR/SP is used to stream the IP-MULTICAST-STATS-TYPE record instances.

The CCAP MUST support streaming of IP-MULTICAST-STATS-TYPE record collections as a time interval session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the IP-MULTICAST-STATS-TYPE records.

7.5.3.2.11 Requirements for DOCSIS CMTS CM Downstream OFDM Service Definition

The CCAP MUST implement CMTS-CM-DS-OFDM-STATUS-TYPE as specified in [DOCSIS-CMTS-CM-DS-OFDM-STATUS-TYPE].

7.5.3.2.11.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the CMTS CM Downstream OFDM Service Definition.
- IPDR/SP is used to stream the CMTS-CM-DS-OFDM-STATUS-TYPE record instances.

The CCAP MUST support streaming of CMTS-CM-DS-OFDM-STATUS-TYPE record collections as a time interval session, an event-based session, and an ad-hoc session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the CMTS-CM-DS-OFDM-STATUS-TYPE records. The CCAP MUST report all new partial service events on an event session.

7.5.3.2.12 Requirements for DOCSIS CMTS CM Downstream OFDM Profile Service Definition

The CCAP MUST implement CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE as specified in [DOCSIS-CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE].

7.5.3.2.12.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the CMTS CM Downstream OFDM Profile Service Definition.
- IPDR/SP is used to stream the CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE record instances.

The CCAP MUST support streaming of CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE record collections as a time interval session, an event-based session, and an ad-hoc session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the CMTS-CM-DS-OFDM-PROFILE-STATUS-TYPE records. The CCAP MUST report all new partial channel events on an event session.

7.5.3.2.13 Requirements for DOCSIS CMTS CM Upstream OFDMA Service Definition

The CCAP MUST implement CMTS-CM-US-OFDMA-STATUS-TYPE as specified in [DOCSIS-CMTS-CM-US-OFDMA-STATUS-TYPE].

7.5.3.2.13.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the CMTS CM Upstream OFDMA Service Definition.
- IPDR/SP is used to stream the CMTS-CM-US-OFDMA-STATUS-TYPE record instances.

The CCAP MUST support streaming of CMTS-CM-US-OFDMA-STATUS-TYPE record collections as a time interval session, an event-based session, and an ad-hoc session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the CMTS-CM-US-OFDMA-STATUS-TYPE records. The CCAP MUST report all new partial service events on an event session.

7.5.3.2.14 Requirements for DOCSIS CMTS CM Upstream OFDMA Profile Service Definition

The CCAP MUST implement CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE as specified in [DOCSIS-CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE].

7.5.3.2.14.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the CMTS CM Upstream OFDMA Profile Service Definition.
- IPDR/SP is used to stream the CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE record instances.

The CCAP MUST support streaming of CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE record collections as a time interval session, an event-based session, and an ad-hoc session. The CCAP MUST support a minimum collection interval of 5 minutes and a maximum collection interval of 1440 minutes with a default of 15 minutes for time interval session streaming of the CMTS-CM-US-OFDMA-PROFILE-STATUS-TYPE records. The CCAP MUST report all new partial channel events on an event session.

7.5.3.2.15 Requirements for DOCSIS Downstream OFDM Profile Statistics Service Definition

The CMTS MUST implement DS-OFDM-PROFILE-STATS-TYPE as specified in [DOCSIS-DS-OFDM-PROFILE-STATS-TYPE].

7.5.3.2.15.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the Downstream OFDM Profile Statistics Service Definition.
- IPDR/SP is used to stream the DS-OFDM-PROFILE-STATS-TYPE record instances.

The CMTS MUST support streaming of DS-OFDM-PROFILE-STATS-TYPE record collections as a time interval session. The CMTS MUST support a minimum collection interval of 1 minute and a maximum collection interval of 60 minutes with a default of 5 minutes for time interval session streaming of the DS-OFDM-PROFILE-STATS-TYPE records.

7.5.3.2.16 Requirements for DOCSIS Upstream OFDMA Profile Statistics Service Definition

The CMTS MUST implement US-OFDMA-PROFILE-STATS-TYPE as specified in [DOCSIS-US-OFDMA-PROFILE-STATS-TYPE].

7.5.3.2.16.1 Record Collection

This Service Definition defines the IPDR Streaming using a two-step process:

- SNMP or other configuration management interface such as CLI is used to configure the DOCSIS Upstream OFDMA Profile Statistics Service Definition.
- IPDR/SP is used to stream the US-OFDMA-PROFILE-STATS-TYPE record instances.

The CMTS MUST support streaming of US-OFDMA-PROFILE-STATS-TYPE record collections as a time interval session, an event-based session, and an ad-hoc session. The CMTS MUST support a minimum collection interval of 1 minute and a maximum collection interval of 60 minutes with a default of 5 minutes for time interval session streaming of the US-OFDMA-PROFILE-STATS-TYPE records.

7.5.3.2.17 Requirements for Auxiliary Schemas

The CCAP MUST implement the auxiliary schemas as specified in Annex C.

7.5.4 gNMI-Based Streaming Interfaces, Protocols and Encodings

Legacy Performance Management functions are based on collection of measurement data using SNMP, where data models are defined using SNMP MIBs, or file transfer mechanisms such as TFTP where data models are defined as binary encoded files. These mechanisms are typically based on a PULL model where back office applications or collection and monitoring systems retrieve data from network devices where measurements are performed. These collections systems request the data from the network devices. The term Streaming Telemetry in this section refers to gNMI-based streaming telemetry.

Streaming Telemetry represents existing and new forms of network statistics and new methods of gathering and exposing operational data. Instead of the traditional data PULL model, a PUSH model is used where data can be streamed to back office applications in {near} real-time. Richer data formats are used such as YANG and/or REST APIs. Applications can subscribe to selected elements of a device's YANG data models using a standard protocol such as NETCONF, RESTCONF or gNMI/gRPC [gNMI]/[gRPC]. Streaming Telemetry allows monitored data to be pushed from the monitored or target device, such as the CCAP, to an external collector application at a higher frequency than polling, as well as to push data only when a change is recorded. A periodic collection method, when a device pushes data at a defined interval, is better suited to monitoring of frequently changing metrics, e.g., data plane statistical counters. An on-change collection method is a better fit for monitoring infrequently changing data such as state objects, faults, or error counters. Through a combination of these methods, Streaming Telemetry provides a highly flexible, efficient communication process for automatic near real-time access to operational data represented by the device's YANG models. It also leverages off-the-shelf tools for configuration, data collection and inspection.

To stream data from the target device, a Streaming Telemetry Client establishes a subscription to a data set which can be any subset of a device's YANG model. A subscription is a contract between a monitored device and a

collector application that defines the data set to be pushed and the collection methods to be used. Subscription allows clients/applications to subscribe to modeled data of the monitored device. The target device then pushes the data to the collector as per agreed contract.

This section defines the use of the gRPC Network Management Interface (gNMI) [gNMI] standard for Streaming Telemetry from a CCAP (the target device). In the sections that follow, the terms "target device" and "Streaming Telemetry Server" refer to the CCAP.

Note that this section focuses on the definition of gNMI-based Streaming Telemetry to continuously monitor the operational data of the CCAP. This does not apply to configuration of the CCAP. Configuration of the CCAP Streaming Telemetry Server follows the normal Configuration Management methods defined in Section 6.

7.5.4.1 Streaming Telemetry gNMI Protocol Stack

The CCAP implements a gNMI Telemetry Server that communicates over a single TCP session with a Telemetry Client in the Streaming Telemetry system or back office application. The CCAP supports each TCP session to a Telemetry Client to be established in one of two methods:

- "Dial-in", where the Telemetry Client originates the TCP session to a TCP server socket on the CCAP; or
- "Dial-out", where the CCAP's Telemetry Server originates the TCP session to a TCP server socket on the Telemetry Client using a gRPC Tunnel.

The CCAP operates Streaming Telemetry with the stack of protocol layers as shown in Figure 89 for "dial-in" operation and Figure 90 for "dial-out" operation.

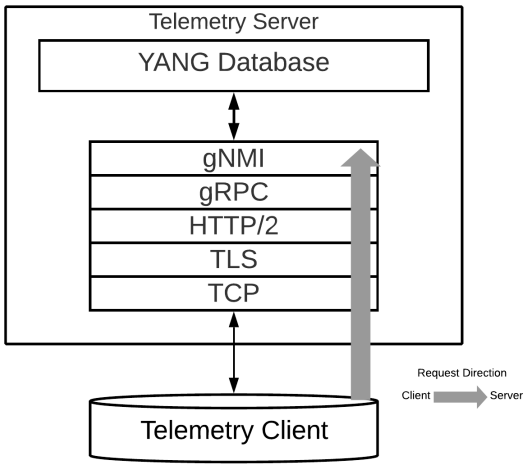


Figure 89 - Streaming Telemetry Dial-in Protocol Stack

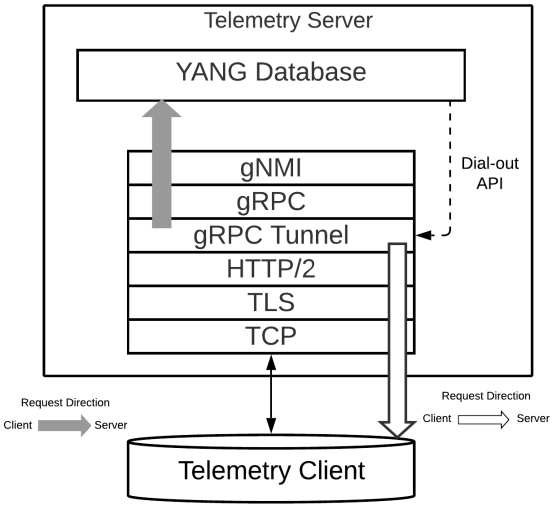


Figure 90 - Streaming Telemetry Dial-out Protocol Stack

The CCAP supports connections to multiple Telemetry Clients that could have different dialing methods. Once the Telemetry Client and CCAP's Telemetry Server establish a TCP session, they negotiate a Transport Layer Security relationship with TLS 1.2. Once the Telemetry Client and CCAP establish TLS 1.2, they negotiate an HTTP/2 session.

On the CCAP, the gRPC layer always acts as a gRPC server, providing a set of services to the gNMI layer. The most important gNMI service for Streaming Telemetry is the "Subscribe" service. Using the Subscribe RPC, the Telemetry Client sends SubscribeRequest messages to the CCAP. A subscription consists of one or more paths along with a subscription mode which describes the longevity of the subscription. The mode determines the triggers for updates sent by the CCAP. The Telemetry Client can create a subscription which has a dedicated stream to return one-off data (mode=ONCE), a subscription that utilizes a stream to periodically request a set of data (mode=POLL), or a long-lived subscription that streams data according to the triggers specified within the individual subscription's mode (mode=STREAM). The CCAP responds to SubscriptionRequest messages with one or more Subscribe Response messages over the established Subscribe RPC.

For "dial-in" operation, the HTTP/2 [RFC 7540], TLS 1.2 [RFC 5246], and TCP [RFC 793] protocol layers operate as servers as defined in their respective standards.

For "dial-out" operation, the HTTP/2, TLS 1.2, and TCP protocol layers operate as clients as defined in their standards in order to initiate a TCP session. With "dial-out", the CCAP implements a gRPC Tunnel ("grpc-tunnel") sub-layer between the HTTP layer and the gRPC layer to tunnel connections between the HTTP/2 client and the Telemetry Client's gRPC server.

The CCAP grpc-tunnel sublayer emulates an HTTP/2 client; upon a control API request, the CCAP dials out to a corresponding grpc-tunnel sub-layer in the Streaming Telemetry Client that emulates an HTTP/2 server. Once the HTTP/2 session is established, the grpc-tunnel sub-layers transparently forward packets between the HTTP/2 layer and the gRPC layer in both the CCAP and Streaming Telemetry Client. When the Streaming Telemetry Client's grpc-tunnel control API indicates the tunnel is initially attached, then the Streaming Telemetry Client's gNMI client invokes a SubscribeRequest service that is eventually delivered to the CCAP's gNMI server layer. Refer to [gRPC-TUNNEL] for additional details.

7.5.4.2 gNMI Service Definition

Streaming Telemetry requires encoding of all messages with gRPC Protocol Buffers (GPB) [GPB] using proto3. Operation with any other message encoding is vendor-specific.

The gNMI standard [gNMI] defines a single gRPC service consisting of four RPCs; the specification of gNMI-based Streaming Telemetry in this document uses only two of them:

- rpc Capabilities(CapabilityRequest) returns (CapabilityResponse);
- rpc Subscribe(stream SubscribeRequest) returns (stream SubscribeResponse)

Each gNMI Connection can have multiple concurrent SubscribeRequest messages pending, and each SubscribeRequest can receive multiple SubscribeResponse messages returned. HTTP/2 handles concurrent forwarding of all gRPC messages.

The roles of the Streaming Telemetry sub-systems are as follows:

- The CCAP serves the role of the gNMI target. The CCAP is required to support a YANG model for all data reported by Telemetry subscriptions. The CCAP accepts subscription requests from the Telemetry Client via the SubscribeRequest gNMI message. The CCAP streams the monitored data to the Telemetry Client via a stream of SubscribeResponse messages.
- The Telemetry Client serves the role of both subscriber and collector of Telemetry data. The Telemetry Client is responsible for sending all SubscribeRequest messages to the CCAP and receiving all SubscribeResponse messages for the subscribed data. The Telemetry Client can either dial in to the CCAP or the CCAP can dial out to the Telemetry Client.

7.5.4.3 Telemetry Client Authorization

The CCAP provides a Streaming Telemetry Configuration Management Information Model to provide back office provisioning of Telemetry Client authorizations, as specified in Section 6.5.11.

When a connection to a Streaming Telemetry Client is successful, the CCAP MUST log an event with EventId 89020000.

A back office application can monitor current Streaming Telemetry connections and associated SubscribeRequest RPCs within the CCAP as described in Section 7.5.5.

7.5.4.4 CCAP Streaming Telemetry Requirements

The CCAP implements a gNMI Streaming Telemetry Server with the requirements listed in this section.

The CCAP MUST support gNMI/gRPC [gNMI]/[gRPC] over HTTP/2 [RFC 7540].

The CCAP MUST support dial-in connection establishment mode for Telemetry Clients subject to authorization access controls. The dial-in mode is a method of connection establishment in which the CCAP accepts incoming connection requests from a Telemetry Client.

The CCAP MUST support dial-out connection establishment mode for Telemetry Clients. The dial-out mode is a method of connection establishment in which the CCAP initiates an outgoing TCP connection to a Telemetry Client.

This specification does not formulate requirements when the Telemetry Client is required to connect to the CCAP, nor how long the connections are maintained. Note that dial-in access to the CCAP from Telemetry Clients is disabled by default and enabled by the operator's back office applications.

The CCAP MUST support gNMI Connections for a minimum of four (4) Telemetry Clients.

The CCAP MUST support any combination of dial-in or dial-out concurrent connections to Telemetry Clients.

When the CCAP rejects an attempted connection because the maximum number of connections has been reached, the CCAP MUST log an event with EventId 89020008.

The CCAP MUST support a gNMI Capabilities service request for the CapabilityRequest RPC and respond with CapabilityResponse RPCs.

The CCAP MUST support a gNMI Subscribe service request for the SubscribeRequest RPC and respond with SubscribeResponse RPCs.

When a subscription is successfully established with the Streaming Telemetry Client, the CCAP MUST log an event with EventId 89020006.

If a subscription with the Streaming Telemetry Client fails, the CCAP MUST log an event with EventId 89020007.

If the Streaming Telemetry Client cancels an active subscription, the CCAP MUST log an event with EventId 89020009.

If the Streaming Telemetry Client terminates an active gRPC Channel, the CCAP MUST log an event with EventId 89020010.

The CCAP's support for gNMI "Get" and "Set" RPCs is outside the scope of this specification.

The CCAP MUST support TLS1.2 for mutual authentication of gNMI-based Streaming Telemetry connections.

The CCAP MAY support later TLS versions for mutual authentication of gNMI-based Streaming Telemetry connections.

The CCAP MUST support CableLabs PKI issued certificates for authentication of gNMI-based Streaming Telemetry connections.

The CCAP streams the monitored data to the Telemetry Client via gNMI SubscribeResponse messages. The data is transferred in the form of gRPC Protocol Buffers (GPB) messages described with proto3.

The CCAP MUST support gRPC Protocol Buffers (GPB) version 3 (proto3) [GPB Encoding] as the encapsulation protocol for all structured data types in gNMI.

The CCAP MUST support Key-Value GPB encoding for gNMI.

The CCAP MUST support compact GPB encoding for gNMI.

The CCAP MAY support other gNMI structured data type encapsulations.

7.5.4.4.1 gNMI Connection Maintenance

Connections between a CCAP's Telemetry Server and Telemetry Client may fail due to failures in either device or failures in the network. Detection of and recovery from connection failures is required to provide a robust interface between Telemetry Client and a CCAP. This section describes a method for detecting and recovering from such failures.

The algorithm described herein applies to a single HTTP/2 connection between the CCAP and a Telemetry Client over which gNMI is being run. This algorithm is run separately on each gNMI Connection. Although there is typically only a single gNMI Connection between a particular CCAP and Telemetry Client, there can exist more than one gNMI Connection between the CCAP and Telemetry Client under special circumstances. These circumstances are described in [RFC 7540] as follows:

> *Clients SHOULD NOT open more than one HTTP/2 connection to a given host and port pair, where the host is derived from a URI, a selected alternative service, or a configured proxy.*
>
> *A client can create additional connections as replacements, either to replace connections that are near to exhausting the available stream identifier space (Section 5.1.1), to refresh the keying material for a TLS connection, or to replace connections that have encountered errors (Section 5.4.1).*

A CCAP MUST be capable of accepting a second HTTP/2 connection from a particular Telemetry Client. A Telemetry Client can establish a second connection for a variety of reasons, for example, to replace a connection that has experienced a keepalive failure. A CCAP MUST support processing gNMI requests from the most recently opened HTTP/2 connection from a particular Telemetry Client. If a second connection is established between a CCAP and a Telemetry Client, then the CCAP MAY disconnect the older connection. Note that the gNMI subscription is coupled to the HTTP/2 connection, and therefore after establishing a second HTTP/2 connection, the Telemetry Client will need to establish a new subscription on that new connection.

gRPC [gRPC] can utilize HTTP/2 PING frames [RFC 7540] to detect failed gRPC connections. The algorithm for using HTTP/2 PING frames to detect failed gRPC connections described herein is based on available open source implementations of gRPC; however, this specification does not require the use of any particular open source implementation.

Each HTTP/2 PING frame contains an ACK flag. An HTTP/2 PING frame that has the ACK flag cleared is referred to simply as a "PING". An HTTP/2 PING frame that has the ACK flag set is referred to as a "PING response". This follows the convention used in [RFC 7540].

The CCAP and Telemetry Client are both responsible for sending PINGs on idle connections according to the configuration of the device. They are both responsible for responding to a received PING by sending a PING response. The PING/PING response functionality is specified completely in [RFC 7540]. Both the Telemetry Client and CCAP can be configured to detect connections that have been idle for too long and take appropriate action to terminate the connection.

When one end of a gNMI Connection detects that it has not received an HTTP/2 frame from the other end after a configured amount of time, it will send a PING to the other end. After sending the PING frame, the sender waits for a configured time period. If any frame is received from the other end of the connection in that time period, then the sender takes no further action. If no frame is received in that time period, then the sender will close the connection. This allows both sides to independently detect broken connections and take the proper corrective action.

After a CCAP terminates a dial-out connection due to inactivity, the CCAP MUST attempt to initiate a new dial-out connection as described in Section 7.5.4.4.1.2.2, Dial-Out Connection Loss.

7.5.4.4.1.1 gNMI Connection Maintenance Parameters

7.5.4.4.1.1.1 CCAP Telemetry Server Parameters

For *dial-in* connections, the CCAP is expected to perform connection maintenance for the purposes of recovering stranded resources.

For *dial-out* connections the CCAP is expected to perform connection maintenance for the purposes of detecting connection failures and initiating recovery.

Given that the purpose of the CCAP connection maintenance is different for the case of dial-in versus dial-out, the "Time" parameter will have different defaults for the two different types of connections.

The following parameters are used to control the CCAP with respect to gNMI Connection maintenance (Note that the parameter names below originate from the Go language open source implementation of gRPC, see [gRPC KA Pkg]):

- **Time** – When the CCAP does not see any activity from the Telemetry Client on a connection for *Time* seconds, the CCAP MUST send a PING to the Telemetry Client. The default value is 600 seconds for dial-in connections and 60 seconds for dial-out connections.
- **TimeOut** – When the CCAP does not see any activity from the Telemetry Client on a connection for *TimeOut* seconds after sending a PING, the CCAP MUST close the connection. The default value is 20 seconds, matching the default used by gRPC.
- **MinTime** – If the CCAP receives PING within *MinTime* seconds of receiving a previous PING, then the CCAP MAY close the connection. The MinTime serves to prevent the CCAP from becoming overloaded with PINGs. The default value is 5 seconds. The minimum value for this parameter is 3 seconds.
- **PermitWithoutStream** – *PermitWithoutStream* is set to False and there are no active RPCs on a connection, then the CCAP MUST ignore the *Time* and *TimeOut* parameters and refrain from sending PING frames on the connection. The default value is True.

The dial-in default values are chosen to reduce strain on the connection while allowing the CCAP to recover stranded resources within a reasonable time. For dial-in connections it is expected that the Telemetry Client will provide the functionality of more rapidly detecting a connection failure and initiating recovery.

The dial-out defaults are intended to more rapidly detect a connection loss and initiate recovery.

7.5.4.4.1.1.2 Telemetry Client Parameters (Informative)

For *dial-in* connections the Telemetry Client is expected to perform connection maintenance for the purposes of detecting connection failures and initiating recovery.

For *dial-out* connections, the Telemetry Client is expected to perform connection maintenance for the purposes of recovering stranded resources.

The Telemetry Client parameters are provided for informational purposes only, and are not intended to place any requirements on Telemetry Clients. The following parameters are used to control the Telemetry Client with respect to gNMI Connection maintenance:

- **Time** – After a duration of this *Time*, if the Telemetry Client doesn't detect any activity it pings the CCAP to detect if the transport is still alive.
- **Timeout** – After having pinged for keepalive check, the Telemetry Client waits for a duration of *Timeout* and if no activity is seen even after that the connection is closed.

PermitWithoutStream – If True, the Telemetry Client sends keepalive pings even with no active RPCs. If False, when there are no active RPCs, *Time* and *Timeout* will be ignored and no keepalive pings will be sent.

7.5.4.4.1.2 Streaming Telemetry Connection Errors

The CCAP MUST meet the mandatory requirements for error detection and disconnection of each of the Streaming Telemetry network layer protocols TCP, TLS, HTTP/2, gRPC and gNMI. Unless explicitly required in this specification, configuration and operation of optional requirements of the Streaming Telemetry network layer protocols is vendor-specific.

7.5.4.4.1.2.1 Dial-In Connection Loss

With dial-in operation, the Telemetry Client is responsible for the maintenance of the network connection to the CCAP, e.g., restoring the connection if the TCP connection drops.

When the CCAP detects a connection failure to a dial-in Telemetry Client, the CCAP MUST:

- Terminate the gRPC connection if it has not previously been terminated
- Terminate all subscriptions for the Telemetry Client whose connection was lost
- Log event with EventId 89020002

A Telemetry Client establishes new subscriptions when it reconnects to the CCAP.

7.5.4.4.1.2.2 Dial-Out Connection Loss

The CCAP is responsible for the maintenance of a dial-out connection to a Telemetry Client. In case of a dial-out connection failure, the CCAP periodically attempts to re-establish the connection to the Telemetry Client. Once the connection is established, the Telemetry Client is responsible for re-establishing desired subscriptions with new SubscribeRequest messages.

When the CCAP detects a connection failure to a dial-out Telemetry Client, the CCAP MUST:

- Terminate the gRPC connection if it has not previously been terminated
- Terminate all subscriptions for the Telemetry Client whose connection was lost
- Log event with EventId 89020003

A failure of a dial-out connection can occur during connection establishment or during ongoing connection operation. The CCAP handles both establishment and operational failures as described in the next Section.

7.5.4.4.1.2.2.1 Connection Restoration

When the CCAP detects the dial-out connection has failed, the CCAP MUST retry the connection periodically using a truncated exponential backoff algorithm with retry parameters as configured by the TelemetryAuthClientListCfg object of Section 6.5.11.7, TelemetryAuthClientListCfg.

7.5.5 Streaming IPDR/SP Service Definitions using gNMI

7.5.5.1 Streaming Protocols

7.5.5.1.1 TM Forum Internet Protocol Detail Record Streaming Protocol (IPDR/SP)

The Internet Protocol Detail Record Streaming Protocol (IPDR/SP) is developed by TM Forum. TM Forum is a global industry association for service providers and their suppliers in the telecommunications industry. TM Forum provides an open, collaborative environment along with practical tools and information to help its members in their digital transformation initiatives. The protocol details can be found at [IPDR/SP]. Refer to Section 7.5.3.1, Streaming Telemetry IPDR/SP Protocol Stack for CCAP support of IPDR/SP.

IPDR data collection methodologies, as specified in Section 7.5.3.1.5, Documents and Collection Methodologies, include:

- Time Interval Session
- Event Based Session
- Ad-hoc Session

7.5.5.1.2 OpenConfig gRPC Network Management Interface (gNMI)

The gRPC Network Management Interface (gNMI) is developed by OpenConfig. OpenConfig is an informal working group of network operators sharing the goal of moving their networks toward a more dynamic, programmable infrastructure by adopting software-defined networking principles such as declarative configuration and model-driven management and operations. The protocol details can be found at [gNMI] and [gNMI-SPEC]. Refer to Section 7.5.3 for CCAP support of gNMI for Streaming Telemetry.

gNMI data collection methodologies, as specified in Section 7.5.4.1, include:

- Stream Subscription
- Poll Subscription
- Once Subscription

7.5.5.2 Data Models and Encodings

7.5.5.2.1 IPDR Service Definitions

IPDR defines data models, referred to as IPDR documents, using XML Schemas defined according to the IPDR Service Specification Design Guide [IPDR/SSDG]. CableLabs is the authoritative source for defining IPDR Service Definitions for DOCSIS services. Refer to Section 7.5.3.2, IPDR Service Definition Schemas for CCAP support of IPDR Service Definitions.

IPDR/SP data is encoded as specified in [IPDR/XDR].

7.5.5.2.2 gNMI Google Protocol Buffers

gNMI Streaming Telemetry requires encoding of all messages with gRPC Protocol Buffers (GPB) [GPB]. Protocol Buffers (protobuf) were developed by Google as open source software and provide a language-neutral, platform-neutral, extensible mechanism for serializing structured data. The Telemetry Server streams Telemetry data to the Telemetry Client via gNMI SubscribeResponse messages. The data is transferred in the form of gRPC Protocol Buffers (GPB) messages described with proto3. The Telemetry Server can support both Key-Value GPB encoding or compact GPB encoding for gNMI. Proto3 files

The OpenConfig YANG Go Tools (https://github.com/openconfig/ygot) can be used to convert YANG modules into streaming data encodings for gNMI.

CableLabs is the authoritative source for defining YANG modules for DOCSIS services.

7.5.5.3 Protocol Mappings

This section highlights the IPDR/SP and gNMI protocol mappings. The table below highlights the correlations between these protocols.

Table 487 - Streaming Protocol Mappings

IPDR/SP Session Type	IPDR/SP Record Type	gNMI/gRPC Subscription Type	gNMI/gRPC Subscription Mode
Time Interval	Interval, Start, Stop	STREAM	SAMPLE
Event Based	Event (see Note 1)	STREAM, POLL	ON_CHANGE
Ad-hoc	Start, Stop or Event	ONCE	N/A

Note 1: CMTS vendors do not always use Event record types for Event based session. In some cases, Start and Stop records are used, such as for CMTS-CM-REG-STATUS-TYPE records.

7.5.5.4 Data Collection

This section lists the data records that can be collected using the Streaming Protocols.

7.5.5.4.1 CCAP Subscriber Usage Statistics

7.5.5.4.1.1 SAMIS-TYPE-1

DOCSIS-SAMIS-TYPE-1 is an IPDR Service Definition schema defining the Subscriber Account Management (SAMIS) Type 1 IPDR data record. SAMIS-TYPE-1 is based on the inclusive streaming model where all fields are included in each streamed record. The schema for DOCSIS-SAMIS-TYPE-1 is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-1/DOCSIS-SAMIS-TYPE-1_3.5.1-A.1.xsd

The following service flow data elements are contained in the schema, and map to the YANG defined in the *cablelabs-yang-docsis-qos-status* module:

Schema Element	YANG Leaf/List
ServiceFlowChSet	channel-set-id
ServiceAppId	application-id
ServiceDsMulticast	usage
ServiceIdentifier	sid
ServiceClassName	name
ServiceDirection	direction
ServiceOctetsPassed	octets
ServicePktsPassed	packets
ServiceSlaDropPkts	policed-dropped-pkts
ServiceSlaDelayPkts	policed-delayed-pkts
ServiceTimeCreated	created
ServiceTimeActive	active

The following CCAP correlation meta-data elements are also contained in the schema, and map to the YANG that is defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List

CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime		(Not defined in YANG)
CmtsIpv4Addr	cablelabs-ccap-common-yang-types	host->address
CmtsIpv6Addr	cablelabs-ccap-common-yang-types	host->address
CmtsMdIfName	ietf-interfaces	name
CmtsMdIfIndex	ietf-interfaces	if-index
ServiceGateId	cablelabs-ccap-docsis-packet-cable	cmts-gate-id-value

The following CM correlation meta-data elements are also contained in the schema, and map to the YANG defined in the *cablelabs-ccap-cmts-cm* module:

Schema Element	YANG Leaf/List
CmMacAddr	mac-addr
CmIpv4Addr	ipv4-addr
CmIpv6Addr	ipv6-addr
CmIpv6LinkLocalAddr	ipv6-link-local
CmQosVersion	qos-version
CmRegStatusValue	reg-status
CmLastRegTime	last-reg-time

The following IPDR protocol specific data is contained in the schema:

- RecType
- RecCreationTime

The CCAP supports streaming of SAMIS-TYPE-1 record collections as a time interval session and an ad-hoc session. The CCAP supports a minimum collection interval of 15 minutes (default value) and a maximum collection interval of 1440 minutes for a time interval session.

7.5.5.4.1.1.1 CCAP Subscriber Usage Statistics YANG Tree

The CableLabs future CCAP (the Network Function) device YANG tree can be pruned down to include the required subscriber usage billing record data nodes as shown below:

7.5.5.4.1.1.1.1 module: cablelabs-ccap-docsis40

```
+--rw ccap
   +--rw name?              string
   +--rw host
       +--rw (address-or-hostname)?
           +--:(address)
               +--rw address    inet:ip-address
           +--:(name)
               +--rw name       inet:domain-name
```

7.5.5.4.1.1.1.2 module: cablelabs-ccap-docsis-qos

```
+--rw docsis
   +--rw docs-qos
   +--rw docs-qos-config
      +--rw service-class* [name]
            +--rw name                                    string
            +--rw application-id?                         uint32
      +--ro docs-qos-status
         +--ro service-flow* [interface-index id]
            +--ro interface-index                  interface-index
            +--ro id                               service-flow-id
```

```
            +--ro direction?                              cl-types:direction-type
            +--ro channel-set-id?                         channel-set-id
            +--ro service-flow-stats* [interface-index service-flow-id]
               +--ro interface-index            interface-index
               +--ro service-flow-id            service-flow-id
               +--ro packets?                   ietf-yang:counter64
               +--ro octets?                    ietf-yang:counter64
               +--ro created?                   ietf-yang:timestamp
               +--ro active?                    ietf-yang:counter32
               +--ro policed-dropped-packets?   ietf-yang:counter32
               +--ro policed-delayed-packets?   ietf-yang:counter32
```

7.5.5.4.1.1.1.3 module: cablelabs-ccap-docsis-mac-domain

```
   +--rw docsis
   +--rw docs-mac-domain
      +--rw mac-domain* [mac-domain-name]
         +--rw mac-domain-name                          string
      +--ro cable-modems* [cm-mac-address cm-index]
```

7.5.5.4.1.1.1.4 module: cablelabs-ccap-cmts-cm

```
   +--rw interface
      +--ro cmts-cm-reg-status* [id]
         +--ro mac-addr              ietf-yang:mac-address
         +--ro md-if-index           cl-ccap-common-types:if-index
         +--ro ipv6-addr?             ietf-inet:ipv6-address
         +--ro ipv4-addr?              ietf-inet:ipv4-address
         +--ro reg-status?             cmts-cm-reg-state
         +--ro qos-version?           int32
         +--ro last-reg-time?         ietf-yang:date-and-time
```

7.5.5.4.1.1.1.5 module: ietf-interfaces

```
  +--rw interfaces
   +--rw interface* [name]
     +--rw name                        string
     +--rw type                        identityref
     +--ro if-index                    int32 {if-mib}?
```

7.5.5.4.1.1.2 CCAP Subscriber Usage Statistics Paths

This section lists the future YANG node paths for the CCAP subscriber usage billing data set.

```
/cap/name

/ccap/host/address

/ccap/docsis/docs-mac-domain/mac-domain=[mac-domain-name]/mac-domain-name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/interface/cmts-cm-reg-status=[id]/mac-addr

/ccap/interface/cmts-cm-reg-status=[id]/ipv4-addr

/ccap/interface/cmts-cm-reg-status=[id]/ipv6-addr

/ccap/interface/cmts-cm-reg-status=[id]/md-if-index

/ccap/interface/cmts-cm-reg-status=[id]/qos-version

/ccap/interface/cmts-cm-reg-status=[id]/reg-status

/ccap/interface/cmts-cm-reg-status=[id]/last-reg-time

/ccap/docsis/docs-packet-cable/packet-cable-config/cmts-gate-id-value

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/name

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/application-id

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/channel-set-id
```

```
/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/direction

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/service-flow-id

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/octets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/packets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/policed-dropped-packets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/policed-delayed-packets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/active
```

7.5.5.4.1.2 SAMIS-TYPE-2

DOCSIS-SAMIS-TYPE-2 is an IPDR Service Definition schema defining the Subscriber Account Management (SAMIS) Type 2 IPDR data record. SAMIS-TYPE-2 is based on the optimized streaming model where only updated fields are included in each streamed record. The schema for DOCSIS-SAMIS-TYPE-2 is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-2/DOCSIS-SAMIS-TYPE-2_3.5.1-A.1.xsd

The following service flow data elements are contained in the schema and map to the YANG defined in the *cablelabs-yang-docsis-qos* module:

Schema Element	YANG Leaf/List
ServiceFlowChSet	channel-set-id
ServiceAppId	application-id
ServiceDsMulticast	usage
ServiceIdentifier	sid
ServiceClassName	name
ServiceDirection	direction
ServiceOctetsPassed	octets
ServicePktsPassed	packets
ServiceSlaDropPkts	policed-dropped-pkts
ServiceSlaDelayPkts	policed-delayed-pkts
ServiceTimeCreated	created
ServiceTimeActive	active

The following CCAP correlation meta-data elements are also contained in the schema, and map to the YANG that is defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime		(Not defined in YANG)
CmtsMdIfName	ietf-interfaces	name
CmtsMdIfIndex	ietf-interfaces	if-index
ServiceGateId	cablelabs-ccap-docsis-packet-cable	cmts-gate-id-value

The following CM correlation meta-data elements are also contained in the schema, and map to the YANG defined in the *cablelabs-ccap-cmts-cm* module:

Schema Element	YANG Leaf/List
CmMacAddr	mac-addr

The following IPDR protocol-specific data is contained in the schema:

- RecType
- RecCreationTime

The CCAP supports streaming of SAMIS-TYPE-2 record collections as a time interval session and an ad-hoc session. The CCAP supports a minimum collection interval of 15 minutes (default value) and a maximum collection interval of 1440 minutes for a time interval session.

7.5.5.4.1.2.1 CCAP Optimized Subscriber Usage Statistics YANG Tree

The CableLabs future CCAP (the Network Function) device YANG tree can be pruned down to include the required subscriber usage billing record data nodes as shown below:

7.5.5.4.1.2.1.1 module: cablelabs-ccap-docsis40

```
+--rw ccap
   +--rw name?                        string
```

7.5.5.4.1.2.1.2 module: cablelabs-ccap-docsis-qos

```
 +--rw docsis
   +--rw docs-qos
     +--rw docs-qos-config
        +--rw service-class* [name]
            +--rw name                                        string
            +--rw application-id?                             uint32
     +--ro docs-qos-status
        +--ro service-flow* [interface-index id]
            +--ro interface-index                          interface-index
            +--ro id                                       service-flow-id
            +--ro direction?                               cl-types:direction-type
            +--ro channel-set-id?                          channel-set-id
            +--ro service-flow-stats* [interface-index service-flow-id]
               +--ro interface-index            interface-index
               +--ro service-flow-id            service-flow-id
               +--ro packets?                   ietf-yang:counter64
               +--ro octets?                    ietf-yang:counter64
               +--ro created?                   ietf-yang:timestamp
               +--ro active?                    ietf-yang:counter32
               +--ro policed-dropped-packets?   ietf-yang:counter32
               +--ro policed-delayed-packets?   ietf-yang:counter32
```

7.5.5.4.1.2.1.3 module: cablelabs-ccap-docsis-mac-domain

```
      +--rw docsis
      +--rw docs-mac-domain
        +--rw mac-domain* [mac-domain-name]
                  +--rw mac-domain-name                          string
```

7.5.5.4.1.2.1.4 module: cablelabs-ccap-docsis-packet-cable

```
+-- docsis
 +--rw docs- packet-cable
        +--rw packet-cable-config!
            +--rw cmts-gate-id-value                    uint32
```

7.5.5.4.1.2.1.5 module: ietf-interfaces

```
  +--rw interfaces
     +--rw interface* [name]
       +--rw name                          string
       +--rw type                          identityref
       +--ro if-index                      int32 {if-mib}?
```

7.5.5.4.1.2.2 CCAP Optimized Subscriber Usage Statistics Paths

This section lists the future YANG node paths for the CCAP subscriber usage billing data set.

```
/ccap/name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/docsis/docs-qos/docs-qos-status/cmts-mac-to-service-flow=[cable-modem-mac service-flow-
id]/cable-modem-mac

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/channel-set-id

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/application-id

/ccap/docsis/docs-packet-cable/packet-cable-config/cmts-gate-id-value

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/name

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/direction

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/service-flow-id

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/octets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/packets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/policed-dropped-packets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/policed-delayed-packets

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/service-flow-
stats=[interface-index service-flow-id]/active
```

7.5.5.4.2 CCAP CM Registration Status

7.5.5.4.2.1 CMTS-CM-REG-STATUS-TYPE

DOCSIS-CMTS-CM-REG-STATUS-TYPE is an IPDR Service Definition Schema that defines the Registration status of the CM as perceived by the CMTS. The schema for CMTS-CM-REG-STATUS-TYPE is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-REG-STATUS-TYPE/DOCSIS-CMTS-CM-REG-STATUS-TYPE_3.5.1-B.2.xsd

The following CM registration status data elements are contained in the schema, and map to the YANG defined in the *cablelabs-ccap-cmts-cm* module:

Schema Element	YANG Leaf/List
DsProfileIdList	ds-profile-ids* [profile-id]
UsProfileIucList	us-profile-iucs* [iuc]
TcsPhigh	tcs-phigh
TcsDrwTop	tcs-drw-top
MinUsableDsFreq	min-usable-ds-freq
MaxUsableDsFreq	max-usable-ds-freq

MaxUsableUsFreq	max-usable-us-freq
PartialSvcState	partial-svc-state
PartialChanState	partial-chan-state

The following CCAP correlation meta-data elements are also contained in the schema, and map to the YANG that is defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime		~~up-time~~ (Not defined in YANG)
CmtsMdIfName	ietf-interfaces	name
CmtsMdIfIndex	ietf-interfaces	if-index
CmtsMdCmSgId	cablelabs-ccap-cmts-cm	md-cm-sg-id
CmtsRcpId	cablelabs-ccap-cmts-cm	rcp-id
CmtsRccStatusId	cablelabs-ccap-cmts-cm	rcc-status-id
CmtsRcsId	cablelabs-ccap-cmts-cm	rcs-id
CmtsTcsId	cablelabs-ccap-cmts-cm	tcs-id

The following CM correlation meta-data elements are also contained in the schema, and map to the YANG defined in the *cablelabs-ccap-cmts-cm* module:

Schema Element	YANG Leaf/List
CmMacAddr	mac-addr
CmIpv4Addr	ipv4-addr
CmIpv6Addr	ipv6-addr
CmIpv6LinkLocalAddr	ipv6-link-local
CmQosVersion	qos-version
CmRegStatusValue	reg-status
CmLastRegTime	last-reg-time
CmEnergyMgtEnabled	energy-mgt-enabled
CmEnergyMgtOperStatus	energy-mgt-oper-status

The following IPDR protocol specific data is contained in the schema:

- RecType
- RecCreationTime

7.5.5.4.2.2 CCAP CM Registration Status YANG Tree

The CableLabs future CCAP (the Network Function) device YANG tree can be pruned down to include the required CM registration data nodes as shown below:

7.5.5.4.2.2.1 module: cablelabs-ccap-docsis40

```
+--rw ccap
     +--rw name?                        string
```

7.5.5.4.2.2.2 module: ietf-interfaces

```
  +--rw interfaces
    +--rw interface* [name]
```

```
   +--rw name string
   +--ro if-index int32 {if-mib}?
```

7.5.5.4.2.2.3 module: cablelabs-ccap-cmts-cm

```
 +--ro cmts-cm-reg-status* [id]
    +--ro id?                                uint32
    +--ro mac-addr?                          ietf-yang:mac-address
    +--ro ipv6-addr?                         inet:ipv6-address
    +--ro ipv6-link-local?                   inet:ipv6-address
    +--ro ipv4-addr?                         inet:ipv4-address
    +--ro reg-status?                         cmts-cm-reg-state
    +--ro md-if-index?                       cl-ccap-common-types:if-index
    +--ro md-cm-sg-id?                       uint32
    +--ro rcp-id?                            cl-ccap-common-types:rcp-id
    +--ro rcc-status-id?                     uint32
    +--ro rcs-id?                            cl-docsis-qos-types:channel-set-id
    +--ro tcs-id?                            cl-docsis-qos-types:channel-set-id
    +--ro qos-version?                       int32
    +--ro last-reg-time?                     ietf-yang:date-and-time
    +--ro addr-resolution-regs?              ietf-yang:counter32
    +--ro energy-mgt-enabled?                energy-management-mode
    +--ro energy-mgt-oper-status?            energy-management-mode
    +--ro assigned-em-ids?                   cl-common-types:octet-data-type
    +--ro ds-profile-ids*                cl-common-types:octet-data-type
    +--ro us-profile-iucs*               cl-common-types:octet-data-type
    +--ro tcs-phigh?                         uint16
    +--ro tcs-drw-top?                       uint8
    +--ro min-usable-ds-freq?                uint32
    +--ro max-usable-ds-freq?                uint32
    +--ro max-usable-us-freq?                uint32
    +--ro partial-svc-state?                 partial-service-type
    +--ro partial-chan-state?                partial-channel-type
    +--ro cmts-cm-ds-ofdm-channel-status* [if-index]
       +--ro if-index?                                cl-ccap-common-types:if-index
       +--ro current-partial-service-reason-code?     partial-service-reason-type
       +--ro last-partial-service-time?               ietf-yang:date-and-time
       +--ro last-partial-service-reason-code?        partial-service-reason-type
       +--ro num-partial-service-incidents?           ietf-yang:counter32
       +--ro num-partial-channel-incidents?           ietf-yang:counter32
       +--ro preferred-profile?                       uint8
       +--ro cmts-cm-ds-ofdm-profile-status* [profile-id]
          +--ro profile-id?                           uint8
          +--ro partial-channel-reason-code?          partial-channel-reason-type
          +--ro last-partial-channel-time?            ietf-yang:date-and-time
          +--ro last-partial-channel-reason-code?     partial-channel-reason-type
    +--ro cmts-cm-us-ofdma-channel-status* [if-index]
       +--ro if-index?                                cl-ccap-common-types:if-index
       +--ro rx-power?                                cl-common-types:tenths16
       +--ro mean-rx-mer?                             cl-common-types:hundredths16
       +--ro standard-deviation-rx-mer?               cl-common-types:hundredths16
       +--ro rx-mer-threshold?                        uint8
       +--ro threshold-rx-mer-value?                  cl-common-types:hundredths16
       +--ro threshold-rx-merg-highest-freq?          uint32
       +--ro microreflections?                        uint16
       +--ro high-resolution-timing-offset?           int32
       +--ro is-muted?                                boolean
       +--ro ranging-status?                          ranging-status
       +--ro current-partial-service-reason-code?     partial-service-reason-type
       +--ro last-partial-service-time?               ietf-yang:date-and-time
       +--ro last-partial-service-reason-code?        partial-service-reason-type
       +--ro num-partial-service-incidents?           ietf-yang:counter32
       +--ro cmts-cm-us-ofdma-profile-status* [data-iuc]
          +--ro data-iuc?                  uint8
          +--ro total-codewords?           ietf-yang:counter64
          +--ro corrected-codewords?       ietf-yang:counter64
          +--ro unreliable-codewords?      ietf-yang:counter64
          +--ro pre-fec-error-free-cw?     ietf-yang:counter32
          +--ro timestamp?                 ietf-yang:date-and-time
    +--ro cmts-cm-us-status* [id]
       +--ro id?                                -> /ccap/interface/cmts-cm-reg-status/id
```

```
      +--ro ch-if-index?                    cl-ccap-common-types:if-index
      +--ro modulation-type?                cl-docsis-types:us-channel-type
      +--ro rx-power?                       cl-common-types:tenths16
      +--ro signal-noise?                   cl-common-types:tenths16
      +--ro microreflections?               uint16
      +--ro eq-data?                        cl-docsis-types:equalizer-data
      +--ro unerroreds?                     ietf-yang:counter32
      +--ro correcteds?                     ietf-yang:counter32
      +--ro uncorrectables?                 ietf-yang:counter32
      +--ro high-resolution-timing-offset?  int32
      +--ro is-muted?                       boolean
      +--ro ranging-status?                 ranging-status
   +--ro cmts-cm-em-stats* [id]
       +--ro id?                          -> /ccap/interface/cmts-cm-reg-status/id
       +--ro em1x1-mode-total-duration?   uint32
       +--ro dls-mode-total-duration?     uint32
       +--ro last-dls-time?               ietf-yang:date-and-time
       +--ro dls-wakeup-events?           ietf-yang:counter32
```

7.5.5.4.2.3 CCAP CM Registration Status Paths

This section lists the future YANG node paths for the CCAP CM registration status data set.

```
/ccap/name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/interface/cmts-cm-reg-status=[id]/md-cm-sg-id

/ccap/interface/cmts-cm-reg-status=[id]/md-if-index

/ccap/interface/cmts-cm-reg-status=[id]/rcp-id

/ccap/interface/cmts-cm-reg-status=[id]/rcc-status-id

/ccap/interface/cmts-cm-reg-status=[id]/rcs-id

/ccap/interface/cmts-cm-reg-status=[id]/tcs-id

/ccap/interface/cmts-cm-reg-status=[id]/mac-addr

/ccap/interface/cmts-cm-reg-status=[id]/ipv4-addr

/ccap/interface/cmts-cm-reg-status=[id]/ipv6-addr
/ccap/interface/cmts-cm-reg-status=[id]/qos-version

/ccap/interface/cmts-cm-reg-status=[id]/reg-status

/ccap/interface/cmts-cm-reg-status=[id]/last-reg-time

/ccap/interface/cmts-cm-reg-status=[id]/energy-mgt-enabled
/ccap/interface/cmts-cm-reg-status=[id]/energy-mgt-oper-status
/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-em-stats=[id]/em1x1-mode-total-duration
/ccap/interface/cmts-cm-reg-status=[id]/ds-prole-ids*

/ccap/interface/cmts-cm-reg-status=[id]/us-profile-iucs*

/ccap/interface/cmts-cm-reg-status=[id]/tcs-drw-top

/ccap/interface/cmts-cm-reg-status=[id]/min-usable-ds-freq

/ccap/interface/cmts-cm-reg-status=[id]/max-usable-ds-freq
/ccap/interface/cmts-cm-reg-status=[id]/max-usable-us-freq
/ccap/interface/cmts-cm-reg-status=[id]/partial-svc-state
/ccap/interface/cmts-cm-reg-status=[id]/partial-chan-state
```

7.5.5.4.3 CCAP CM Upstream Statistics

7.5.5.4.3.1 CMTS-CM-US-STATS-TYPE

DOCSIS-CMTS-CM-US-STATS is an IPDR Service Definition Schema that defines the Upstream Channel statistics. This definition supports multiple upstream channels. The schema for DOCSIS-CMTS-CM-US-STATS-TYPE is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-US-STATS-TYPE/DOCSIS-CMTS-CM-US-STATS-TYPE_3.5.1-A.2.xsd

The following CCAP CM upstream statistic data elements are contained in the schema, and map to the YANG defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsCmUsChIfName	IETF-INTERFACES	name
CmtsCmUsChIfIndex	IETF-INTERFACES	if-index
CmtsCmUsChId	cablelabs-ccap-cmts-cm	id
CmtsCmUsModulationType	cablelabs-ccap-cmts-cm	modulation-type
CmtsCmUsRxPower	cablelabs-ccap-cmts-cm	rx-power
CmtsCmUsSignalNoise	cablelabs-ccap-cmts-cm	signal-noise
CmtsCmUsMicroreflections	cablelabs-ccap-cmts-cm	microreflections
CmtsCmUsEqData	cablelabs-ccap-cmts-cm	eq-data
CmtsCmUsUnerroreds	cablelabs-ccap-cmts-cm	unerroreds
CmtsCmUsCorrecteds	cablelabs-ccap-cmts-cm	correcteds
CmtsCmUsUncorrectables	cablelabs-ccap-cmts-cm	uncorrectables
CmtsCmUsHighResolutionTimingOffset	cablelabs-ccap-cmts-cm	high-resolution-timing-offset
CmtsCmUsIsMuted	cablelabs-ccap-cmts-cm	is-muted
CmtsCmUsRangingStatus	cablelabs-ccap-cmts-cm	ranging-status

The following CCAP correlation meta-data elements are also contained in the schema, and map to the YANG that is defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime		(Not defined in YANG)
CmtsMdIfName	ietf-interfaces	name

The following CM correlation meta-data elements are also contained in the schema, and map to the YANG defined in the *cablelabs-ccap-cmts-cm* module:

Schema Element	YANG Leaf/List
CmMacAddr	mac-addr
CmRegStatusId	id

The following IPDR protocol specific data is contained in the schema:

- RecType
- RecCreationTime

7.5.5.4.3.2 CCAP CM Upstream Statistics YANG Tree

The CableLabs future CCAP (the Network Function) device YANG tree can be pruned down to include the required CM upstream statistics data nodes as shown below:

7.5.5.4.3.2.1 module: cablelabs-ccap-docsis40

```
+--rw ccap
     +--rw name?                       string
```

7.5.5.4.3.2.2 module: ietf-interfaces

```
+--rw interfaces
  +--rw interface* [name]
  +--rw name string
  +--ro if-index int32 {if-mib}?
```

7.5.5.4.3.2.3 module: cablelabs-ccap-cmts-cm

```
+--ro cmts-cm-reg-status* [id]

   +--ro mac-addr           ietf-yang:mac-address
   +--ro id                      uint32
   +--ro cmts-cm-us-status* [id]
      +--ro id                                -> /ccap/interface/cmts-cm-reg-status/id
      +--ro ch-if-index?                      cl-ccap-common-types:if-index
      +--ro modulation-type?                  cl-docsis-types:us-channel-type
      +--ro rx-power?                         cl-common-types:tenths16
      +--ro signal-noise?                     cl-common-types:tenths16
      +--ro microreflections?                 uint16
      +--ro eq-data?                          cl-docsis-types:equalizer-data
      +--ro unerroreds?                       ietf-yang:counter32
      +--ro correcteds?                       ietf-yang:counter32
      +--ro uncorrectables?                   ietf-yang:counter32
      +--ro high-resolution-timing-offset?    int32
      +--ro is-muted?                         boolean
      +--ro ranging-status?                   ranging-status
```

7.5.5.4.3.3 CCAP CM Upstream Statistics Paths

This section lists the future YANG node paths for the CCAP CM upstream statistics data set.

```
/ccap/name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/interface/cmts-cm-reg-status=[id]/mac-addr

/ccap/interface/cmts-cm-reg-status=[id]/id

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/id

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/ch-if-index

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/modulation-type

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/rx-power

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/signal-noise

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/microreflections

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/unerroreds

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/correcteds

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/uncorrectables

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/high-resolution-timing-offset

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/is-muted

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/ranging-status

/ccap/interface/cmts-cm-reg-status=[id]/cmts-cm-us-status=[id]/eq-data
```

7.5.5.4.4 CCAP Downstream Utilization Statistics

7.5.5.4.4.1 CMTS-DS-UTIL-STATS-TYPE

DOCSIS-CMTS-DS-UTIL-STATS-TYPE is an IPDR Service Definition Schema that defines downstream utilization statistics for a specified downstream interface for the specified CCAP. The schema for CMTS-DS-UTIL-STATS-TYPE is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-DS-UTIL-STATS-TYPE/DOCSIS-CMTS-DS-UTIL-STATS-TYPE_3.5.1-A.3.xsd

The following downstream data elements are contained in the schema, and map to the YANG defined in multiple modules

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime	cablelabs-docsis-<network-function>	up-time (Not defined in YANG)
CmtsMdIfIndex	ietf-interfaces	if-index
DsIfIndex	ietf-interfaces	if-index
DsIfName	ietf-interfaces	name
DsChId	cablelabs-ccap-rf-ofdm-status	channel-id
DsUtilInterval	cablelabs-ccap-rf-ofdm-status	ofdm-channel-utilization
DsUtilIndexPercentage		channel-ut-utilization channel-utilization (Not defined in YANG)
DsUtilTotalBytes		down-channel-counter-total-bytes total-bytes (Not defined in YANG)
DsUtilUsedBytes		down-channel-counter-used-bytes used-bytes (Not defined in YANG)

The following IPDR protocol specific data is contained in the schema:

- RecType
- RecCreationTime

The CCAP creates CMTS-DS-UTIL-STATS-TYPE records using the configured utilization interval. The CCAP supports streaming of CMTS-DS-UTIL-STATS-TYPE record collections as an event-based session.

7.5.5.4.4.2 CCAP Downstream Utilization Statistics YANG Tree

7.5.5.4.4.2.1 module: cablelabs-ccap-docsis40

```
+--rw ccap
     +--rw name?                      string
```

7.5.5.4.4.2.2 module: ietf-interfaces

```
+--rw interfaces
   +--rw interface* [name]
     +--rw name                       string
     +--rw type                       identityref
     +--ro if-index                   int32 {if-mib}?
```

7.5.5.4.4.2.3 module: cablelabs-ccap-rf-ofdm-status

```
     +--ro ds-ofdm-channel-status* [if-index]
     +--ro if-index                          cl-ccap-common-types:if-index
     +--ro admin-state?                      cl-common-types:admin-string
     +--ro channel-id?                       uint8
     +--ro lower-bdry-freq?                  uint32
     +--ro upper-bdry-freq?                  uint32
```

```
      +--ro lower-bdry-freq-encomp-spectrum?   uint32
      +--ro upper-bdry-freq-encomp-spectrum?   uint32
      +--ro first-active-subcarrier-num?       uint32
      +--ro last-active-subcarrier-num?        uint32
      +--ro num-active-subcarriers?            uint32
      +--ro plc-freq?                          uint32
      +--ro subcarrier-zero-freq?              uint32
      +--ro subcarrier-spacing?                cl-ccap-common-types:subcarrier-spacing-type
      +--ro lower-guardband-width?             uint32
      +--ro upper-guardband-width?             uint32
      +--ro cyclic-prefix?                     cl-ccap-rf-ofdm:ofdm-cyclic-prefix-type
      +--ro rolloff-period?                    cl-ccap-rf-ofdm:ofdm-windowing-type
      +--ro time-interleaver-depth?            uint8
      +--ro num-pilots?                        uint32
      +--ro pilot-scale-factor?                uint32
      +--ro ncp-modulation?                    cl-docsis-types:ds-ofdm-modulation-type
      +--ro ofdm-channel-utilization?          cl-common-types:percent
      +--ro power-adjust?                      int16
      +--ro ds-ofdm-channel-power* [band-index]
         +--ro band-index     uint8
         +--ro center-freq?   uint64
         +--ro tx-power?      cl-common-types:tenths16
      +--ro ds-ofdm-subcarrier-type* [start-subcarrier-id]
         +--ro start-subcarrier-id    uint32
         +--ro end-subcarrier-id?     uint32
         +--ro subcarrier-type?       enumeration
      +--ro ds-ofdm-profile-status* [profile-id]
         +--ro profile-id                              uint8
         +--ro config-change-count?                    uint8
         +--ro profile-full-channel-speed?             uint64
         +--ro profile-out-octets?                     ietf-yang:counter64
         +--ro profile-out-unicast-octets?             ietf-yang:counter64
         +--ro profile-out-multicast-octets?           ietf-yang:counter64
         +--ro profile-out-frame?                      ietf-yang:counter64
         +--ro proile-out-unicast-frame?               ietf-yang:counter64
         +--ro profle-out-multicast-frame?             ietf-yang:counter64
         +--ro profile-counter-discontinuity-time?     ietf-yang:timestamp
         +--ro profile-assigned-cm-ct?                 uint32
         +--ro ds-ofm-subcarrier-status* [start-subcarrier-id]
            +--ro start-subcarrier-id    uint32
            +--ro end-subcarrier-id?     uint32
            +--ro skip?                  boolean
            +--ro main-modulation?       cl-docsis-types:ds-ofdm-modulation-type
            +--ro skip-modulation?       cl-docsis-types:ds-ofdm-modulation-type
      +--ro fdx-enabled?                       boolean
```

7.5.5.4.4.2.4 module: cablelabs-ccap-docsis-mac-domain

```
    +--rw docsis
      +--rw docs-mac-domain
         +--rw mac-domain* [mac-domain-name]
                    +--rw mac-domain-name                              string
```

7.5.5.4.4.3 CCAP Downstream Utilization Statistics Paths

This section lists the future YANG node paths for the CCAP downstream utilization statistics data set.

`/ccap/name`

`/interfaces/interface=[name]/name`

`/interfaces/interface=[name]/if-index`

`/ccap/chassis/slot=[slot-number]/ds-rf-port=[port-number]/ofdm-channel=[ofdm-channel-index]`

`/ccap/chassis/slot=[slot-number]/ds-rf-port=[port-number]/ds-ofdm-channel-status=[if-index]`

`/ccap/chassis/slot=[slot-number]/ds-rf-port=[port-number]/ds-ofdm-channel-status=[if-index]/ofdm-channel-utilization`

7.5.5.4.5 CCAP Upstream Utilization Statistics

7.5.5.4.5.1 CMTS-US-UTIL-STATS-TYPE

DOCSIS-CMTS-US-UTIL-STATS-TYPE is an IPDR Service Definition Schema that defines upstream utilization statistics for a specified upstream interface for the specified CCAP. The schema for DOCSIS-CMTS-US-UTIL-STATS-TYPE is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-US-UTIL-STATS-TYPE/DOCSIS-CMTS-US-UTIL-STATS-TYPE_3.5.1-A.5.xsd

The following upstream data elements are contained in the schema, and map to the YANG defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
UsIfIndex	ietf-interfaces	if-index
UsIfName	ietf-interfaces	name
UsChId	cablelabs-ccap-rf-ofdma-status	channel-id
UsUtilInterval	cablelabs-ccap-rf-ofdma-status	ofdma-channel-utilization
UsUtilIndexPercentage		channel-ut-utilization (Not defined in YANG)
UsUtilTotalMslots		total-mini-slots (Not defined in YANG)
UsUtilUcastGrantedMslots		ucast-granted-mini-slots (Not defined in YANG)
UsUtilTotalCntnMslots		contention-mini-slots (Not defined in YANG)
UsUtilUsedCntnMslots		used-contention-mini-slots (Not defined in YANG)
UsUtilCollCntnMslots		collision-contention-mini-slots (Not defined in YANG)
UsUtilTotalCntnReqMslots		total-content-req-mini-slots (Not defined in YANG)
UsUtilUsedCntnReqMslots		used-contention-request-mini-slots (Not defined in YANG)
UsUtilCollCntnReqMslots		collision-contention-request-mini-slots (Not defined in YANG)
UsUtilTotalCntnReqDataMslots		total-contention-request-data-mini-slots (Not defined in YANG)
UsUtilUsedCntnReqDataMslots		used-contention-request-data-mini-slots (Not defined in YANG)
UsUtilCollCntnReqDataMslots		collision-contention-request-data-mini-slots (Not defined in YANG)
UsUtilTotalCntnInitMaintMslots		total-contention-init-main-mini-slots (Not defined in YANG)
UsUtilUsedCntnInitMaintMslots		used-contention-init-main-mini-slots (Not defined in YANG)
UsUtilCollCntnInitMaintMslots		collision-contention-init-main-mini-slots (Not defined in YANG)

The following CCAP correlation meta-data elements are also contained in the schema, and map to the YANG that is defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime		up-time (Not defined in YANG)
CmtsMdIfIndex	ietf-interfaces	if-index

The following IPDR protocol specific data is contained in the schema:

- RecType
- RecCreationTime

7.5.5.4.5.2 CCAP Upstream Utilization Statistics YANG Tree

7.5.5.4.5.2.1 module: cablelabs-ccap-docsis40

```
  +--rw ccap
     +--rw name?                       string
```

7.5.5.4.5.2.2 module: ietf-interfaces

```
  +--rw interfaces
     +--rw interface* [name]
       +--rw name                        string
       +--ro if-index                    int32 {if-mib}?
```

7.5.5.4.5.2.3 module: cablelabs-ccap-docsis-mac-domain

```
+--rw mac-domain* [mac-domain-name]
   +--rw mac-domain-name string
```

7.5.5.4.5.2.4 module: cablelabs-ccap-rf-ofdma-status

```
  +--rw ccap
     +--rw chassis
       +--rw slot* [slot-number]
          +--rw (line-card-type)
             +--:(rf-line-card)
               +--rw us-rf-port* [port-number]
                 +--ro us-ofdma-channel-status* [if-index]
                    +--ro if-index?                              cl-common-types:if-index
                    +--ro channel-id?                            uint8
                    +--ro template-index?                        uint8
                    +--ro config-change-count?                   uint8
                    +--ro target-rx-power?                       cl-common-types:tenths16
                    +--ro lower-bdry-freq?                       uint32
                    +--ro upper-bdry-freq?                       uint32
                    +--ro subcarrier-spacing?                    cl-ccap-common-types:subcarrier-
spacing-type
                    +--ro cyclic-prefix?                         cl-ccap-ofdma-tp:ofdma-cyclic-
prefix-type
                    +--ro num-symbols-per-frame?                 uint32
                    +--ro rolloff-period?                        cl-ccap-common-types:ofdma-
windowing-type
                    +--ro pre-eq-enable?                         boolean
                    +--ro fine-range-guardband?                  uint32
                    +--ro fine-range-num-subcarriers?            uint16
                    +--ro fine-range-preamble-length?            uint16
                    +--ro initial-range-guardband?               uint32
                    +--ro initial-range-num-subcarriers?         uint16
                    +--ro initial-range-preamble-length?         uint16
                    +--ro provisioned-attribute-mask?            cl-docsis-types:attribute-mask-type
                    +--ro tx-backoff-start?                      uint8
                    +--ro tx-backoff-end?                        uint8
                    +--ro ranging-backoff-start?                 uint8
                    +--ro ranging-backoff-end?                   uint8
                    +--ro ofdma-channel-utilization?             uint8
                    +--ro subcarrier-zero-freq?                  uint32
                    +--ro target-map-interval?                   uint16
                    +--ro cmts-up-channel-total-cms?             ietf-yang:gauge32
                    +--ro us-ofdma-channel-data-iuc-stats* [data-iuc]
                       +--ro data-iuc                               uint8
                       +--ro minislot-pilot-pattern?                uint8
                       +--ro minislot-modulation?                   cl-ccap-common-types:ofdma-
modulation-type
                       +--ro total-codewords?                       ietf-yang:counter64
```

```
                        +--ro corrected-codewords?              ietf-yang:counter64
                        +--ro unreliable-codewords?             ietf-yang:counter64
                        +--ro in-octets?                        ietf-yang:counter64
                        +--ro counter-dicontinuity-time?        ietf-yang:timestamp
                        +--ro assigned-cm-ct?                   uint32
                        +--ro iuc-average-mer?                  cl-common-types:tenths16
                        +--ro us-ofdma-data-iuc-detail-status* [lower-freq]
                          +--ro lower-freq               uint32
                          +--ro upper-freq?              uint32
                          +--ro minislot-pilot-pattern?  uint8
                          +--ro minislot-modulation?     cl-ccap-common-types:ofdma-modulation-
type
                          +--ro lower-subcarrier-id?     uint32
                          +--ro upper-subcarrier-id?     uint32
                      +--ro us-ofdma-ranging-iuc-status* [iuc]
                        +--ro iuc                uint8
                        +--ro guardband?         uint16
                        +--ro num-subcarriers?   uint16
                      +--ro us-ofma-subcarrier-type* [start-subcarrier-id]
                        +--ro start-subcarrier-id    uint32
                        +--ro end-subcarrier-id?     uint32
                        +--ro subcarrier-type?       enumeration
                      +--ro us-ofdma-overlap-channel-status* [index]
                        +--ro index              uint8
                        +--ro docsis-chan-id?    cl-ccap-common-types:chid
                        +--ro upper-bdry-freq?   uint32
                      +--ro fdx-enabled?                        boolean
```

7.5.5.4.5.3 CCAP Upstream Utilization Statistics Paths

This section lists the future YANG node paths for the CCAP upstream utilization statistics data set.

```
/ccap/name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/docsis/cmts-cm-reg-status=[id]/mac-addr

/ccap/chassis/slot=[slot-number]/us-rf-port=[port-number]/us-ofdma-channel-status=[if-
index]/channel-id

/ccap/chassis/slot=[slot-number]/us-rf-port=[port-number]/us-ofdma-channel-status=[if-
index]/channel-utilization-interval
```

7.5.5.4.6 CCAP Service Flows

7.5.5.4.6.1 CMTS-CM-SERVICE-FLOW-TYPE

DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE is is an IPDR Service Definition schema defining details of service flows. The schema for DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE/DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE_3.5.1-B.1.xsd

The following service flow data elements are contained in the schema, and map to the YANG defined in the *cablelabs-yang-docsis-qos* module:

Schema Element	YANG Leaf/List
ServiceFlowChSet	channel-set-id
ServiceAppId	application-id
ServiceDsMulticast	usage
ServiceIdentifier	id
ServiceClassName	name
ServiceDirection	direction
ServiceTrafficPriority	priority

Schema Element	YANG Leaf/List
ServiceMaxSustained	max-traffic-rate
ServiceMaxBurst	max-traffic-burst
ServiceMinReservedRate	min-reserved-rate
ServiceMinReservedPktSize	min-reserved-packet
ServiceIpTos	dscp-overwrite
ServicePeakRate	peak-traffic-rate
ServiceSchedule	scheduling-type
ServiceNomPollInterval	nominal-polling-interval
ServiceTolPollJitter	tolerated-poll-jitter
ServiceUGSize	unsolicited-grant-size
ServiceNomGrantInterval	nominal-grant-interval
ServiceTolGrantJitter	tolerated-grant-jitter
ServiceGrantsPerInterval	grants-per-interval
ServicePacketClassifiers	packet-class
ServiceTimeCreated	created

The following CCAP correlation meta-data elements are also contained in the schema, and map to the YANG that is defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	name
CmtsSysUpTime		up-time (Not defined in YANG)
CmtsMdIfName	ietf-interfaces	name
CmtsMdIfIndex	ietf-interfaces	if-index
ServiceGateId	cablelabs-ccap-docsis-packet-cable	cmts-gate-id-value

The following IPDR protocol specific data is contained in the schema:

- RecType
- RecCreationTime

7.5.5.4.6.2 CCAP Service Flow YANG Tree

The CableLabs future CCAP (the Network Function) device YANG tree can be pruned down to include the required service flow data nodes as shown below:

7.5.5.4.6.2.1 module: cablelabs-ccap-docsis40

```
  +--rw ccap
     +--rw name?                        string
```

7.5.5.4.6.2.2 module: ietf-interfaces

```
+--rw interfaces
  +--rw interface* [name]
  +--rw name string
  +--ro if-index int32 {if-mib}?
```

7.5.5.4.6.2.3 module: cablelabs-yang-docsis-qos

```
+-- docs-qos-config
   +-- service-class* [name]
      +-- name?                                  string
      +-- priority?                              uint8
      +-- max-traffic-rate?                      cl-common-types:bit-rate
```

```
      +-- max-traffic-burst?                          uint32
      +-- min-reserved-rate?                          cl-common-types:bit-rate
      +-- min-reserved-packet?                        uint16
      +-- max-concatenated-burst?                     uint16
      +-- nominal-polling-interval?                   uint32
      +-- tolerated-poll-jitter?                      uint32
      +-- unsolicited-grant-size?                     uint16
      +-- nominal-grant-interval?                     uint32
      +-- tolerated-grant-jitter?                     uint32
      +-- grants-per-interval?                        uint8
      +-- guaranteed-grant-interval?                  uint16
      +-- guaranteed-grant-rate?                      cl-common-types:bit-rate
      +-- guaranteed-request-interval?                uint16
      +-- max-latency?                                uint32
      +-- active-timeout?                             uint16
      +-- admitted-timeout?                           uint16
      +-- scheduling-type?                            cl-docsis-qos-types:service-flow-
scheduling-type
      +-- request-policy?                             cl-common-types:octet-data-type
      +-- tos-and-mask?                               cl-common-types:octet-data-type
      +-- tos-or-mask?                                cl-common-types:octet-data-type
      +-- direction?                                  cl-docsis-qos-types:direction-type
      +-- dscp-overwrite?                             int32
      +-- required-attribute-mask?                    cl-docsis-types:attribute-mask-type
      +-- forbidden-attribute-mask?                   cl-docsis-types:attribute-mask-type
      +-- attribute-aggregate-rule-mask?              cl-common-types:octet-data-type
      +-- application-id?                             uint32
      +-- multiplier-contention-request-window?       uint8
      +-- multiplier-bytes-requested?                 uint8
      +-- max-requests-per-sid-cluster?               uint8
      +-- max-outstanding-bytes-per-sid-cluster?      uint32
      +-- max-total-bytes-requested-per-sid-cluster?  uint32
      +-- max-time-in-sid-cluster?                    uint16
      +-- peak-traffic-rate?                          cl-common-types:bit-rate
      +-- ds-resequencing?                            cl-docsis-qos-types:ds-resequencing-type
      +-- minimum-buffer?                             uint32
      +-- target-buffer?                              uint32
      +-- maximum-buffer?                             uint32
      +-- aqm-disabled                                boolean
      +-- classic-aqm-latency-target?                 uint8
      +-- aqm-algorithm?                              cl-docsis-qos-types:aqm-algorithm-type
      +-- immediate-aqm-max-threshold?                uint16
      +-- immediate-aqm-range-exponent-ramp?          uint8
      +-- latency-hist-bin-edges?                     cl-common-types:octet-data-type
      +-- data-rate-unit-setting?                     cl-docsis-qos-types:data-rate-type
      +-- pgs-activity-detection-disable?             boolean

+--ro docs-qos-status
    +--ro service-flow* [interface-index id]
       +--ro interface-index                        cl-docsis-qos-types:interface-index
       +--ro id                                     cl-docsis-qos-types:service-flow-id
       +--ro sid?                                   uint16
       +--ro direction?                             cl-docsis-qos-types:direction-type
       +--ro primary?                               boolean
       +--ro parameter-set-type-status?             bits
       +--ro channel-set-id?                        cl-docsis-qos-types:channel-set-id
       +--ro attribute-assign-success?              boolean
       +--ro downstream-service-id?                 cl-docsis-qos-types:downstream-service-id
       +--ro max-requests-per-sid-cluster?          uint8
       +--ro max-outstanding-bytes-per-sid-cluster? uint32
       +--ro max-total-bytes-per-sid-cluster?       uint32
       +--ro max-time-in-sid-cluster?               uint16
       +--ro buffer-size?                           uint32
       +--ro iatc-profile-name?                     string
       +--ro aggregate-service-flow-id?             -> /ccap/docsis/docs-qos/docs-qos-
status/aggregate-service-flow/id
       +--ro type?
```

7.5.5.4.6.2.4 module: cablelabs-ccap-docsis-packet-cable

```
+--rw docs-packet-cable
```

```
+-- (packet-cable)?
   +--:(packet-cable-config)
      +--rw cmts-gate-id-value uint32
```

7.5.5.4.6.3 CCAP Service Flow Paths

This section lists the future YANG node paths for the CCAP service flow data set.

```
/ccap/name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/docsis/docs-qos/docs-qs-config/service-class=[name]/application-id

/ccap/docsis/docs-qos/docs-qos-status/cmts-downsteam-service-id=[downstream-service-id interface-
index]/usage

/ccap/docsis/docs-qos/docs-qos-status/cmts-downsteam-service-id=[downstream-service-id interface-
index]/downstream-service-id

/ccap/docsis/docs-packet-cable/cmts-gate-id-value

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/name

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-index id]/direction

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/max-traffic-rate

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/max-traffic-burst

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/min-reserved-rate

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/dscp-overwrite

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/peak-traffic-rate

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/scheduling-type

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/nominal-polling-interval

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/nominal-grant-interval

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/tolerated-grant-jitter

/ccap/docsis/docs-qos/docs-qos-config/service-class=[name]/grants-per-interval

/ccap/docsis/docs-qos/docs-qos/service-class=[name]/application-id

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-inidex id]/packet-class=[interface-
index id service-flow-id]

/ccap/docsis/docs-qos/docs-qos-status/service-flow=[interface-inidex id]/service-flow-
stats=[interface-index service-flow-id]/created
```

7.5.5.4.7 CPE Information

7.5.5.4.7.1 CPE-TYPE

DOCSIS-CPE-TYPE is an IPDR Service Definition Schema that defines the Customer Premise Equipment (CPE) attached to a CM as perceived by the CMTS. The schema for DOCSIS-CPE-TYPE is located at:

http://mibs.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CPE-TYPE/DOCSIS-CPE-TYPE_3.5.1-A.2.xsd

The following CPE elements are contained in the schema, and map to the YANG defined in multiple modules:

Schema Element	YANG Module	YANG Leaf/List
CmtsHostName	cablelabs-ccap-docsis40	ccap/name
CmtsSysUpTime		/ccap/system-grp/system-status/up-time
CmtsMdIfName	ietf-interfaces	/interfaces/interface/name
CmtsMdIfIndex	ietf-interfaces	/interfaces/interface/if-index

Schema Element	YANG Module	YANG Leaf/List
CmMacAddr	cablelabs-ccap-cmts-cm	/ccap/docsis/cmts-cm-reg-status/mac-addr
CpeMacAddr	ietf-interfaces	NA
CpeIpv4AddrList		/ccap/docsis/docs-subscriber-management/subscriber-cpe-status/ip-addr
CpeIpv6AddrList		/ccap/docsis/docs-subscriber-management/subscriber-cpe-status/ip-addr
CpeFqdn		NA

7.5.5.4.7.2 CPE YANG Tree

The CableLabs future CCAP (the Network Function) device YANG tree can be pruned down to include the required CPE nodes as shown below:

7.5.5.4.7.2.1 module: cablelabs-ccap-docsis40

```
  +--rw ccap
     +--rw name?                        string
```

7.5.5.4.7.2.2 module: ietf-interfaces

```
+--rw interfaces
  +--rw interface* [name]
  +--rw name string
  +--ro if-index int32 {if-mib}?
```

7.5.5.4.7.2.3 module: cablelabs-ccap-cmts-cm

```
  +--ro cmts-cm-reg-status* [id]
     +--ro mac-addr           ietf-yang:mac-address
     +--ro id                      uint32
```

7.5.5.4.7.3 CPE Paths

This section lists the future YANG node paths for the CPE data set.

```
/ccap/name

/interfaces/interface=[name]/name

/interfaces/interface=[name]/if-index

/ccap/interfaces/cmts-cm-reg-status[id]/mac-addr

/interfaces/interface=[name]/phys-address
```

7.5.6 Streaming Telemetry Status Information Models

This section defines the Information Models for DOCSIS CCAP Streaming Telemetry Status use cases, including status for gNMI Streaming Telemetry Clients and status for IPDR Collectors.

7.5.6.1 IPDR Streaming Telemetry Status Information Model

The IPDR Streaming Telemetry Status class diagram in Figure 91 - IPDR Streaming Telemetry Status defines classes for reporting status and performance management information for CCAP IPDR Streaming Telemetry connections and subscriptions, and classes for reporting CCAP capabilities for IPDR Streaming Telemetry. The IPDR Streaming Telemetry Status classes are rooted from the StreamingTelemetryStatus class and the IpdrTelemetryCapabilities class is rooted from the Capabilities class.

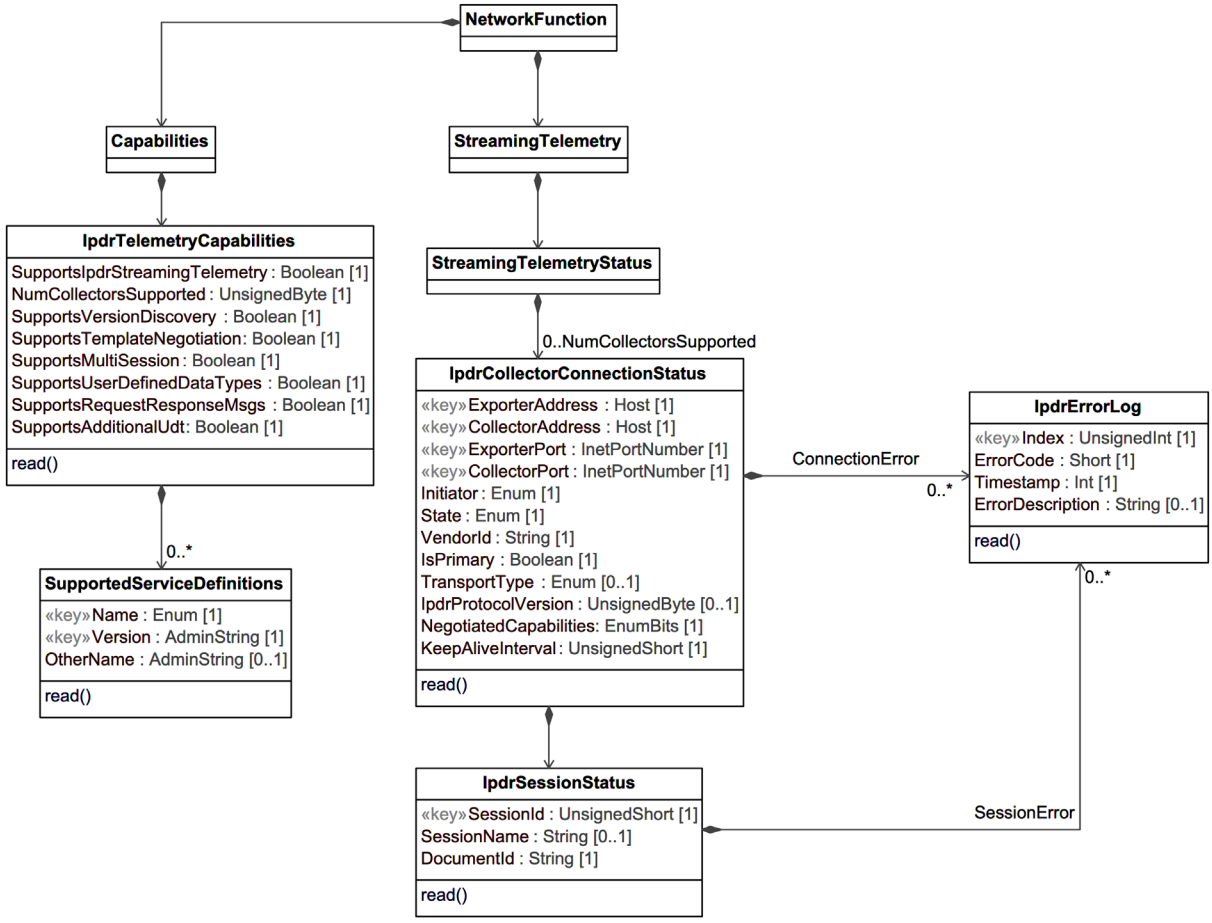


Figure 91 - IPDR Streaming Telemetry Status Information Model

7.5.6.1.1 NetworkFunction

The NetworkFunction object is the root of the Streaming Telemetry objects and is included in Figure 91 - IPDR Streaming Telemetry Status for reference.

7.5.6.1.2 StreamingTelemetry

The StreamingTelemetry object is the container for all CCAP Streaming Telemetry classes.

Table 488 - StreamingTelemetry Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
StreamingTelemetryStatus	Directed Composition to StreamingTelemetryStatus	1	0..*	

7.5.6.1.3 StreamingTelemetryStatus

The StreamingTelemetryStatus object is the container for Streaming Telemetry Status information.

Table 489 - StreamingTelemetryStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpdrCollectorConnectionStatus	Directed Composition to IpdrCollectorConnectionStatus	1	0..NumCollectorsSupported	

7.5.6.1.4 IpdrCollectorConnectionStatus

The IpdrCollectorConnectionStatus object reports the status of IPDR Collectors connected to, or in the process of connecting to, the CCAP's IPDR Exporter.

Table 490 - IpdrCollectorConnectionStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
ExporterAddress	Host	Key		
CollectorAddress	Host	Key		
ExporterPort	InetPortNumber	Key		
CollectorPort	InetPortNumber	Key		
Initiator	Enum	Read-only	collector(1), exporter(2)	
State	Enum	Read-only	other(0), unknown(1), disconnected(2), serviceDiscovery(3), query(4) connected(5), sessionInitiation(6), activeSession(7)	
VendorId	String	Read-only		
IsPrimary	Boolean	Read-only		
TransportType	Enum	Read-only	other(0), tcp(1), sctp(2), beep(3)	
IpdrProtocolVersion	UnsignedByte	Read-only		
NegotiatedCapabilities	EnumBits	Read-only	templateNegotiation(0), multiSession(1), userDefinedDataTypes(2), requestResponseMsgs(3), additionalUdts(4) additionalCapabilities(5)	
KeepAliveInterval	UnsignedShort	Read-only		seconds

Table 491 - IpdrCollectorConnectionStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpdrSessionStatus	Directed Composition to IpdrSessionStatus	1	1	
IpdrErrorLog	DirectedComposition to IpdrErrorLog	1	0..*	ConnectionError

7.5.6.1.4.1 ExporterAddress

This key attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the IPDR Exporter for the connection.

The CCAP MUST support configuring an IP address for the IpdrCollectorConnectionStatus ExporterAddress attribute.

The CCAP SHOULD support configuring an FQDN for the IpdrCollectorConnectionStatus ExporterAddress attribute.

7.5.6.1.4.2 CollectorAddress

This key attribute contains the IP address or a fully qualified domain name (FQDN) assigned to the IPDR Collector for the connection.

The CCAP MUST support configuring an IP address for the IpdrCollectorConnectionStatus CollectorAddress attribute.

The CCAP SHOULD support configuring an FQDN for the IpdrCollectorConnectionStatus CollectorAddress attribute.

7.5.6.1.4.3 ExporterPort

This key attribute is the TCP port used by the IPDR Exporter for the connection.

7.5.6.1.4.4 CollectorPort

This key attribute is the TCP port used by the IPDR Collector for the connection.

7.5.6.1.4.5 Initiator

This attribute reports which IPDR connection endpoint (Exporter or Collector) initiated the connection.

7.5.6.1.4.6 State

This attribute reports the state of the IPDR connection.

A value of 'other' indicates the state of the Streaming Telemetry connection between the Exporter and Collector is other than the currently defined states.

A value of 'unknown' indicates the state of the Streaming Telemetry connection between the Exporter and Collector is not known.

Refer to [IPDR/SP] for the IPDR/SP State Diagrams and remaining state definitions.

7.5.6.1.4.7 VendorId

This attribute is a string that identifies the vendor of the IPDR collector application.

7.5.6.1.4.8 IsPrimary

This attribute reports whether the IPDR connection is with the primary Collector.

A value 'true' indicates the IPDR connection is with the primary Collector.

A value ‘false’ indicates the IPDR connection is with a backup/standby Collector.

7.5.6.1.4.9 TransportType

This optional attribute reports which transport layer protocol is used to transfer data records in this IPDR connection.

Refer to [IPDR/SP] for the supported IPDR/SP transport layer protocols.

7.5.6.1.4.10 IpdrProtocolVersion

This optional attribute reports the version of the IPDR Streaming Protocol used for this connection.

Refer to [IPDR/SP] for the supported IPDR Streaming Protocol versions.

7.5.6.1.4.11 NegotiatedCapabilities

This attribute reports which of the optional IPDR protocol capabilities supported by the CCAP are used for this connection.

If bit 0 is set, the connection uses Template Negotiation as specified in [IPDR/SP].

If bit 1 is set, the connection uses Multiple Sessions as specified in [IPDR/SP].

If bit 2 is set, the connection uses User Defined Data Types as specified in [IPDR/SP].

If bit 3 is set, the connection uses Request/Response messages as specified in [IPDR/SP].

If bit 4 is set, the connection uses Additional User Defined Types as specified in [IPDR/SP].

If bit 5 is set, the connection uses Further Capabilities as specified in [IPDR/SP].

7.5.6.1.4.12 KeepAliveInterval

This attribute reports the Collector's keep alive interval for this IPDR connection. This interval is the time in seconds at which IPDR "KEEP ALIVE" messages are sent from the IPDR Collector to the CCAP IPDR Exporter during periods of inactivity.

7.5.6.1.5 IpdrSessionStatus

The IpdrSessionStatus object reports the status of active IPDR sessions.

Table 492 - IpdrSessionStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
SessionId	UnsignedShort	Key		
SessionName	String	Read-only		
DocumentId	String	Read-only	SIZE(0..16)	

Table 493 - IpdrSessionStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpdrErrorLog	DirectedComposition to IpdrErrorLog	1	0..*	SessionError

7.5.6.1.5.1 SessionId

This key attribute uniquely identifies the IPDR/SP session instance.

7.5.6.1.5.2 SessionName

This optional attribute reports a human-readable ASCII name identifying the IDPR/SP session instance.

7.5.6.1.5.3 DocumentId

This attribute reports the identifier of the IDPR Document transmitted by the IPDR Exporter during the session.

Refer to [IPDR/SP] for additional details on the DocumentId field.

7.5.6.1.6 IpdrErrorLog

This object reports IPDR/SP connection errors and session errors.

Table 494 - IpdrErrorLog Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Index	UnsignedInt	Key		
ErrorCode	Short	Read-only		
Timestamp	Int	Read-only		seconds
ErrorDescription	String	Read-only		

7.5.6.1.6.1 Index

This key attribute uniquely identifies a reported IPDR/SP connection error or session error instance.

7.5.6.1.6.2 ErrorCode

This attribute reports a code describing this IPDR/SP connection error or session error.

Refer to [IPDR/SP] for additional details on the ErrorCode number space.

7.5.6.1.6.3 Timestamp

This attribute reports the timestamp, in seconds from epoch time, the IPDR/SP connection error or status error occurred.

7.5.6.1.6.4 ErrorDescription

This optional attribute reports a human-readable description of the IPDR/SP connection error or session error.

7.5.6.1.7 Capabilities

The Capabilities object is the container for Network Function capabilities.

Table 495 - Capabilities Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
IpdrTelemetryCapabilities	DirectedComposition to IpdrTelemetryCapabilities	1	1	

7.5.6.1.8 IpdrTelemetryCapabilities

The IpdrTelemetryCapabilities object reports CCAP IPDR Streaming Telemetry Capabilities.

The CCAP SHOULD support the IpdrTelemetryCapabilities object.

Table 496 - IpdrTelemetryCapabilities Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
SupportsIdprStreamingTelemetry	Boolean	Read-only		
NumCollectorsSupported	UnsignedByte	Read-only		
SupportsVersionDiscovery	Boolean	Read-only		
SupportsTemplateNegotiation	Boolean	Read-only		
SupportsMultiSession	Boolean	Read-only		
SupportsUserDefinedDataTypes	Boolean	Read-only		

Attribute Name	Type	Access	Type Constraints	Units
SupportsRequestResponseMsgs	Boolean	Read-only		
SupportsAdditionalUdt	Boolean	Read-only		

Table 497 - IpdrTelemetryCapabilities Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
SupportedServiceDefinitions	DirectedComposition to SupportedServiceDefinitions	1	0..*	

7.5.6.1.8.1 SupportsIpdrStreamingTelemetry

This attribute reports whether the CCAP implements an IPDR Exporter function.

A value of 'false' indicates the CCAP does not support IPDR streaming telemetry and other attributes in this object are invalid.

A value of 'true' indicates the CCAP supports IPDR streaming telemetry.

7.5.6.1.8.2 NumCollectorsSupported

This attribute reports the maximum number of IPDR Collectors the CCAP is capable of supporting.

7.5.6.1.8.3 SupportsVersionDiscovery

This attribute reports whether the CCAP supports IPDR/SP version discovery as specified in [IPDR/SP].

A value of 'false' indicates the CCAP does not support IPDR/SP version discovery.

A value of 'true' indicates the CCAP supports IPDR/SP version discovery.

7.5.6.1.8.4 SupportsTemplateNegotiation

This attribute reports whether the CCAP supports IPDR/SP template negotiation as specified in [IPDR/SP].

A value of 'false' indicates the CCAP does not support IPDR/SP template negotiation.

A value of 'true' indicates the CCAP supports IPDR/SP template negotiation.

7.5.6.1.8.5 SupportsMultiSession

This attribute reports whether the CCAP supports IPDR/SP multiple sessions as specified in [IPDR/SP].

A value of 'false' indicates the CCAP does not support IPDR/SP multiple sessions.

A value of 'true' indicates the CCAP supports IPDR/SP multiple sessions.

7.5.6.1.8.6 SupportsUserDefinedDataTypes

This attribute reports whether the CCAP supports IPDR/SP user-defined data types as specified in [IPDR/SP].

A value of 'false' indicates the CCAP does not support IPDR/SP user-defined data types.

A value of 'true' indicates the CCAP supports IPDR/SP user-defined data types.

7.5.6.1.8.7 SupportsRequestResponseMsgs

This attribute reports whether the CCAP supports IPDR/SP Request/Response messages as specified in [IPDR/SP].

A value of 'false' indicates the CCAP does not support IPDR/SP Request/Response messages.

A value of 'true' indicates the CCAP supports IPDR/SP Request/Response messages.

7.5.6.1.8.8 SupportsAdditionalUdt

This attribute reports whether the CCAP supports IPDR/SP additional User Defined Types in the Modify Template and Modify Template Response messages as specified in [IPDR/SP].

A value of 'false' indicates the CCAP does not support IPDR/SP additional User Defined Types.

A value of 'true' indicates the CCAP supports IPDR/SP additional User Defined Types.

7.5.6.1.9 SupportedServiceDefinitions

This object reports information about the IPDR Service Definitions supported by the CCAP.

Table 498 - SupportedServiceDefinitions Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Name	Enum	Key	other(1), cmtsCmServiceFlowType(2), cmtsCmRegStatusType(3), cmtsCmUsStatsType(4), cmtsDsUtilStatsType(5), cmtsUsUtilStatsType(6), cmtsTopologyType(7), cpeType(8), diagLogType(9), diagLogDetailType(10), diagLogEventType(11), samisType1(12), samisType2(13), spectrumMeasurementType(14), ipMulticastStatsType(15), cmtsCmDsOfdmProfileStatusType(16), cmtsCmDsOfdmStatusType(17), cmtsCmUsOfdmaProfileStatusType(18), cmtsCmUsOfdmaStatusType(19), dsOfdmProfileStatsType(20), usOfdmaProfileStatsType(21)	
Version	AdminString	Key		
OtherName	AdminString	Read-only		

7.5.6.1.9.1 Name

This key attribute is the name of the IPDR service definition supported by the CCAP. A value of 'other' can include vendor-specific IPDR service definitions, in conjunction with the OtherName attribute.

7.5.6.1.9.2 Version

This key attribute is the version of the IPDR service definition. The value of this attribute is derived from the IPDR service definition 'version' field (e.g., 3.5.1-A.1).

7.5.6.1.9.3 OtherName

This attribute is the name of the IPDR service definition supported by the CCAP, if Name is 'other'. This can include vendor-specific IPDR service definitions.

7.5.6.2 gNMI Streaming Telemetry Status Data Type Definitions

7.5.6.3 Streaming Telemetry Status Data Type Definitions

This section defines any required data type definitions used in the Streaming Telemetry Status Information Model.

7.5.6.3.1 Streaming Telemetry Status Complex Data Type Definitions

This section defines classes/objects used in the Streaming Telemetry Status Information model as complex data types.

7.5.6.3.1.1 PathType

This class defines parameters defining the encoded data tree path in the gNMI Telemetry Server.

Table 499 - PathType Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Origin	String	Read-only			
Element	PathElemType	Read-only			
Target	String	Read-only			

7.5.6.3.1.1.1 Origin

This attribute is a label to disambiguate the encoded data tree path.

7.5.6.3.1.1.2 Element

This complex attribute reports the encoded data tree path elements.

7.5.6.3.1.1.3 Target

This attribute is the name of the path target.

Reference: [gNMI-SPEC] Paths section

7.5.6.3.1.2 PathElemType

This class defines parameters for the elements of the encoded data tree path in the gNMI Telemetry Server.

Table 500 - PathElemType Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Name	String	Read-only			
Key	KeyValueType	Read-only			

7.5.6.3.1.2.1 Name

This attribute is the name of the element in the encoded data tree path.

7.5.6.3.1.2.2 Key

This complex attribute is the map of the key (attribute) name in the encoded data tree path to its value.

Reference: [gNMI-SPEC] Paths section

7.5.6.3.1.3 KeyValueType

This class defines parameters for the key-value mapping for the encoded data tree path element.

Table 501 - KeyValueType Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Key	String	Read-only			
Value	String	Read-only			

7.5.6.3.1.3.1 Key

This attribute is the name of the attribute in the encoded data tree path element.

7.5.6.3.1.3.2 Value

This attribute is the value of the attribute in the encoded data tree path element.

Reference: [gNMI-SPEC] Paths section

7.5.6.3.1.4 ModelDataType

This class defines parameters describing a set of schema modules.

Table 502 - ModelDataType Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default Value
Name	String	Read-only			
Organization	String	Read-only			
Version	String	Read-only			

7.5.6.3.1.4.1 Name

This attribute is the name of the schema.

7.5.6.3.1.4.2 Organization

This attribute is the name of the organization the published the model.

7.5.6.3.1.4.3 Version

This attribute is the version of the model expressed as a string which represents the semantic version of the catalog entry.

Reference: [gNMI-SPEC] The ModelData message section

7.5.6.4 gNMI Streaming Telemetry Status Information Model

The gNMI Streaming Telemetry Status class diagram in Figure 92 - gNMI Streaming Telemetry Status Information Model defines the Streaming Telemetry Status classes rooted from the StreamingTelemetry class and the TelemetryCapabilities class rooted from the Capabilities class. This class diagram reports status and performance management information for gNMI Streaming Telemetry connections and subscriptions and CCAP gNMO Streaming Telemetry capabilities.

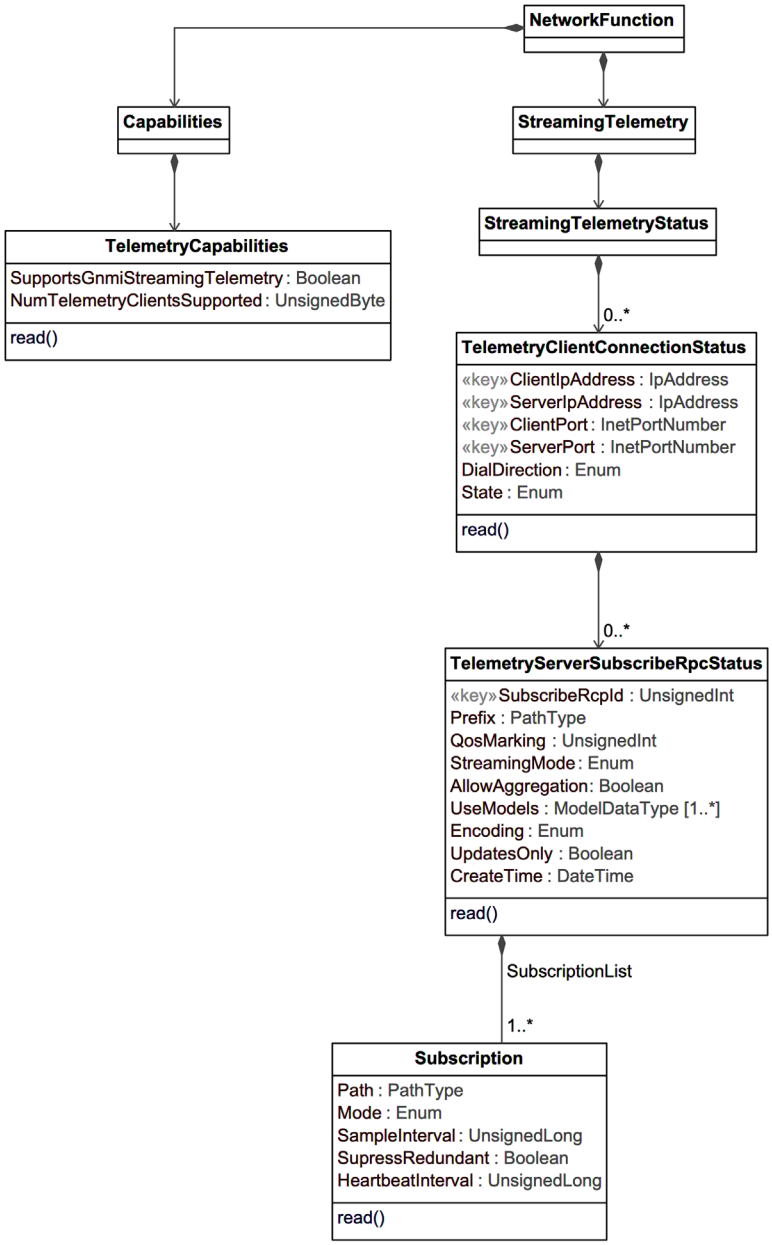


Figure 92 - gNMI Streaming Telemetry Status Information Model

7.5.6.4.1 NetworkFunction

The NetworkFunction object is the root of the Streaming Telemetry objects and is included in Figure 92 for reference.

7.5.6.4.2 StreamingTelemetry

This object is the container for all CCAP Streaming Telemetry classes.

Table 503 - StreamingTelemetry Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
StreamingTelemetryStatus	Directed Composition to StreamingTelemetryStatus	1	0..*	

7.5.6.4.3 StreamingTelemetryStatus

This object is the container for Streaming Telemetry Status information.

Table 504 - StreamingTelemetryStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TelemetryClientConnectionStatus	Directed Composition to TelemetryClientConnectionStatus	1	0..*	

7.5.6.4.4 TelemetryClientConnectionStatus

This object reports the status of gNMI Telemetry Clients connected to, or in the process of connecting to, the gNMI Telemetry Server.

Table 505 - TelemetryClientConnectionStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
ClientIpAddress	IpAddress	Key		
ServerIpAddress	IpAddress	Key		
ClientPort	InetPortNumber	Key		
ServerPort	InetPortNumber	Key		
DialDirection	DialDirectionType	Read-only		
State	Enum	Read-only	other(0), connecting(1), retryWaiting(2), dialOutRetriesExhausted(3), connected(4)	

Table 506 - TelemetryClientConnectionStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TelemetryServerSubscribeRpcStatus	Directed Composition to TelemetryServerSubscribeRpcStatus	1	0..*	

7.5.6.4.4.1 ClientIpAddress

This key attribute reports the IP address of the remote Telemetry Client connected to the Telemetry Server.

7.5.6.4.4.2 ServerIpAddress

This key attribute reports the IP address of the streaming Telemetry Server for the connection.

7.5.6.4.4.3 ClientPort

This key attribute reports the TCP port of the remote Telemetry Client connected to the Telemetry Server.

7.5.6.4.4.4 ServerPort

This key attribute reports the TCP port of the streaming Telemetry Server for the connection.

7.5.6.4.4.5 DialDirection

This attribute reports the method by which a TCP session is established between the Telemetry Server and the Telemetry Client.

7.5.6.4.4.6 State

This attribute reports the state of the Streaming Telemetry connection between the Telemetry Server and the Telemetry Client. Defined values are listed below:

- other: The state of the Streaming Telemetry connection between the Telemetry Server and the Telemetry Client is other than the currently defined states.
- connecting: The Streaming Telemetry connection is in the process of becoming established between the Telemetry Server and the Telemetry Client.
- retryWaiting: The originating source of the Streaming Telemetry connection is waiting to retry establishing a connection after an unsuccessful attempt.
- dialOutRetriesExhausted: The Telemetry Server exhausted the configured maximum number of attempts to establish the Streaming Telemetry connection with the Telemetry Client.
- connected: The Streaming Telemetry connection is established between the Telemetry Server and the Telemetry Client.

7.5.6.4.5 TelemetryServerSubscribeRpcStatus

This object reports the status of gNMI Telemetry Server Subscriptions.

Reference: [gNMI-SPEC] Subscribing to Telemetry Updates section

Table 507 - TelemetryServerSubscribeRpcStatus Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
SubscribeRpcId	UnsignedInt	Key		
Prefix	PathType	Read-only		
QosMarking	UnsignedInt	Read-only		
StreamingMode	Enum	Read-only	stream(0), once(1), poll(2)	
AllowAggregation	Boolean	Read-only		
UseModels	ModelDataType	Read-only		
Encoding	EnumBits	Read-only	json(0), bytes(1), proto(2), ascii(3), jsonIetf(4)	
UpdatesOnly	Boolean	Read-only		
CreateTime	DateTime	Read-only		

Table 508 - TelemetryServerSubscribeRpcStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
Subscription	Directed composition to Subscription	1	1..*	SubscriptionList

7.5.6.4.5.1 SubscribeRpcId

This key attribute is an index for the Telemetry Server subscription instance.

7.5.6.4.5.2 Prefix

This attribute reports the prefix for the path of the elements of the data model tree that the client is subscribed to.

7.5.6.4.5.3 QosMarking

This attribute reports the Differentiated Services Code Point (DSCP) value to be set on telemetry updates transmitted by the Streaming Telemetry Server.

7.5.6.4.5.4 StreamingMode

This attribute reports the streaming mode configured for the telemetry subscription. Defined values are listed below:

- stream(0) indicates telemetry values are streamed by the Telemetry Server to the Telemetry Client
- once(1) indicates telemetry values are transmitted a single time by the Telemetry Server to the Telemetry Client
- poll(2) indicates telemetry values are transmitted from the Telemetry Server to the Telemetry Client in response to a poll request

Reference: [gNMI-SPEC] Creating Subscriptions section

7.5.6.4.5.5 AllowAggregation

This attribute reports whether elements of the schema that are marked as eligible for aggregation should be aggregated or not. Value 'true' indicates elements marked as eligible for aggregation should be aggregated. Value 'false' indicates elements marked as eligible for aggregation should not be aggregated.

Reference: [gNMI-SPEC] Subscribing to Telemetry Updates section

7.5.6.4.5.6 UseModels

This complex attribute reports the set of schema definition modules that define the data elements the Telemetry Server returns in response to a GetRequest message received from a Telemetry Client.

Reference: [gNMI-SPEC] The GetRequest Message section

7.5.6.4.5.7 Encoding

This optional attribute reports the encoding formats supported by the Telemetry Server for telemetry data. Defined values are listed below:

- json(0): JSON encoded text
- bytes(1): arbitrarily encoded bytes
- proto(2): encoded according to out-of-band agreed Protobuf
- ascii(3): ASCII text of an out-of-band agreed format

  jsonIetf(4): JSON encoded text as defined by IETF RFC-7951

7.5.6.4.5.8 UpdatesOnly

This optional attribute reports whether the Telemetry Server has been configured to send only state updates to the Telemetry Client. If StreamingMode reports stream(0), value 'true' for UpdatesOnly indicates the initial state of telemetry data is not sent to the Telemetry Client but instead only the sync message followed by any subsequent updates to the current state are sent. If StreamingMode reports once(1) or poll(2) the value 'true' for UpdatesOnly indicates the Telemetry Server sends only the sync message. Value 'false' for UpdatesOnly indicates the Telemetry Server sends the initial state with the updates in the telemetry data sent to the Telemetry Client.

Reference: [gNMI-SPEC] Sending Telemetry Updates section

7.5.6.4.5.9 CreateTime

This attribute reports the day and time of day the subscription was created.

7.5.6.4.6 Subscription

This object reports the list of subscriptions provided in the Subscribe RPC. The device can automatically create an internal index when reading instances of this object.

Reference: [gNMI-SPEC] The Subscription Message section

Table 509 - Subscription Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
Path	PathType	Read-only		
Mode	Enum	Read-only	targetDefined(0), onChange(1), sample(2)	
SampleInterval	UnsignedLong	Read-only		ns
SuppressRedundant	Boolean	Read-only		
HeartbeatInterval	UnsignedLong	Read-only		ns

7.5.6.4.6.1 Path

This attribute reports the encoded data tree path for the Streaming Telemetry subscription.

7.5.6.4.6.2 Mode

This attribute reports the subscription mode used for the subscription, specifying how the Telemetry Server is required to return values in the subscription. Defined values are listed below:

- targetDefined(0): The Telemetry Server selects the relevant mode for each path element
- onChange(1): The Telemetry Server sends an update on path element value change
- sample(2): The Telemetry Server samples values according to the interval.

7.5.6.4.6.3 SampleInterval

This attribute reports the length of time between samples when the subscription is configured for Sample mode (Subscription::Mode = sample(2)), reported in nanoseconds.

7.5.6.4.6.4 SuppressRedundant

This attribute reports whether the subscription is configured to include in a sample values that have not changed, if the subscription is configured for Sample mode (Subscription::Mode = sample(2)). If the subscription is configured for Sample mode, a value 'true' for SuppressRedundant indicates values that have not changed will not be included in a sample, and a value 'false' for SuppressRedundant indicates values that have not changed will be included in a sample. This attribute should be ignored if the subscription is not configured for Sample mode.

7.5.6.4.6.5 HeartbeatInterval

This attribute reports the maximum allowable silent period in nanoseconds when the subscription is configured for Sample mode and the value of SuppressRedundant is 'true'. The Telemetry Server is required to send a sample at least once during the period defined by HeartbeatInterval if the subscription is configured for Sample mode and SuppressRedundant is 'true'. This attribute should be ignored if the subscription is not configured for Sample mode or if the value of SuppressRedundant is 'false'.

7.5.6.4.7 Capabilities

This object is the container for all CCAP capabilities classes.

Table 510 - Capabilities Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
TelemetryCapabilities	Directed Composition to TelemetryCapabilities	1	1	

7.5.6.4.8 TelemetryCapabilities

This object reports CCAP gNMI Streaming Telemetry capabilities. The CCAP SHOULD support the TelemetryCapabilities object.

Table 511 - TelemetryCapabilities Object Attributes

Attribute Name	Type	Access	Type Constraints	Units
SupportsGnmiStreamingTelemetry	Boolean	Read-only		
NumTelemetryClientsSupported	UnsignedByte	Read-only	0|4..255	

7.5.6.4.8.1 SupportsGnmiStreamingTelemetry

This attribute reports the CCAP's support for Streaming Telemetry using gRPC Network Management Interface (gNMI) protocol [gNMI]. Value 'true' indicates the CCAP supports Streaming Telemetry using gNMI. Value 'false' indicates the CCAP does not support Streaming Telemetry using gNMI.

7.5.6.4.8.2 NumTelemetryClientsSupported

This attribute reports the number of Telemetry Clients supported by the CCAP. This attribute should be ignored if the value of SupportsGnmiStreamingTelemetry is 'false'. If the network function supports gNMI streaming telemetry (TelemetryCapabilities::SupportsGnmiStreamingTelemetry = 'true') then the value NumTelemetryClientsSupported cannot be less than four.

8 ACCOUNTING MANAGEMENT

8.1 SAMIS

This specification defines an accounting management interface for subscriber usage-based applications denominated Subscriber Account Management Interface Specification (SAMIS). SAMIS is defined to enable prospective vendors of cable modems and cable modem termination systems to address the operational requirements of subscriber account management in a uniform and consistent manner. It is the intention that this would enable operators and other interested parties to define, design and develop Operations and Business Support Systems necessary for the commercial deployment of different class of services over cable networks, with accompanying usage-based billing of services for each individual subscriber.

Subscriber Account Management described here refers to the following business processes and terms:

Class of Service Provisioning Processes, which are involved in the automatic and dynamic provisioning and enforcement of subscribed class of policy-based service level agreements (SLAs).

Usage-Based Billing Processes, which are involved in the processing of bills based on services rendered to and consumed by paying subscribers. This Specification focuses primarily on bandwidth-centric usage-based billing scenarios. It complements the PacketCable Event Messages Specification [PKT EM].

The business processes defined above are aligned with the scenarios for Subscriber Account Management described in Appendix I of [OSSIv3.0]. In order to develop the DOCSIS-OSS Subscriber Account Management Specification, it is necessary to consider high-level business processes common to cable operators and the associated operational scenarios. These issues are discussed in Annex B.

The CCAP MUST support collection of usage information, for use by the billing system, via an interface known as the Subscriber Accounting Management Interface Specification (SAMIS).

8.1.1 Subscriber Usage Billing and class of services

The [MULPIv4.0] specification uses the concept of class of service, as the term to indicate the type of data services a CM requests and receives from the CCAP. From a high-level perspective class of services are observed as subscriber types (e.g., residential or business) and the DOCSIS RFI MAC layer parameters fulfill the subscriber service needs.

The [MULPIv4.0] specification supports a DOCSIS 1.1 QoS service class definition type that offers queuing and scheduling services. The DOCSIS 1.0 Class of Service (CoS) service class definition type has been deprecated and is not supported in DOCSIS 4.0.

8.1.1.1 DOCSIS 1.1 Quality of Service (QoS)

The [MULPIv4.0] specification provides a mechanism for a CM to register with its CCAP and to configure itself based on external QoS parameters when it is powered up or reset.

To quote (in part) from the Theory of Operation section of [MULPIv4.0]:

The principal mechanism for providing enhanced QoS is to classify packets traversing the RF MAC interface into a Service Flow. A Service Flow is a unidirectional flow of packets that provide a particular Quality of Service. The CM and the CMTS provide this QoS by shaping, policing, and prioritizing traffic according to the QoS Parameter Set defined for the Service Flow.

The requirements for Quality of Service include:

- A configuration and registration function for pre-configuring CM-based QoS Service Flows and traffic parameters.
- Utilization of QoS traffic parameters for downstream Service Flows.
- Classification of packets arriving from the upper layer service interface to a specific active Service Flow

- Grouping of Service Flow properties into named Service Classes, so upper layer entities and external applications (at both the CM and the CCAP) can request Service Flows with desired QoS parameters in a globally consistent way.

A Service Class Name (SCN) is defined in the CCAP by provisioning (see [OSSIv3.0] Annex O). An SCN provides an association to a QoS Parameter Set. Service Flows that are created using an SCN are considered to be "named" Service Flows. The SCN identifies the service characteristics of a Service Flow to external systems such as a billing system or customer service system. For consistency in billing, operators should ensure that SCNs are unique within an area serviced by the same BSS that utilizes this interface. A descriptive SCN might be something like PrimaryUp, GoldUp, VoiceDn, or BronzeDn to indicate the nature and direction of the Service Flow to the external system.

A Service Package implements a Service Level Agreement (SLA) between the MSO and its Subscribers on the RFI interface. A Service Package might be known by a name such as Gold, Silver, or Bronze. A Service Package is itself implemented by the set of named Service Flows (using SCNs) that are placed into a CM Configuration File that is stored on a Config File server. **Note:** The CM Configuration File contains several kinds of information needed to properly configure the CM and its relationship with the CMTS, but for the sake of this discussion only the Service Flow and Quality of Service components are of interest. The set of Service Flows defined in the CM Config File are used to create active Service Flows when the CM registers with the CCAP. Note that many Subscribers are assigned to the same Service Package and, therefore, many CMs use the same CM Config File to establish their active Service Flows.

A Service Package has to define at least two Service Flows known as Primary Service Flows that are used by default when a packet matches none of the classifiers for the other Service Flows. A CM Config File that implements a Service Package, therefore, needs to define the two primary Service Flows using SCNs (e.g., PrimaryUp and PrimaryDn) that are known to the CCAP if these Service Flows are to be visible to external systems by this billing interface. Note that it is often the practice in a usage sensitive billing environment to segregate the operator's own maintenance traffic, to and from the CM, into the primary service flows so that this traffic is not reflected in the traffic counters associated the subscriber's SLA service flows.

The [MULPIv4.0] specification also provides for dynamically created Service Flows. An example could be a set of dynamic Service Flows created by an embedded PacketCable Multimedia Terminal Adapter (eMTA) to manage VoIP signaling and media flows. All dynamic Service Flows need to be created using an SCN known to the CCAP if they are to be visible to the billing system. These dynamic SCNs do not need to appear in the CM Config File but the MTA may refer to them directly during its own initialization and operation.

During initialization, a CM communicates with a DHCP Server that provides the CM with its assigned IP address and, in addition, receives a pointer to the Config File server that stores the assigned CM Config File for that CM. The CM reads the CM Config File and forwards the set of Service Flow definitions (using SCNs) up to the CCAP. The CCAP then performs a macro-expansion on the SCNs (using its provisioned SCN templates) into QoS Parameter Sets sent in the Registration Response for the CM. Internally, each active Service Flow is identified by a 32-bit SFID assigned by the CCAP to a specific CM (relative to the RFI interface). For billing purposes, however, the SFID is not sufficient as the only identifier of a Service Flow because the billing system cannot distinguish the class of service being delivered by one SFID from another. Therefore, the SCN is necessary, in addition to the SFID, to identify the Service Flow's class of service characteristics to the billing system.

The billing system can then rate the charges differently for each of the Service Flow traffic counts based on its Service Class (e.g., Gold octet counts are likely to be charged more than Bronze octet counts). Thus, the billing system obtains, from the CCAP, the traffic counts for each named Service Flow (identified by SFID and SCN) that a subscriber's CM uses during the billing data collection interval. This is true even if multiple active Service Flows (i.e., SFIDs) are created using the same SCN for a given CM over time. This will result in multiple billing records for the CM for Service Flows that have the same SCN (but different SFIDs). Note that the SFID is the primary key to the Service Flow. When an active Service Flow exists across multiple sequential billing files, the SFID allows the sequence of recorded counter values to be correlated to the same Service Flow instance.

8.1.1.2 High-Level Requirements for Subscriber Usage Billing Records

This section provides the high-level, functional requirements of the Subscriber Usage Billing interface.

The CCAP provides formatted Subscriber Usage Billing Records for all subscribers attached to the CCAP, on demand, to mediation or billing systems.

The transfer of these Usage Billing Records from the CCAP to the mediation/billing system uses the streaming model defined in [IPDR/SP]. This is a mechanism for transmission of Usage Billing Records in near "real-time" from the CCAP to the mediation system.

The CCAP needs to support a minimum billing record transfer interval of 15 minutes.

The CCAP MUST support the processing and transmitting of Subscriber Usage Billing Records as follows:

- A Subscriber Usage Billing Record identifies the CCAP by host name and IP address and the date and time record is sent. The sysUpTime value for the CCAP is recorded, as well as the MAC domain, downstream and upstream information, the CM is registered on to facilitate the characterization of cable interfaces usage.
- A Subscriber Usage Billing Record is identified by CM MAC address (but not necessarily sorted). The Subscriber's current CM IP address is also present in the billing record for the Subscriber. If the CCAP is tracking CPE addresses behind the Subscriber's CM, then these CPE MAC and IP addresses are also to be present in the billing record as well. CPE FQDNs (Fully Qualified Domain Name) are to be present in the billing record only if gleaned from DHCP relay agent transactions (reverse DNS queries are not required).
- A Subscriber Usage Billing Record has entries for each active Service Flow (identified by SFID and Service Class Name) used by all CMs operating in DOCSIS 1.1 (or higher) registration mode during the collection interval. This includes all currently running Service Flows, as well as all terminated Service Flows that were deleted and logged during the collection interval. A provisioned or admitted state SF that was deleted before it became active, is not recorded in the billing document, even though it was logged by the CCAP.
- A Subscriber Usage Billing Record identifies a running Service Flows or a terminated Service Flow, as well as a de-registered CM. A terminated Service Flow is reported into a Subscriber Usage Billing Record once.
- A Subscriber Usage Billing Record identifies the Service Flow direction as upstream or downstream. It collects the number of packets and octets passed for each upstream and downstream Service Flow. The number of packets dropped and the number of packets delayed due to enforcement of QoS maximum throughput parameters (SLA) are also collected for each Service Flow. In the case of an upstream Service Flow, the reported SLA drop and delay counters represent only the QoS policing performed by the CCAP. Note that since it is possible for a Subscriber to switch back and forth from one service package to another, or to have dynamic service flows occur multiple times, it is possible that there will be multiple Subscriber Usage Records for a given SCN during the collection period. This could also occur if a CM re-registers for any reason (such as CM power failure).
- All traffic counters within a Subscriber Usage Billing Record are absolute 32-bit or 64-bit counters. These traffic counters need to be reset to zero by the CCAP if it re-initializes its management interface. The CCAP sysUpTime value is used to determine if the management interface has been reset between adjacent collection intervals. It is expected that the 64-bit counters will not roll over within the service lifetime of the CCAP.

8.1.1.3 Subscriber Usage Billing Records Mapping to Existing DOCSIS Data model

In Section 8.1.1.2 the High-level requirements for Subscriber Usage Billing includes counters for consumption-based billing. Part of that section deals with the collection of counters associated with DOCSIS 1.1 Quality of Service. The mapping described below is required to consistently define the Subscriber Usage Billing service specification based on mandatory and well-defined counter requirements as much as possible.

The [MULPIv4.0] specification does not define MAC layer primitives for usage counters associated to SFIDs to be mapped to Management models like SNMP or this Subscriber Usage Billing service specification.

DOCSIS mandatory QoS counter requirements are contained in this specification. They are defined as Information Models in Section 7.2 of this specification; see Section 7.1 for details on the corresponding SNMP SMI data models.

Table 506 describes the Subscriber Usage Billing model mapping to this specification standard management object base and other requirements not defined in this specification. See Table Notes immediately following Table 506.

Table 512 - Subscriber Usage Billing Model Mapping to DOCSIS Management Object

Subscriber Usage Billing Service Definition Elements		DOCS-QOS3-MIB DOCSIS QoS model Unicast and Multicast SFs
Elements	Type	OBJECT-TYPE Record Interim, Stop
serviceIdentifier	UnsignedInt	docsQosServiceFlowId[1],
serviceGateId	UnsignedInt	N/A[2]
serviceClassName	String	docsQosParamSetServiceClassName[1], docsQosServiceFlowLogServiceClassName
serviceDirection	UnsignedInt	docsQosServiceFlowDirection, docsQosServiceFlowLogDirection
serviceOctetPassed	UnsignedLong	docsQosServiceFlowOctets, docsQosServiceFlowLogOctets
servicePktsPassed	UnsignedLong	docsQosServiceFlowPkts, docsQosServiceFlowLogPkts
serviceSlaDropPkts	UnsignedInt	docsQosServiceFlowPolicedDropPkts, docsQosServiceFlowLogPolicedDropPkts
serviceSlaDelayPkts	UnsignedInt	docsQosServiceFlowPolicedDelayPkts, docsQosServiceFlowLogPolicedDelayPkts
serviceTimeCreated	UnsignedInt	docsQosServiceFlowTimeCreated, docsQosServiceFlowLogTimeCreated
serviceTimeActive	UnsignedInt	docsQosServiceFlowTimeActive, docsQosServiceFlowLogTimeActive
Table Notes: [1] serviceIdentifier: for interim records applicable only to 'active' Service Flows [2] serviceGateId is not part of the DOCSIS QoS model but is available from [PCMM]		

These elements are defined in Annex C, Auxiliary Schemas for DOCSIS IPDR Service Definitions (Normative).

Reporting on Multicast flows based upon DS Multicast does not provide sufficient information for Accounting purposes. The current definition for Multicast flow reporting is for the purposes of Capacity Management. Multicast reporting for Accounting purposes is a subject of future extensibility.

The model above is intended to de-couple the internal management primitives of the required MIB objects as an indication that both processes might be updated independently, or as direct relationships of existing management objects. Therefore, in the case of an active Subscriber Usage Billing IPDR/SP Session, the CCAP SHOULD NOT allow the deletion of Service Flow log records until they have been exported by [IPDR/SP].

8.1.1.4 SAMIS Records Optimization

The CMTS MAY provide mechanisms to prevent exporting Subscriber Usage Billing Records (record suppression) that contain redundant information from a Collector perspective. If traffic counters (octets or packets) of a SFID reported in a previous collection interval do not change, the CMTS does not generate a record for this SFID for this collection interval. The serviceTimeActive counter is not considered a traffic counter and therefore does not influence record suppression.

8.1.1.5 Billing Collection Interval Subscriber Usage Billing Records Export

In the case of streaming data at the end of a collection interval, the CCAP (Exporter) MUST create a new IPDR document by starting and stopping an IPDR/SP Session every collection period. Note that between scheduled collection cycles, the CCAP and the Collector(s) maintain an open TCP stream Connection and the Collector is also in a flow ready state. The CCAP MUST initiate a new Session when it is ready to transmit a complete set of IPDR records to the Collector for the current collection interval. Once the complete set of IPDR records has been transmitted, the CCAP MUST stop the session immediately or stop the session at the end of the collection interval, thereby closing the IPDR document for the current collection interval. When the session is stopped immediately, all subsequent terminated SF's MUST be buffered by the Exporter until they can be transmitted in the next scheduled collection interval. The CCAP MAY also leave the session open until the next collection interval. In addition to the scheduled collection cycles, the CCAP MAY also initiate an unscheduled Session with a Collector whenever it needs to transmit IPDR records for terminated SFs because it is in danger of losing data (e.g., its SF log buffer is about to overflow). This unscheduled Session will only contain RecType = Stop IPDR records for the terminated

SFs in the log buffer, thereby clearing the buffer. It is imperative that logged SFs are only reported once into an IPDR document. If no connection is available (e.g., for an unscheduled Session or existing open Session) with a Collector, then the CCAP MUST delete the oldest SF log entries first.

Other Management strategies may provide Collector control over the streaming data by executing FlowStop and FlowStart at its convenience (for example to perform load balancing or force the termination of streaming from an Exporter).

8.1.2 DOCSIS Subscriber Usage Billing Requirements

The CCAP MUST support Subscriber Usage Billing by implementing this Subscriber Accounting Management Interface Specification (SAMIS) based on [IPDR/BSR].

9 FAULT MANAGEMENT AND REPORTING REQUIREMENTS

9.1 Fault Management Requirements and Transport Protocols

This section defines requirements for remote monitoring/detection, diagnosis, reporting, and correction of problems.

9.2 Event Reporting

The CCAP MUST log events using standard mechanisms defined in section 8 of [CM-OSSIv4.0].

The CCAP MUST support all Mandatory ("M") CMTS MIB objects that have an SNMP access type of accessible for SNMP Notifications ("Acc-FN") in Annex A and in Annex A of [L2VPN].

The CCAP MUST log events when loss of fan, loss of power supply, and temperature issues are detected. These events are specified in Annex A. The CCAP is expected to implement additional physical and environmental events beyond the three basic ones listed here.

9.2.1 SNMP Usage

In the DOCSIS environment, SNMP is one method is used to achieve the goals of fault management: remote detection, diagnosis, reporting, and correction of CMTS/CCAP network faults.

The CMTS/CCAP sends SNMP notifications to one or more NMSs (subject to operator-imposed policy). CMTS/CCAP requirements for SNMP notifications are detailed in Section 9.2.2.1.2**.** The CMTS/CCAP sends events to a syslog server. The CMTS/CCAP requirements for syslog events are detailed in Section 9.2.2.1.3.

9.2.2 Event Notification

The CMTS/CCAP generates asynchronous events that indicate malfunction situations and notify the operator about important events. The methods for reporting events are defined below:

1. Stored in Local Log (docsDevEventTable from [RFC 4639]).
2. Reported to SNMP entities as an SNMP notification.
3. Sent as a message to a Syslog server.
4. Optionally reported to NETCONF clients as a NETCONF notification.

This specification defines the support of DOCSIS specific events (see Annex D Format and Content for Event, SYSLOG, and SNMP Notification (Normative)) and IETF events. The former are normally in the form of SNMP notifications. The delivery of IETF Notifications to local log and syslog server is optional.

Event Notifications are enabled and disabled via configuration settings.

Events can be reported to Local Log, Syslog, and/or SNMP notifications based on the configuration settings defined in the EventReportingCfg object (see Section 6.5.9.6.4).

The CMTS and CCAP MUST support event notifications via local event logging.

The CMTS and CCAP MUST support event notifications via Syslog, including limiting/throttling, as specified in [RFC 4639].

The CMTS and CCAP MUST support event notification via SNMP traps, including limiting/throttling, as specified in [RFC 4639].

9.2.2.1 Format of Events

The subsections which follow explain in detail how the CMTS and CCAP reports standard events by any of the following three mechanisms: local event logging, SNMP notification, and Syslog.

Annex B lists all DOCSIS event definitions.

9.2.2.1.1 Local Event Logging

The CCAP MUST maintain Local Log events, defined in [RFC 4639], in local non-volatile storage.

The CMTS and CCAP MAY retain events designated for local volatile storage in local non-volatile storage.

The CCAP Local Log non-volatile storage events MUST persist across reboots.

A CMTS MUST maintain Local Log events, defined in Annex D, in local-volatile storage or local non-volatile storage or both. A CMTS MAY retain in local non-volatile storage events designated for local volatile storage.

A CMTS MUST implement its Local Log as a cyclic buffer. The number of entries supported by the CMTS for the Local Log is vendor specific with a minimum of ten entries. The CMTS Local Log MAY persist across reboots. The CMTS MUST provide access to the Local Log events through the docsDevEventTable [RFC 4639].

Section 9.2.2.1.3 describes rules to generate unique EventIds from the error code.

The [RFC 4639] docsDevEvIndex object provides relative ordering of events in the log. The creation of local-volatile and local non-volatile logs necessitates a method for synchronizing docsDevEvIndex values between the two Local Logs after reboot. A CMTS which supports local non-volatile storage MUST adhere to the rules listed below for creating local volatile and local non-volatile logs following a re-boot:

Renumber the values of docsDevEvIndex maintained in the local non-volatile log beginning with 1.

Initialize the local volatile log with the contents of the local non-volatile log.

Use the value of the last restored non-volatile docsDevEvIndex plus one as the docsDevEvIndex for the first event recorded in the new active session's local volatile log.

The CMTS MUST clear both the local volatile and local non-volatile event logs when an event log reset is initiated through an SNMP SET of the docsDevEvControl object [RFC 4639].

9.2.2.1.2 SNMP Notifications

The CCAP MUST implement the generic SNMP notifications according to Annex A.

When any event causes a generic SNMP notification occurrence in a CMTS, the CMTS MUST send notifications if throttling/limiting mechanism [RFC 4639] and other limitations [RFC 3413] do not restrict notification sending.

The CCAP MUST implement SNMP notifications defined in [DOCS-DIAG-MIB] and [DOCS-IF3-MIB].

The CCAP MUST support at least 4 SNMP trap destinations.

The CCAP MUST support the ability to filter traps individually and filter traps by priority level.

A CMTS operating in SNMP v1/v2c NmAccess mode MUST support SNMPv1 and SNMPv2c Traps as defined in [RFC 3416].

A CMTS operating in SNMP Coexistence mode MUST support SNMP notification type 'trap' and 'inform' as defined in [RFC 3416] and [RFC 3413].

The CMTS MUST send notifications for any event, if docsDevEvControl object [RFC 4639], throttling/limiting mechanism [RFC 4639] and [RFC 3413] limitations applied later do not restrict notification sending.

The CMTS MUST NOT report via SNMP notifications vendor-specific events that are not described in instructions submitted with certification testing application documentation.

9.2.2.1.3 Syslog

The CCAP MUST support at least 4 Syslog servers as recipients.

The CMTS and CCAP MUST support Syslog messages that communicate interface up/down events, user login/logout events, configuration changes, and access failures.

The CCAP MUST support the Syslog format defined by [RFC 3164].

The CCAP SHOULD support the Syslog format defined by [RFC 5424].

When the CCAP sends a Syslog message for a DOCSIS-defined event, the CCAP MUST send it in the format specified by the value of SyslogServer::Format. If the value of SyslogServer::Format is 'rfc3164', the CCAP uses the following format for the Syslog message:

```
<level>TIMESTAMP HOSTNAME CCAP[vendor]: <eventId> text vendor-specific-text
```

If the CCAP supports [RFC 5424] and the value of SyslogServer::Format is ‘rfc5424’, the CCAP uses the message format defined in [RFC 5424] for the Syslog message.

Following are descriptions for Syslog message elements in the format shown above when the value of SyslogServer::Format is 'rfc3164':

- *level* is an ASCII representation of the event priority, enclosed in angle brackets, which is constructed as an OR of the default Facility (128) and event priority (0-7). The resulting level ranges between 128 and 135.
- *TIMESTAMP* and *HOSTNAME* follow the format of [RFC 3164]. The single space after *TIMESTAMP* is part of the *TIMESTAMP* field. The single space after *HOSTNAME* is part of the *HOSTNAME* field.
- *vendor* is the vendor name for the vendor-specific syslog messages or DOCSIS for the standard DOCSIS messages.
- *device type* is an ASCII representation of the device sending the syslog message. The value for *device type* can be one of the following: CCAP, CMTS, CCAP Core, MAC Manager, or MAC-NE.
- *eventId* is an ASCII representation of the INTEGER number in decimal format, enclosed in angle brackets, which uniquely identifies the type of event. The CMTS and CCAP MUST equate the eventId with the value stored in the docsDevEvId object in docsDevEventTable. For the standard DOCSIS events this number is converted from the error code using the rules defined in [CANN].

  See Annex D for event definitions.
- *text* contains the textual description for the standard DOCSIS event message, as defined in Annex D.
- *vendor-specific-text* contains vendor specific information. This field is optional.

Refer to Annex D.3 for several Syslog event message example constructs.

The CMTS and CCAP MAY report non-DOCSIS events in the standard syslog message format [RFC 3164] rather than the DOCSIS syslog message format defined above.

When the CMTS or CCAP sends a syslog message for an event not defined in this specification, the CMTS or CCAP MAY send it according to the format and semantics of the elements defined above.

9.2.2.2 BIT Values for docsDevEvReporting (RFC 4639)

Permissible BIT values for [RFC 4639] docsDevEvReporting objects include:

1: local(0)

2: traps(1)

3: syslog(2)

4: localVolatile(8)

5: stdInterface(9)

Bit-0 means non-volatile Local Log storage and bit-8 is used for volatile Local Log storage (see Section 9.2.2.1). Bit-1 means SNMP Notifications which correspond to both SNMP Trap and SNMP Inform.

For backward compatibility with Pre-3.0 DOCSIS devices, the CMTS MUST support bit-3 in docsDevEvReporting BITS encoding for volatile Local Log storage.

DOCSIS 3.0 devices need to support bit override mechanisms during SNMP SET operations with either one-byte or two-byte BITS encoding for docsDevEvReporting for backward compatibility with Pre-3.0 DOCSIS behavior.

The CMTS MUST use the bit-3 value to set both bit-3 and bit-8 for SNMP SET operations on docsDevEvReporting using a one-byte BITS encoded value; therefore, the CMTS reports bit-3 and bit-8 with identical values for SNMP GET operations.

The CMTS MUST use the bit-8 value to set bit-3 and bit-8 for SNMP SET operations, irrespective of the bit-3 value, on docsDevEvReporting using a two or more byte BITS encoded value.

The CMTS MAY support bit-9 in docsDevEvReporting BITS encoding in accordance with [RFC 4639] definition.

A CMTS that reports an event by SNMP Notification or syslog MUST also report the event by a Local Log (volatile or non-volatile).

Combinations of docsDevEvReporting with traps(1) and/or syslog(2) bits with no Local Log bits (bit-0, bit-3 or bit-8) set are known as unacceptable combinations.

The CMTS MUST reject and report a 'Wrong Value' error for SNMPv2c/v3 PDUs or a 'Bad Value' error for SNMPv1 PDUs for any attempt to set docsDevEvReporting with unacceptable combinations.

The CMTS MUST accept any SNMP SET operation to docsDevEvReporting different than the unacceptable combinations.

The CMTS MUST ignore any undefined bits in docsDevEvReporting on SNMP SET operations and report a zero value for those bits.

Refer to Section 9.2.2.1.1 for details on Local Log requirements for the CMTS.

If CMTS supports both volatile and non-volatile storage, the CMTS MUST maintain the non-volatile storage when both non-volatile Local Log and volatile Local Log bits are set for a specific docsDevEvReporting event priority. If CMTS supports both volatile and non-volatile storage, the CMTS MAY maintain the volatile storage when both non-volatile Local Log and volatile Local Log bits are set for a specific docsDevEvReporting event priority. When both non-volatile Local Log and volatile Local Log bits are set for a specific docsDevEvReporting event priority, the CMTS MUST NOT report duplicate events in the docsDevEventTable.

9.2.2.3 Standard Events for CCAP

Aside from the procedures defined in this document, event recording conforms to the requirements of [RFC 4639]. Event descriptions are defined in English. A CMTS MUST implement event descriptors such that no event descriptor is longer than 255 characters, which is the maximum defined for SnmpAdminString [RFC 3411].

Events are considered identical if the EventId is the same AND the event arguments are the same. For identical events occurring consecutively, the CMTS and CCAP MAY choose to store only a single event.

If the CCAP stores as a single event multiple identical events that occur consecutively, the CCAP MUST reflect the most recent event in the event description.

The EventId digit is a 32-bit unsigned integer. EventIds ranging [RFC 4639] from 0 to (2^{31} - 1) are reserved by DOCSIS. The CMTS MUST report in the docsDevEvTable [RFC 4639] the EventId as a 32-bit unsigned integer and convert the EventId from the error codes defined in Annex D to be consistent with this number format.

The CCAP MUST maintain the non-volatile storage when both non-volatile Local Log and volatile Local Log bits are set for a specific event priority, configured in the Reporting attribute of the EventReportingCfg object (see Section 6.5.9.6.4).

The CCAP MAY maintain the volatile storage when both non-volatile Local Log and volatile Local Log bits are set for a specific event priority.

When both non-volatile Local Log and volatile Local Log bits are set for a specific event priority, the CCAP MUST report the event as a single event in the docsDevEventTable.

Event priority levels for the CCAP will use the following categories:

Emergency(1) events indicate fatal hardware or software failure that prevent normal system operation (all services are affected).

Alert(2) events indicate a major hardware or software failure that causes some service interruption (no redundancy available).

Critical(3) events indicate a major hardware or software failure that does not cause an interrupt of the normal data flow. This level of event may be also used when some redundant device was automatically activated to replace the defective device.

Error(4) events indicate that an incorrect input signal (external system error) is causing temporary or permanent interruption of the normal data flow.

Warning(5) events indicate a minor failure that does not cause any interrupt of the data flow.

Notice(6) events indicate that a specified alarm condition has been removed.

Information(7) events indicate a milestone or checkpoint in normal operation that could be of particular importance for troubleshooting.

Debug(8) events are reserved for vendor-specific events.

The reporting mechanism for each priority can be changed from the default reporting mechanism via the EventReportingCfg object defined in this specification (see Section 6.5.9.6.4).

9.2.2.4 Standard DOCSIS Events for CMTS

CMTSs use the same levels of the event priorities as a CM (see [CM-OSSIv4.0]); however, the priority definition of the events is different. Events with the priority level of 'Warning' and less, specify problems that could affect the individual user (for example, individual CM registration problem).

Every CMTS vendor may define their own set of 'Alert' events.

Priority level of 'Error' indicates problems with a group of CMs (for example CMs that share same upstream channel).

Priority level of 'Critical' indicates a problem that affects the whole cable system operation but is not a faulty condition of the CMTS device.

Priority level of 'Emergency' is vendor-specific and indicates problems with the CMTS hardware or software, which prevents CMTS operation.

During CMTS initialization or reinitialization, the CMTS MUST support, as a minimum, the default event reporting mechanism shown in Table 513 - CMTS Default Event Reporting Mechanism Versus Priority (Non-Volatile Local Log Support Only) or Table 514 - CMTS Default Event Reporting Mechanism Versus Priority (Volatile Local Log Support Only) or Table 515 - CMTS Default Event Reporting Mechanism Versus Priority.

The CMTS MAY implement default reporting mechanisms above the minimum requirements listed in Table 513 - CMTS Default Event Reporting Mechanism Versus Priority (Non-Volatile Local Log Support Only) or Table 514 - CMTS Default Event Reporting Mechanism Versus Priority (Volatile Local Log Support Only) or Table 515 - CMTS Default Event Reporting Mechanism Versus Priority with the exception of the 'Debug' priority level.

The reporting mechanism for each priority could be changed from the default reporting mechanism by using docsDevEvReporting object of DOCS-CABLE-DEVICE-MIB [RFC 4639].

Table 513 - CMTS Default Event Reporting Mechanism Versus Priority (Non-Volatile Local Log Support Only)

Event Priority	Local Log Non-volatile	SNMP Notification	Syslog	Local Log Volatile
Emergency	Yes	No	No	Not Used
Alert	Yes	No	No	Not Used
Critical	Yes	Yes	Yes	Not Used
Error	Yes	Yes	Yes	Not Used
Warning	Yes	Yes	Yes	Not Used
Notice	Yes	Yes	Yes	Not Used

Event Priority	Local Log Non-volatile	SNMP Notification	Syslog	Local Log Volatile
Informational	No	No	No	Not Used
Debug	No	No	No	Not Used

Table 514 - CMTS Default Event Reporting Mechanism Versus Priority (Volatile Local Log Support Only)

Event Priority	Local Log Non-volatile	SNMP Notification	Syslog	Local Log Volatile
Emergency	Not Used	No	No	Yes
Alert	Not Used	No	No	Yes
Critical	Not Used	Yes	Yes	Yes
Error	Not Used	Yes	Yes	Yes
Warning	Not Used	Yes	Yes	Yes
Notice	Not Used	Yes	Yes	Yes
Informational	Not Used	No	No	No
Debug	Not Used	No	No	No

Table 515 - CMTS Default Event Reporting Mechanism Versus Priority

Event Priority	Local Log Non-volatile	SNMP Notification	Syslog	Local Log Volatile
Emergency	Yes	No	No	No
Alert	Yes	No	No	No
Critical	Yes	Yes	Yes	No
Error	No	Yes	Yes	Yes
Warning	No	Yes	Yes	Yes
Notice	No	Yes	Yes	Yes
Informational	No	No	No	No
Debug	No	No	No	No

The CMTS MUST format notifications for standard DOCSIS events as specified in Annex D.

9.2.2.5 Vendor-Specific Events

The CMTS MUST implement EventIds ranging from 2^{31} to (2^{32} - 1) as vendor-specific EventIds using the following format:

Bit 31 is set to indicate vendor-specific event

Bits 30-16 contain the lower 15 bits of the vendor's SNMP enterprise number

Bits 15-0 are used by the vendor to number events

9.2.2.5.1 Event Priorities and Vendor-Specific Events

This specification defines events that make use of a sub-set of the Event Priority Levels. Vendor-specific events can be defined for any Event Priority Level. Table 510 summarizes those considerations.

A CMTS and CCAP MUST assign DOCSIS and vendor specific events as indicated in Table 516 - Event Priorities Assignment.

Table 516 - Event Priorities Assignment

Event Priority	CMTS and CCAP Event Assignment
Emergency	Vendor-Specific
Alert	CMTS and CCAP and Vendor-Specific (optional*)
Critical	CMTS and CCAP and Vendor-Specific (optional*)
Error	CMTS and CCAP and Vendor-Specific (optional*)
Warning	CMTS and CCAP and Vendor-Specific (optional*)
Notice	CMTS and CCAP and Vendor-Specific (optional*)
Information	CMTS and CCAP and Vendor-Specific (optional*)
Debug	Vendor-Specific
Table Note: *Vendor-specific optional event definitions are recommended only where the CCAP allows for sufficient storage of such events.	

9.2.3 NETCONF Notifications

NETCONF Notifications [RFC 5277] is an optional mechanism that provides an asynchronous notification message service built on top of the base NETCONF protocol. The mechanism is based on the concept of clients subscribing to events belonging to named event streams. Clients can associate filter parameters with the subscriptions to receive a defined subset of all events belonging to a stream.

Notification replay is an integral part of the NETCONF Notifications framework. It provides the ability for clients to request sending (or resending) recently generated notifications based on a specific start and an optional stop time. If no stop time is provided, the notification stream will continue until the subscription is terminated.

The CCAP MAY implement NETCONF Notifications towards OSS, as specified in [RFC 5277].

If the CCAP implements NETCONF Notifications towards OSS, the CCAP MUST use the YANG module specified for this purpose in [CCAP-EVENTS-YANG].

9.2.4 Trap and Syslog Throttling, Limiting and Inhibiting

A CMTS MUST support SNMP TRAP/INFORM and syslog throttling and limiting as described in DOCS-CABLE-DEVICE-MIB [RFC 4639], regardless of SNMP mode.

9.2.5 Non-SNMP Fault Management Protocols

The OSS can use a variety of tools and techniques to examine faults at multiple layers. For the IP layer, useful non-SNMP based tools include ping (ICMP Echo and Echo Reply), and trace route (UDP and various ICMP Destination Unreachable flavors). The CMTS MUST support IP end-station generation of ICMP error messages and processing of all ICMP messages.

For the Ethernet layer, Service OAM provides Connectivity Fault Management as specified in [L2VPN].

Syslog requirements are defined in Section 9.2.2.1.3.

9.3 Fault Management Information Model

9.3.1 Event Notification Information Model

The objects for CCAP Event Notification are derived from the docsDevEventTable in [RFC 4639] and are used without modification. They are shown here for completeness.

Reference: [RFC 4639]

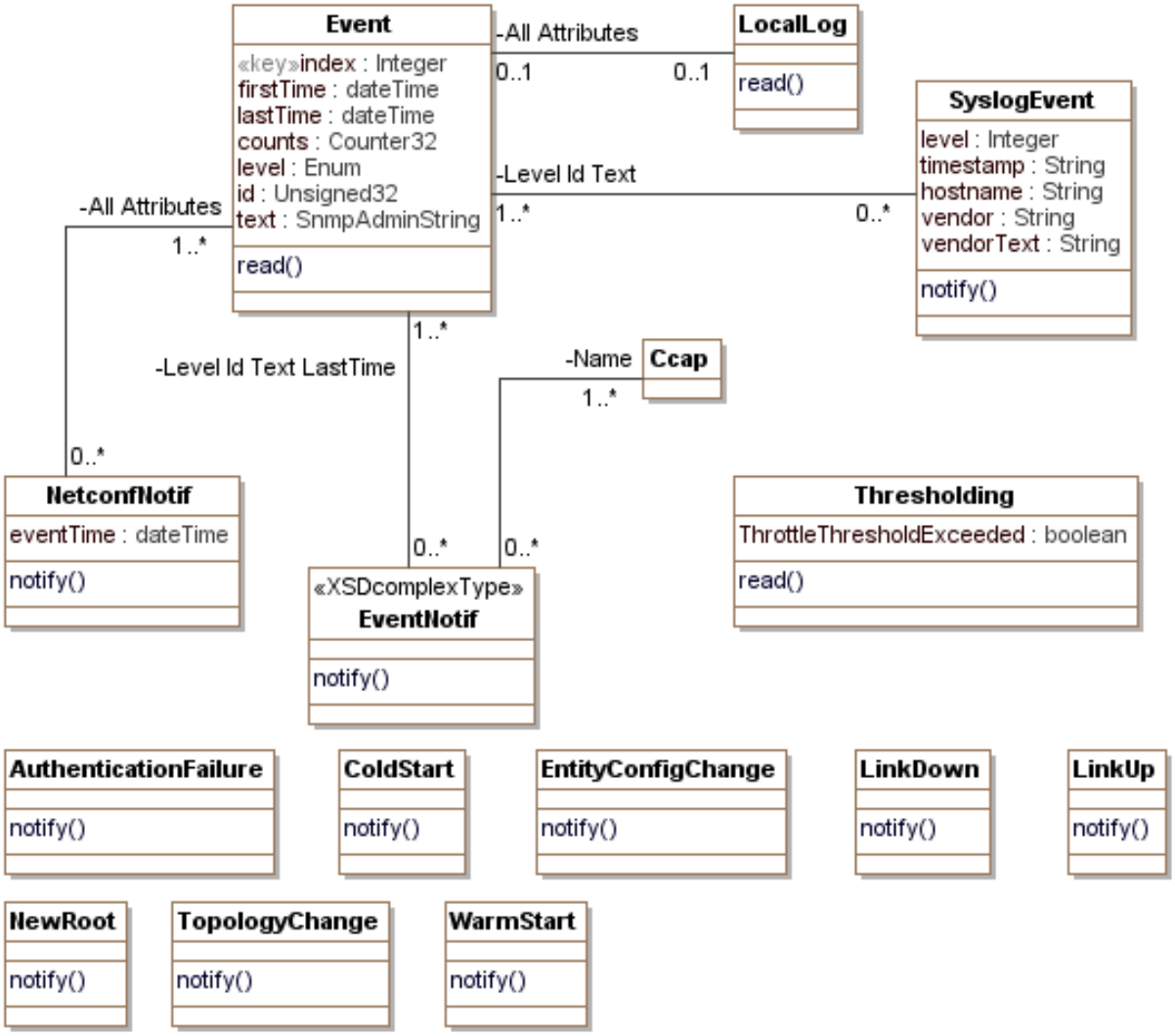


Figure 93 - CCAP Event Notification Information Model

9.3.1.1 Event

This object represents the abstract definition of an event object for the CMTS. The realization of the event object depends on the management protocol that carries the event as an autonomous notification. The event can also be logged in an event log.

9.3.1.2 EventNotif

This object represents the abstract definition of an SNMP event notification for the CMTS.

9.3.1.3 SyslogEvent

This object represents the abstract definition of a syslog event notification for the CMTS.

9.3.1.4 NetconfNotif

This object represents the abstract definition of a NETCONF event notification for the CMTS which supports the NETCONF protocol.

9.3.1.5 LocalLog

This object represents the abstract definition of an event stored in the CMTS volatile and/or non-volatile local log.

9.4 Leakage Detection Test Interface

The CCAP MUST implement Leakage Detection Test Interface requirements defined in [CCAP-OSSIv3.1] Leakage Detection Test Interface section.

10 STREAMING TELEMETRY PNM INFORMATION MODELS

This section defines the Information Models for PNM to support Streaming Telemetry of measurement results and YANG-based configuration of tests. Attributes defined in this section are intended to be realized in CableLabs YANG modules.

The Information Models are divided into 3 sections:

1. Data type definitions including simple and complex data types.
2. Class Diagrams containing classes and their associations that define static information relevant to the feature. This also includes notifications related to the feature.
3. Component Diagrams defining operations on an interface that can be executed on the device (over the interface) for the feature.

10.1 PNM Common Information Models

This section defines the Information Models common to all PNM Use Cases.

10.1.1 PNM Common Data Type Definitions

This section defines any required data type definitions used in the Information Model.

Table 517 - PNM Common Data Types

Data Type Name	Base Type	Permitted Values	Reference
PnmTestType	Enum	other(0), dsOfdmSymbolCapture(1), dsOfdmNoisePowerRatio(2), dsOfdmProfileTest(3), usOfdmaActiveAndQuietProbe(4), usSpectrumCapture(5) usImpulseNoise(6), usHistogram(7), usOfdmaRxPower(8), usOfdmaRxMer(9)	
PnmTestTypeBits	EnumBits	other(0), dsOfdmSymbolCapture(1), dsOfdmNoisePowerRatio(2), dsOfdmProfileTest(3), usOfdmaActiveAndQuietProbe(4), usSpectrumCapture(5) usImpulseNoise(6), usHistogram(7), usOfdmaRxPower(8), usOfdmaRxMer(9)	

10.1.1.1 PnmTestType

This data type enumerates the allowed Proactive Network Maintenance (PNM) test types defined for DOCSIS.

- other(0) is provided for vendor proprietary test types.
- dsOfdmSymbolCapture(1) refers to the DOCSIS Downstream OFDM Symbol Capture PNM test.
- dsOfdmNoisePowerRatio(2) refers to the DOCSIS Downstream OFDM Noise Power Ratio Measurement.
- dsOfdmProfileTest(3) refers to the DOCSIS Downstream OFDM Profile Test.

- usOfdmaActiveAndQuietProbe(4) refers to the DOCSIS Upstream Capture for Active and Quiet Probe test.
- usSpectrumCapture(5) refers to the DOCSIS Upstream Triggered Spectrum Capture test.
- usImpulseNoise(6) refers to the DOCSIS Upstream Impulse Noise Statistics test.
- usHistogram(7) refers to the DOCSIS Upstream Histogram test.
- usOfmdaRxPower(8) refers to the DOCSIS Upstream OFDMA Receive Power measurement.
- usOfdmaRxMer(9) refers to the DOCSIS Upstream OFDMA Receive Modulation Error Ratio per Subcarrier test.

10.1.1.2 PnmTestTypeBits

This data type indicates which of the DOCSIS PNM tests are supported by the CCAP. PnmTestTypeBits data type is reported in BITS format, with value 0 for each bit definition indicating the CCAP does not support the corresponding DOCSIS PNM test, and value 1 for each bit definition indicating the CCAP supports the corresponding DOCSIS PNM test.

- Bit 0 other(0) is provided for vendor proprietary test types.
- Bit 1 dsOfdmSymbolCapture(1) refers to the DOCSIS Downstream OFDM Symbol Capture PNM test.
- Bit 2 dsOfdmNoisePowerRatio(2) refers to the DOCSIS Downstream OFDM Noise Power Ratio Measurement.
- Bit 3 dsOfdmProfileTest(3) refers to the DOCSIS Downstream OFDM Profile Test.
- Bit 4 usOfdmaActiveAndQuietProbe(4) refers to the DOCSIS Upstream Capture for Active and Quiet Probe test.
- Bit 5 usSpectrumCapture(5) refers to the DOCSIS Upstream Triggered Spectrum Capture test.
- Bit 6 usImpulseNoise(6) refers to the DOCSIS Upstream Impulse Noise Statistics test.
- Bit 9 usHistogram(7) refers to the DOCSIS Upstream Histogram test.
- Bit 10 usOfmdaRxPower(8) refers to the DOCSIS Upstream OFDMA Receive Power measurement.
- Bit 11 usOfdmaRxMer(9) refers to the DOCSIS Upstream OFDMA Receive Modulation Error Ratio per Subcarrier test.

10.1.1.3 PNM Common Complex Data Type Definitions

This section defines classes/objects used in the PNM Information Models as complex data types.

10.1.1.4 Response

This class defines a standard response mechanism for operations defined in the PNM Component Diagrams. All defined operations should include a Response output parameter.

Table 518 - Response Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units
Success	Boolean	Yes		N/A
ErrorTag	Enum	No		N/A
ErrorMessage	String	No		N/A

10.1.1.4.1 Success

This attribute reports the success or failure of the operation. True indicates the action performed by the operation was successful.

10.1.1.4.2 ErrorTag

This attribute reports the Error Tag if the action performed by the operation was unsuccessful. This attribute is not included if the action was successful. Refer to the Error Conditions section for each operation definition for the list of possible errors for that operation.

10.1.1.4.3 ErrorMessage

This attribute reports the Error Message if the action performed by the operation was unsuccessful. This attribute is not included if the action was successful. Refer to the Error Conditions section for each operation definition for the list of possible errors for that operation.

10.1.2 PNM Common Class Diagram

The following diagram defines the Proactive Network Maintenance (PNM) Common related classes and signals (notifications).

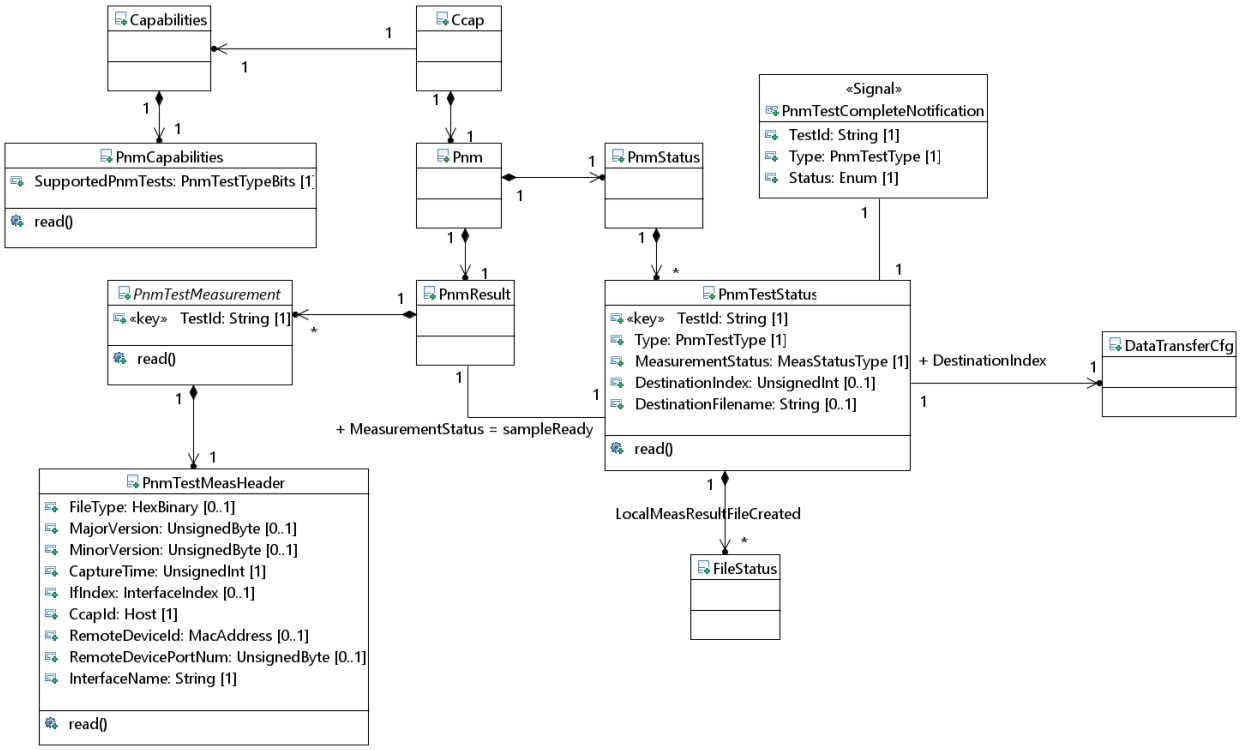


Figure 94 - PNM Common Class Diagram

10.1.2.1 Capabilities

The Capabilities class is the container for CCAP capabilities, which includes all capabilities for a CCAP device.

Table 519 - Capabilities Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmCapabilities	Directed Composition to PnmCapabilities	1	1	

10.1.2.2 PnmCapabilities

The PnmCapabilities class reports CCAP device PNM capabilities common to multiple PNM test functions.

Table 520 - PnmCapabilities Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SupportedPnmTests	PnmTestTypeBits	Yes			

10.1.2.2.1 SupportedPnmTests

This attribute indicates which of the defined PNM tests are supported by the CCAP.

10.1.2.3 Pnm

The Pnm class is the top-level container for all PNM test function models.

Table 521 - Pnm Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmResult	Directed Composition to PnmResult	1	1	
PnmStatus	Directed Composition to PnmStatus	1	1	

10.1.2.4 PnmStatus

The PnmStatus class is the container for all status related to PNM test common functionality.

Table 522 - PnmStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmTestStatus	Directed Composition to PnmTestStatus	1	0..*	

10.1.2.5 DataTransferCfg

The DataTransferCfg class is defined in Section 6.6.1.4.4.1.

10.1.2.6 FileStatus

The FileStatus class is defined in Section 6.6.1.4.4.1.

10.1.2.7 PnmTestStatus

The PnmTestStatus class reports the status of historical, active and scheduled PNM test instances.

Table 523 - PnmTestStatus Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units
TestId	String	Yes (Key)		
Type	PnmTestType	Yes		
MeasurementStatus	MeasStatusType	Yes		
DestinationIndex	UnsignedInt	No		
DestinationFilename	String	No		

Table 524 - PnmTestStatus Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmTestCompleteNotification	Association to PnmTestCompleteNotification	1	1	
FileStatus	Directed Composition to FileStatus	1	0..*	LocalMeasResultFileCreated
DataTransferCfg	Directed Association to DataTransferCfg	1	1	DestinationIndex

10.1.2.7.1 TestId

This key attribute is a string uniquely identifying a PNM test instance.

10.1.2.7.2 Type

This attribute reports the type of PNM test the status applies to.

10.1.2.7.3 MeasurementStatus

This attribute reports the status of the PNM test instance.

10.1.2.7.4 DestinationIndex

This attribute uniquely identifies a destination for PNM test result measurements. This attribute refers to an instance of the DataTransferCfg object.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.1.2.7.5 DestinationFilename

This attribute identifies a destination filename for PNM test result measurements. This attribute is an extension to an instance of the DataTransferCfg object, defining a filename.

10.1.2.8 PnmTestCompleteNotification

PnmTestCompleteNotification is an asynchronous notification informing the PNM Server about the status of the completed, failed or aborted PNM test instance. This notification is sent by the CCAP when a PNM test terminates.

Table 525 - PnmTestCompleteNotification Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TestId	String	Yes	N/A	N/A	N/A
Type	PnmTestType	Yes		N/A	N/A

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Status	Enum	Yes	other(0), success(1), aborted(2), error(3)		

10.1.2.8.1 TestId

This key attribute is a string uniquely identifying a PNM test instance. See the object definition of TestStatus for a definition of the TestId format.

10.1.2.8.2 Type

This attribute reports the type of PNM test the status applies to.

10.1.2.8.3 Status

This attribute reports the state of the completed PNM test instance.

- other(0) is provided for vendor-proprietary status.
- success(1) indicates the PNM test instance completed successfully and results are available and/or have been uploaded.
- aborted(2) indicates the PNM test instance was aborted and test results were discarded.
- error(3) indicates an error occurred during the execution of the PNM test instance and the test results were discarded.

10.1.2.9 PnmResult

The PnmResult class is the top-level container for all test measurements related to PNM test functionality.

Table 526 - PnmResult Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmTestMeasurement	Directed Composition to PnmTestMeasurement	1	0..*	

10.1.2.10 PnmTestMeasurement

The PnmTestMeasurement class reports the measurement results of PNM test instances. This is an abstract class where each of the different PNM tests realize this class through inheritance/specialization. This class is instantiated each time a PNM test is executed and the MeasurementStatus attribute contains a value of 'sampleReady' for the PnmTestStatus object.

Table 527 - PnmTestMeasurement Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units
TestId	String	Yes (Key)		

Table 528 - PnmTestMeasurement Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmTestMeasHeader	Directed composition to PnmTestMeasHeader	1	1	
PnmTestStatus	Association to PnmTestStatus	1	1	MeasurementStatus = sampleReady

10.1.2.10.1 TestId

This key attribute is a string uniquely identifying a PNM test instance.

10.1.2.11 PnmTestMeasHeader

This object contains the common PNM header information for reporting measurements results. This class refactors the PnmCaptureFile class defined in Section 7.3.3.1.

Table 529 - PnmTestMeasHeader Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
FileType	HexBinary	No	SIZE (4)		
MajorVersion	UnsignedByte	No			
MinorVersion	UnsignedByte	No			
CaptureTime	UnsignedInt	Yes			
IfIndex	InterfaceIndex	No			
CcapId	Host	Yes			
RemoteDeviceId	MacAddress	No			
RemoteDevicePortNum	UnsignedByte	No			
InterfaceName	String	Yes			

10.1.2.11.1 FileType

This attribute is a copy of the PnmCaptureFile::FileType attribute.

10.1.2.11.2 MajorVersion

This attribute is a copy of the PnmCaptureFile::MajorVersion attribute.

10.1.2.11.3 MinorVersion

This attribute is a copy of the PnmCaptureFile::MinorVersion attribute.

10.1.2.11.4 CaptureTime

This attribute is a copy of the PnmCaptureFile::CaptureTime attribute.

10.1.2.11.5 IfIndex

This attribute is a copy of the PnmCaptureFile::IfIndex attribute.

10.1.2.11.6 CcapId

This attribute is a copy of the PnmCaptureFile::UniqueCcapId attribute but the data type is updated to Host.

10.1.2.11.7 RemoteDeviceId

This attribute is a copy of the PnmCaptureFile::RpdId attribute but the data type is updated to MacAddress.

10.1.2.11.8 RemoteDevicePortNum

This attribute is a copy of the PnmCaptureFile::RpdPortNum attribute but the data type is updated to UnsignedByte.

10.1.2.11.9 InterfaceName

This attribute defines the unique interface name for the interface under PNM test or measurement.

10.1.3 PNM Common Component Diagram

The PNM Common component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the common PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.1.3.1 PnmTestManagement Component Diagram

The PnmTestManagement component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the common PNM operations.

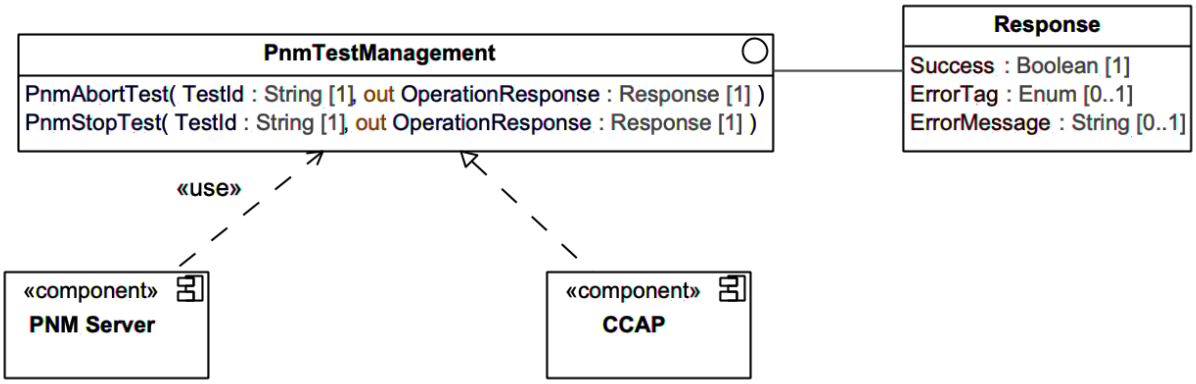


Figure 95 - PnmTestManagement Component Diagram

10.1.3.2 PnmAbortTest Operation

PnmAbortTest is a non-blocking asynchronous operation that terminates execution of specific running PNM test instances. The CCAP is not required to provide measurement results after being invoked with the PnmAbortTest operation.

A successful operation will result in the CCAP ceasing sampling for the PNM test instance specified by the TestId, discarding captured measurement data, sending a response with value ‘success’, and terminating all actions of the PNM test instance.

Table 530 - PnmAbortTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
TestId	String		In	1		
OperationResponse	Response		Out	1		

10.1.3.2.1 Parameter Definitions

10.1.3.2.1.1 TestId

This attribute is a string uniquely identifying a PNM test instance.

10.1.3.2.1.2 OperationResponse

The CCAP response to the PnmAbortTest operation command. Refer to the definition of the common Response class for details.

10.1.3.2.2 Error Conditions

The following table defines the possible error conditions for the PnmAbortTest operation.

Table 531 - PnmAbortTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	TestId does not exist on the device
Not In Valid State	Test is not in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.1.3.3 PnmStopTest Operation

PnmStopTest is a non-blocking asynchronous operation that terminates execution of specific running PNM test instances. The PnmStopTest operation is a graceful exit of a PNM Test where the CCAP provides the measurement results from the test.

A successful operation will result in the CCAP ceasing sampling for the PNM test instance specified by the TestId, saving captured measurement data, sending a response with value 'success', and terminating all actions of the PNM test instance.

Table 532 - PnmStopTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
TestId	String		In	1		
OperationResponse	Response		Out	1		

10.1.3.3.1 Parameter Definitions

10.1.3.3.1.1 TestId

This attribute is a string uniquely identifying a PNM test instance.

10.1.3.3.1.2 OperationResponse

The CCAP response to the PnmStopTest operation command. Refer to the definition of the common Response class for details.

10.1.3.3.2 Error Conditions

The following table defines the possible error conditions for the PnmStopTest operation.

Table 533 - PnmStopTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	TestId does not exist on the device
Not In Valid State	Test is not in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.2 PNM Downstream Information Models

This section defines the Streaming Telemetry Information Models for Downstream PNM Use Cases.

10.2.1 Measure Downstream OFDM Noise Power Ratio Information Models

This section defines the Information Models for the Measure Downstream Noise Power Ratio (NPR) Use Case.

Downstream OFDM Noise Power Ratio is a PNM Test described in [PHYv3.1] Downstream Noise Power Ratio (NPR) Measurement section. The Measure Downstream OFDM Noise Power Ratio information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Downstream OFDM Noise Power Ratio test.

Refer to Section 7.3.4.2 DsOfdmNoisePowerRatio for a description of the purpose and operation of the Downstream OFDM Noise Power Ratio PNM test.

10.2.1.1 Downstream OFDM Noise Power Ratio Data Type Definitions

No new data types are defined for the Downstream OFDM Noise Power Ratio PNM test.

10.2.1.2 Downstream OFDM Noise Power Ratio Complex Data Type Definitions

This section defines classes/objects used in the PNM Downstream OFDM Noise Power Ratio Information Models as complex data types.

10.2.1.2.1 PnmDsNoisePwrRatioCfg

This class defines the configuration parameters for the Downstream OFDM Noise Power Ratio PNM test. This class refactors the DsOfdmNoisePowerRatio class defined in Section 7.3.4.2 DsOfdmNoisePowerRatio.

Table 534 - PnmDsNoisePwrRatioCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
InterfaceName	String	Yes (Key)			
IfIndex	InterfaceIndex	No			
CcapId	AdminString	No			
StartSubcarrier	UnsignedShort	Yes	0..8191		
StopSubcarrier	UnsignedShort	Yes	0..8191		
Duration	UnsignedShort	Yes		seconds	600

10.2.1.2.1.1 InterfaceName

This attribute contains the CCAP interface name for the downstream interface on which the CCAP will measure subcarriers' Noise Power Ratio on the OFDM channel.

10.2.1.2.1.2 IfIndex

This attribute is the ifIndex of the OFDM Downstream Channel for the Downstream OFDM Noise Power Ratio test. This is an optional attribute.

10.2.1.2.1.3 CcapId

This attribute is a string identifying the CCAP on which Downstream OFDM Noise Power Ratio is measured during the Downstream OFDM Noise Power Ratio test. This is an optional attribute.

10.2.1.2.1.4 StartSubcarrier

This attribute is the subcarrier index corresponding to the frequency at the start of the spectral notch.

10.2.1.2.1.5 StopSubcarrier

This attribute is the subcarrier index corresponding to the frequency at the upper end of the spectral notch.

10.2.1.2.1.6 Duration

This attribute indicates the length of time in seconds that the spectral notch is to be maintained. The CCAP MAY make the excluded subcarriers active after the expiration of the Duration attribute. There is no expectation that CCAP will re-activate the excluded subcarriers immediately after the expiration of the timer. It is recommended that the CCAP use the OCD message to create the spectral notch.

10.2.1.3 Downstream OFDM Noise Power Ratio Class Diagram

The Downstream OFDM Noise Power Ratio PNM test does not return a result so no Result class is defined for this test.

10.2.1.4 Downstream OFDM Noise Power Ratio Component Diagram

The Downstream OFDM Noise Power Ratio component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the Downstream OFDM Noise Power Ratio PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.2.1.4.1 PnmDsNoisePwrRatioTestManagement Component Diagram

The PnmDsNoisePwrRatioTestManagement component diagram illustrates the CCAP and PNM Server components that execute the InitPnmDsNoisePwrRatioTest operation.

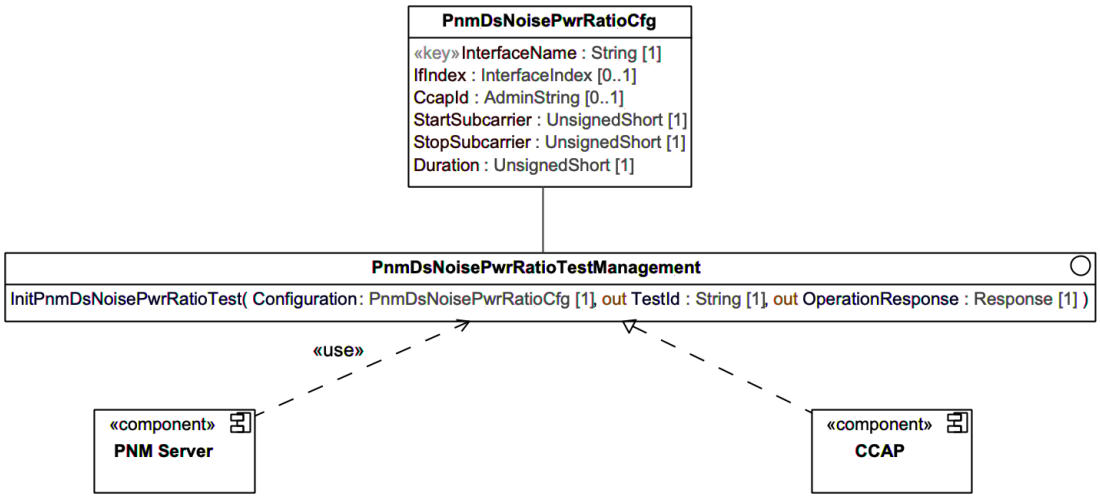


Figure 96 - PnmDsNoisePwrRatioTestManagement Component Diagram

10.2.1.4.1.1 InitPnmDsNoisePwrRatioTest Operation

The InitPnmDsNoisePwrRatioTest is a non-blocking asynchronous operation that initiates the Downstream OFDM Noise Power Ratio PNM test.

A successful operation will result in the CCAP creating a spectral notch in the OFDM downstream channel for the time duration as configured by parameters passed in PnmDsNoisePwrRatioCfg. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

When the CCAP completes the test and restores the channel without the spectral notch, the CCAP will then send the TestCompleteNotification signaling the test has been completed.

Table 535 - InitPnmDsNoisePwrRatioTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
Configuration	PnmDsNoisePwrRatioCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.2.1.4.1.2 Parameter Definitions

10.2.1.4.1.2.1 Configuration

This parameter is the complex set of configuration parameters for the Downstream OFDM Noise Power Ratio PNM test operation. Refer to the class definition for PnmDsNoisePwrRatioCfg for details.

10.2.1.4.1.2.2 TestId

This parameter is a unique identifier for a PNM test instance.

10.2.1.4.1.2.3 OperationResponse

This parameter is the device response to the InitPnmDsNoisePwrRatioTest operation command. Refer to the definition of the common Response class for details.

10.2.1.4.1.3 Error Conditions

The following table defines the possible error conditions for the InitPnmDsNoisePwrRatioTest operation.

Table 536 - InitPnmDsNoisePwrRatioTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.2.2 Capture Downstream OFDM Symbols Information Models

This section defines the Information Models for the Capture Downstream OFDM Symbols Use Case.

Downstream OFDM Symbol Capture is a PNM Test described in [PHYv3.1] Downstream Symbol Capture section. The Capture Downstream OFDM Symbols information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Downstream OFDM Symbol Capture test.

Refer to Section 7.3.4.1 DsOfdmSymbolCapture for a description of the purpose and operation of the Downstream OFDM Symbol Capture PNM test.

10.2.2.1 Downstream OFDM Symbol Capture Data Type Definitions

No new data types are defined for the Downstream OFDM Symbol Capture PNM test.

10.2.2.2 Downstream OFDM Symbol Capture Complex Data Type Definitions

This section defines classes/objects used in the PNM Downstream OFDM Symbol Capture Information Models as complex data types.

10.2.2.2.1 PnmDsOfdmSymbolCaptCfg

This class defines the configuration parameters for the Downstream OFDM Symbol Capture PNM test. This class refactors the DsOfdmSymbolCapture class defined in section 7.3.4.1 DsOfdmSymbolCapture.

Table 537 - PnmDsOfdmSymbolCaptCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
InterfaceName	String	Yes (Key)			
IfIndex	InterfaceIndex	No			
CcapId	AdminString	No			
TriggerGroupId	UnsignedShort	No			0

10.2.2.2.1.1 InterfaceName

This attribute contains the CCAP interface name for the downstream interface on which the CCAP will capture symbols on the OFDM channel.

10.2.2.2.1.2 IfIndex

This attribute is the ifIndex of the OFDM Downstream Channel for the Downstream OFDM Symbol Capture test. This is an optional attribute.

10.2.2.2.1.3 CcapId

This attribute is a string identifying the CCAP on which Downstream OFDM symbols are captured during the Downstream OFDM Symbol Capture test. This is an optional attribute.

10.2.2.2.1.4 TriggerGroupId

This attribute is used by the CCAP to be inserted in the PLC Trigger Message Block to identify a cable modem or a group of cable modems expected to perform Symbol Capture measurements for the designated symbol.

Reference: [MULPIv4.0] Trigger Message Block

10.2.2.3 Downstream OFDM Symbol Capture Class Diagram

The PnmDsOfdmSymbolCaptResultGrp class diagram defines the Downstream OFDM Symbol Capture PNM test measurement classes rooted from the PnmResult class.

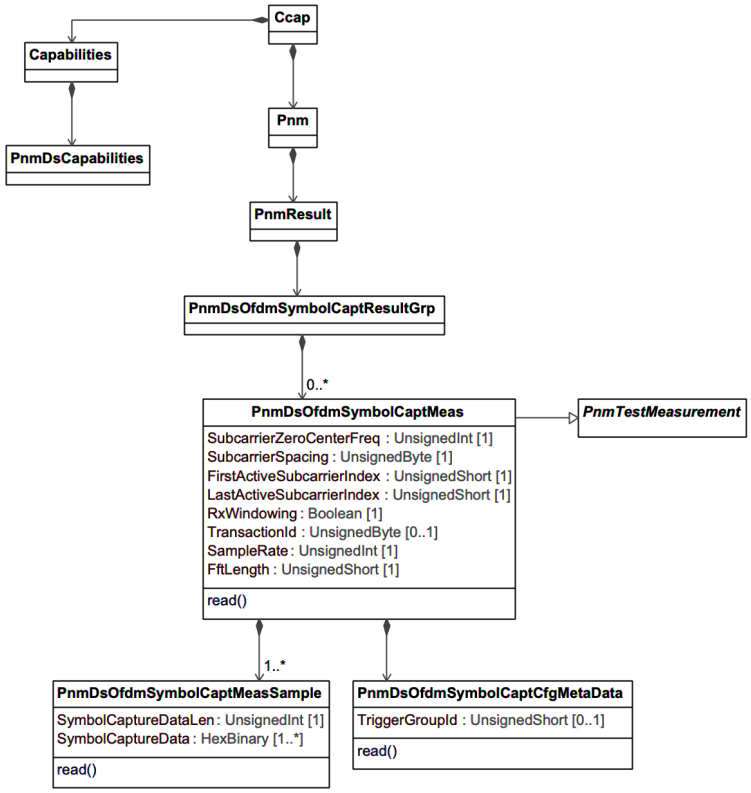


Figure 97 - PnmDsOfdmSymbolCaptResultGrp Class Diagram

10.2.2.3.1 PnmDsOfdmSymbolCaptResultGrp

This class represents a top-level container for the downstream OFDM Symbol Capture PNM test results.

10.2.2.3.2 PnmDsOfdmSymbolCaptMeas

This class contains the PNM measurements results for the downstream Symbol Capture PNM test and inherits the attributes from the abstract class PnmTestMeasurement. This class refactors the CCAP Symbol Capture File Format defined in section 7.3.4.1.11.

Table 538 - PnmDsOfdmSymbolCaptMeas Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SubcarrierZeroCenterFreq	UnsignedInt	Yes		Hz	
SubcarrierSpacing	UnsignedByte	Yes		kHz	
FirstActiveSubcarrierIndex	UnsignedShort	Yes			
LastActiveSubcarrierIndex	UnsignedShort	Yes			
RxWindowing	Boolean	Yes			
TransactionId	UnsignedByte	No			
SampleRate	UnsignedInt	Yes		Hz	
FftLength	UnsignedShort	Yes	512 | 1024 | 2048 | 4096 | 8192		

Table 539 - PnmDsOfdmSymbolCaptMeas Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmDsOfdmSymbolCaptMeasSample	Directed composition to PnmDsOfdmSymbolCaptMeasSample	1	1..*	
PnmDsOfdmSymbolCaptCfgMetaData	Directed composition to PnmDsOfdmSymbolCaptCfgMetaData	1	1	

10.2.2.3.2.1 SubcarrierZeroCenterFreq

This attribute reports the center frequency of subcarrier zero of the OFDM channel.

10.2.2.3.2.2 SubcarrierSpacing

This attribute reports the subcarrier spacing in kilohertz for the OFDM channel.

10.2.2.3.2.3 FirstActiveSubcarrierIndex

This attribute is the subcarrier index of the lowest frequency subcarrier in the Encompassed Spectrum for the OFDM channel.

10.2.2.3.2.4 LastActiveSubcarrierIndex

This attribute is the subcarrier index of the highest frequency subcarrier in the Encompassed Spectrum for the OFDM channel.

10.2.2.3.2.5 RxWindowing

This attribute is a flag indicating if vendor proprietary windowing was enabled during the symbol capture. The value ‘true’ indicates vendor proprietary windowing was used during the symbol capture. The value ‘false’ indicates vendor proprietary windowing was not used during the symbol capture.

10.2.2.3.2.6 TransactionId

This attribute is the Transaction ID sent by the CCAP in the Trigger Message Block. Prior to completion of a measurement this attribute has no meaning. This is an optional attribute.

Reference: [MULPIv4.0] Trigger Message Block

10.2.2.3.2.7 SampleRate

This attribute is the FFT sample rate in use by the cable modem for the channel. Typically, the sample rate for the OFDM downstream channel will be 204800000 Hz.

10.2.2.3.2.8 FftLength

This attribute is the FFT length in use by the cable modem for the channel. Typically, this value is 4096 or 8192 for the OFDM downstream channel.

10.2.2.3.3 PnmDsOfdmSymbolCaptMeasSample

This class contains the captured symbol samples obtained during the downstream OFDM Symbol Capture PNM test. This class refactors the CCAP Symbol Capture File Format defined in section 7.3.4.1.11.

Table 540 - PnmDsOfdmSymbolCaptMeasSample Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SymbolCaptureDataLen	UnsignedInt	Yes		Bytes	
SymbolCaptureData	HexBinary	Yes			

10.2.2.3.3.1 SymbolCaptureDataLen

This attribute indicates the size of the downstream OFDM symbol capture data.

10.2.2.3.3.2 SymbolCaptureData

This attribute contains the complex data values of the downstream OFDM symbol capture. The data is expressed in s2.13 fixed point notation. The average power of a given QAM constellation (not including pilots) = 1.

Reference: [PHYv3.1] Downstream Symbol Capture

10.2.2.3.4 PnmDsOfdmSymbolCaptCfgMetaData

This class contains the PNM test configuration meta data for the downstream OFDM Symbol Capture PNM test. This class refactors the DsOfdmSymbolCapture class defined in section 7.3.4.1 DsOfdmSymbolCapture.

Table 541 - PnmDsOfdmSymbolCaptCfgMetaData Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
TriggerGroupId	UnsignedShort	No			

10.2.2.3.4.1 TriggerGroupId

This attribute is a copy of the PnmDsOfdmSymbolCaptCfg::TriggerGroupId attribute. This is an optional attribute.

10.2.2.4 Downstream OFDM Symbol Capture Component Diagram

The Downstream OFDM Symbol Capture component diagram illustrates the CCAP (Server) and PNM Server (Client) component for the Downstream OFDM Symbol Capture PNM test operation. The CCAP Server component provides as operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.2.2.4.1 PnmDsOfdmSymbolCaptTestManagement Component Diagram

The PnmDsOfdmSymbolCaptTestManagement component diagram illustrate the CCAP and PNM Server components that execute InitPnmDsOfdmSymbolCaptTest operation.

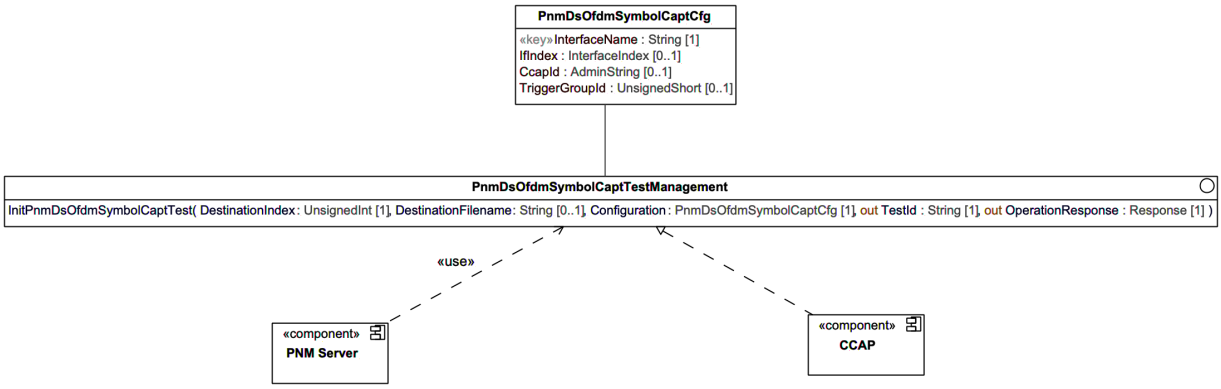


Figure 98 - PnmDsOfdmSymbolCaptTestManagement Component Diagram

10.2.2.4.1.1 InitPnmDsOfdmSymbolCaptTest Operation

The InitPnmDsOfdmSymbolCaptTest is a non-blocking asynchronous operation that initiates the Downstream OFDM Symbol Capture PNM test.

A successful operation will result in the CCAP starting the OFDM symbol sample collection. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

When the CCAP completes the test and measurements, the CCAP will then send the TestCompleteNotification signaling the test results have been uploaded.

The CCAP MUST reject configuring a value for the DestinationIndex of the DsOfdmSymbolCaptureTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 542 - InitPnmDsOfdmSymbolCaptTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmDsOfdmSymbolCaptCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.2.2.4.1.2 Parameter Definitions

10.2.2.4.1.2.1 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.2.2.4.1.2.2 DestinationFilename

This parameter defines the filename for the measurement data file.

10.2.2.4.1.2.3 Configuration

This parameter is the complex set of configuration parameters for the Downstream OFDM Symbol Capture PNM test operation. Refer to the class definition PnmDsOfdmSymbolCaptCfg for details.

10.2.2.4.1.2.4 TestId

This parameter is a unique identifier for a PNM test instance.

10.2.2.4.1.2.5 OperationResponse

This parameter is the device response to the InitPnmDsOfdmSymbolCaptTest operation command. Refer to the definition of the common Response class for details.

10.2.2.4.1.3 Error Conditions

The following table defines the possible error conditions for the InitPnmDsOfdmSymbolCaptTest operation.

Table 543 - InitPnmDsOfdmSymbolCaptTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3 PNM Upstream Information Models

This section defines the Streaming Telemetry Information Models for Upstream PNM Use Cases.

10.3.1 Measure Upstream OFDMA Receive Modulation Error Ratio Test Overview

This section defines the Information Models for the Measure Upstream Receive Modulation Error Ratio (RxMer) Use Case.

Upstream OFDMA Receive MER per Subcarrier is a PNM Test described in [PHYv3.1] Upstream Receive Modulation Error Ratio (RxMER) Per Subcarrier section. The Measure Upstream Receive Modulation Error Ratio information model defines two Streaming Telemetry management interfaces for the operator to configure, execute, and monitor the Upstream OFDMA RxMER per Subcarrier test.

- The Upstream OFDMA Rx MER per Subcarrier streaming telemetry management interface enables the operator to configure, execute, and monitor the US OFDMA RxMER per Subcarrier test a single time for a single cable modem and return a results file, replicating the functionality of the original US OFDMA RxMER per Subcarrier test described in Section 7.3.5.5, UsOfdmaRxMerPerSubcarrier.
- The Multiple Cable Modem Upstream OFDMA Rx MER per Subcarrier streaming telemetry management interface enables the operator to configure, execute, and monitor instances of the Upstream OFDMA Rx MER per Subcarrier test for one or more cable modems in sequence, repeated for a configurable cycle duration. The CCAP can be configured to stream Rx MER per Subcarrier test results from each cable modem to the Telemetry Client using gNMI.

Two methods are defined for selecting the set of cable modems that the CCAP will provide probe opportunities to for the Multiple Cable Upstream OFDMA RxMER per Subcarrier test. These methods leverage the cable modem selection methods defined in [CCAP-OSSIv3.1] for the Leakage Detection Test Interface:

(1) Application/CLI-configured cable modem MAC address list
A cable modem MAC address or a set of cable modem MAC addresses are configured by the operator directly via a CLI or indirectly via an application by writing the PnmMultipleCmUsOfdmaRxMerCfg object CmMacAddressList attribute.

(2) CCAP-determined cable modem MAC address list
When value 0xFF:FF:FF:FF:FF:FF is configured as the value for CmMacAddressList parameters in the PnmMultipleCmUsOfdmaRxMerCfg object, the CCAP determines the list of CM MAC addresses.

Two levels of granularity or scope are supported for the CCAP-determined cable modem MAC address list:

If 0xFF:FF:FF:FF:FF:FF is configured for CmMacAddressList and the configuration attribute InterfaceName is omitted from the Multiple CM US OFDMA RxMER per Subcarrier test configuration, the CCAP selects modems from the entire CCAP scope. If a value is provided for attribute InterfaceName in the Multiple CM US OFDMA RxMER per Subcarrier test configuration, the CCAP is constrained to select modems only from the set of modems that use the CCAP interface specified by InterfaceName. Configuration attribute InterfaceName can specify a MAC Domain or an upstream channel.

10.3.2 Upstream OFDMA RxMER per Subcarrier Test Requirements

The CCAP MUST implement the Upstream OFDMA Rx MER per Subcarrier interface and Multiple Cable Modem Upstream OFDMA Rx MER per Subcarrier interface as described in this specification.

The CCAP MUST accept at least 100 Test Modem MAC addresses in a configured list for the Multiple Cable Modem Upstream OFDMA Rx MER per Subcarrier interface.

10.3.2.1 Upstream OFDMA RxMER per Subcarrier Configuration and Initialization Requirements

The operator configures a set of parameters for an Upstream OFDMA Rx MER per Subcarrier test by creating an instance of PnmUsOfdmaRxMerCfg Object or an instance of PnmMultipleCmUsOfdmaRxMerCfg Object.

When the CCAP is called with InitPnmMultipleCmUsOfdmaRxMerTest operation with value 0xFF:FF:FF:FF:FF:FF for attribute CmMacAddressList and without InterfaceName, the CCAP MUST configure unique CmMacAddressLists for each MAC Domain in its scope with the MAC addresses for all cable modems that match the criteria listed below:

- Each cable modem in a given list is served by the same MAC Domain
- Each cable modem includes in its Transmit Channel Set an OFDMA channel

When the CCAP is called with InitPnmMultipleCmUsOfdmaRxMerTest operation with value 0xFF:FF:FF:FF:FF:FF for attribute CmMacAddressList and a value for InterfaceName, the CCAP MUST configure a CmMacAddressList with the MAC addresses such that each cable modem is served by the OFDMA interface identified by InterfaceName. When the CCAP is called with InitPnmMultipleCmUsOfdmaRxMerTest operation with value 0xFF:FF:FF:FF:FF:FF for attribute CmMacAddressList, the CCAP determines the order in which to issue probe opportunities to the selected cable modems.

When the CCAP is called with InitPnmMultipleCmUsOfdmaRxMerTest operation with no CmMacAddressList attribute and with a value for InterfaceName attribute, the CCAP MUST determine the list of cable modem MAC addresses only from within the set of cable modems using the CCAP interface specified by InterfaceName.

The CCAP MUST reject a call with InitPnmMultipleCmUsOfdmaRxMerTest operation if CmMacAddressList and InterfaceName are both configured and one or more of the cable modem MAC addresses included in CmMacAddressList are not associated with the specified interface.

The CCAP MUST reject a call with InitPnmMultipleCmUsOfdmaRxMerTest operation with no CmMacAddressList attribute and with no InterfaceName attribute as an invalid configuration. At least one of the attributes CmMacAddressList and InterfaceName are required to be present for the configuration to be valid.

The CCAP MUST reject a call with InitPnmMultipleCmUsOfdmaRxMerTest operation in which any required attribute is not present.

10.3.2.2 Upstream OFDMA RxMER per Subcarrier Operational Requirements

When a CCAP receives a call with InitPnmMultipleCmUsOfdmaRxMerTest operation with a valid configuration including a list of cable modem MAC addresses configured for CmMacAddressList, it MUST provide a probe opportunity, measure the upstream receive MER per subcarrier as described in Section 7.3.5.5, UsOfdmaRxMerPerSubcarrier, and return results for each cable modem in the configured cable modem list, one at a time in sequence, then repeat the sequence beginning with first cable modem in the configured list, until the time configured for CycleDuration is exhausted, or until it is terminated by PnmAbortTest operation or PnmStopTest operation.

When a CCAP receives a call with InitPnmMultipleCmUsOfdmaRxMerTest operation with a valid configuration including value 0xFF:FF:FF:FF:FF:FF configured for CmMacAddressList it MUST provide a probe opportunity, measure the upstream receive MER per subcarrier as described in Section 7.3.5.5, UsOfdmaRxMerPerSubcarrier, and return results for each cable modem in the cable modem list configured by the CCAP, one at a time in sequence, then repeat the sequence beginning with first cable modem in the configured list, until the time configured for CycleDuration is exhausted, or until it is terminated by PnmAbortTest operation or PnmStopTest operation.

When PnmAbortTest on a CCAP is called with the TestId of an active Upstream OFDMA RxMER per Subcarrier test or an active Multiple Cable Modem Upstream OFDMA RxMER per Subcarrier test, the CCAP MUST terminate execution of the specified test as described in Section 10.1.3.2, PnmAbortTest Operation.

When PnmStopTest on a CCAP is called with the TestId of an active Upstream OFDMA RxMER per Subcarrier test or an active Multiple Cable Modem Upstream OFDMA RxMER per Subcarrier test, the CCAP MUST terminate execution of the specified test as described in Section 0, PnmStopTest Operation.

10.3.2.3 Upstream OFDMA RxMER Data Type Definitions

This section defines any required data type definitions used in the Information Model.

Table 544 - Upstream Receive MER per Subcarrier Data Types

Data Type Name	Base Type	Permitted Values	Reference
RxMerDataType	HexBinary		RxMerData

10.3.2.3.1 RxMerDataType

This data type represents the Rx MER data as defined in the RxMerData data type in Section 7.3.2.5.

10.3.2.4 Upstream OFDMA RxMER Complex Data Type Definitions

This section defines classes/objects used in the PNM Upstream RxMER per Subcarrier Information Models as complex data types.

10.3.2.4.1 PnmUsOfdmaRxMerCfg

This class defines the configuration parameters for the Upstream RxMER PNM test. This class refactors the UsOfdmaRxMerPerSubcarrier class defined in Section 7.3.5.5, UsOfdmaRxMerPerSubcarrier.

Table 545 - PnmUsOfdmaRxMerCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
InterfaceName	String	Yes			
IfIndex	InterfaceIndex	No			
CcapId	AdminString	No			
CmMacAddress	MacAddress	Yes			
EnablePreEqualization	Boolean	Yes			False
NumAverages	UnsignedByte	Yes	1..255		

10.3.2.4.1.1 InterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will measure subcarriers' MER on the OFDMA channel.

10.3.2.4.1.2 IfIndex

This attribute represents the CCAP OFDMA upstream interface index for the Upstream RxMER per Subcarrier test. This is an optional parameter.

10.3.2.4.1.3 CcapId

This attribute represents a string identifying the CCAP serving the CM transmitting the subcarriers measured during the Upstream RxMER per Subcarrier test. This is an optional parameter.

10.3.2.4.1.4 CmMacAddress

This attribute represents the MAC address of the CM transmitting the subcarriers to be measured.

10.3.2.4.1.5 EnablePreEqualization

This attribute when enabled causes the CCAP to enable pre-equalization in the Probe Information Element for the CM transmitting the subcarriers to be measured.

10.3.2.4.1.6 NumAverages

This attribute controls the number of probes the CCAP will use to calculate the Rx MER per subcarrier. The average will be computed using the "leaky integrator" method, where reported Rx MER per subcarrier value = alpha*accumulated values + (1-alpha)*current value. Alpha is one minus the reciprocal of the number of averages.

For example, if N=25, then alpha = 0.96. A value of 1 indicates no averaging. Re-writing the number of averages will restart the averaging process. If there are no accumulated values, the accumulators are made equal to the first measured bin amplitudes.

10.3.2.4.2 PnmMultipleCmUsOfdmaRxMerCfg

This class defines the configuration parameters for the expanded Upstream RxMER PNM test which supports multiple cable modems and multiple upstream RxMER per Subcarrier test cycles.

Table 546 - PnmMultipleCmUsOfdmaRxMerCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
InterfaceName	String	Yes			
CmMacAddressList	MacAddress	Yes	1..*		

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
IfIndex	InterfaceIndex	No			
CcapId	AdminString	No			
EnablePreEqualization	Boolean	No			False
NumAverages	UnsignedByte	Yes	1..255		
CycleDuration	UnsignedShort	No		minutes	0
ProbeOppInterval	UnsignedShort	No		seconds	0
CycleGap	UnsignedShort	No		minutes	0

10.3.2.4.2.1 InterfaceName

See the description for InterfaceName in section 10.3.2.4.2.1 InterfaceName.

10.3.2.4.2.2 CmMacAddressList

This attribute is a list of one or more cable modem MAC address(es) configuring the CCAP with the CM(s) that will transmit the subcarriers to be measured. If configured with value 0xFF:FF:FF:FF:FF:FF, the CM MAC Address list is populated by the CCAP.

10.3.2.4.2.3 IfIndex

See the description for IfIndex in section 10.3.2.4.1.2 IfIndex.

10.3.2.4.2.4 CcapId

See the description for CcapId in section 10.3.2.4.1.3 CcapId.

10.3.2.4.2.5 EnablePreEqualization

See the description for EnablePreEqualization in section 10.3.2.4.1.5 EnablePreEqualization.

10.3.2.4.2.6 NumAverages

See the description for NumAverages in section 10.3.2.4.1.6 NumAverages.

10.3.2.4.2.7 CycleDuration

This attribute configures the time duration for which the CCAP will execute Upstream OFDMA RxMER per Subcarrier test cycles on the configured set of cable modems, in which one cycle is execution of one Upstream OFDMA RxMER per Subcarrier test as described in section 10.3.1 Measure Upstream OFDMA Receive Modulation Error Ratio Test Overview for each cable modem listed in attribute PnmMultipleCmUsOfdmaRxMerCfg::CmMacAddressList or for each cable modem configured by the CCAP. Value 0 for CycleDuration means no time limit for Upstream OFDMA Rx MER per Subcarrier test cycles and the CCAP executes Upstream OFDMA Rx MER per Subcarrier test cycles repeatedly until it is explicitly terminated by the operator using the PnmAbortTest Operation or explicitly stopped by the operator using the PnmStopTest operation. The default value for CycleDuration is 0.

10.3.2.4.2.8 ProbeOppInterval

This attribute configures the time delay between the completion of the Upstream OFDMA RxMER per Subcarrier test for one cable modem and the assignment of a probe opportunity to the next cable modem in sequence for conducting the Upstream OFDMA RxMER per Subcarrier test for the next cable modem in sequence. Value 0 for ProbeOppInterval means the CCAP is to assign a probe opportunity to the next cable modem in sequence at the next opportunity, without introducing additional delay between completion of the Upstream OFDMA RxMER per subcarrier test for a cable modem and the assignment of a probe opportunity for the next cable modem in sequence. The default value for ProbeOppInterval is 0.

10.3.2.4.2.9 CycleGap

This attribute configures the time delay between the completion of one cycle of the Upstream OFDMA RxMER per subcarrier test for all configured cable modems and the initiation of the next Upstream OFDMA RxMER per subcarrier test cycle for all configured cable modems. Value 0 for CycleGap means the CCAP is to continue assigning probe opportunities to cable modems to start the Upstream OFDMA Rx MER per Subcarrier test cycle over again at the next opportunity, without introducing additional delay between the completion of one test cycle and the initiation of the next test cycle. The default value for CycleGap is 0.

10.3.2.5 Upstream OFDMA RxMER Class Diagram

The following diagram defines the Upstream OFDMA RxMER PNM test measurement classes rooted from the PnmResult class.

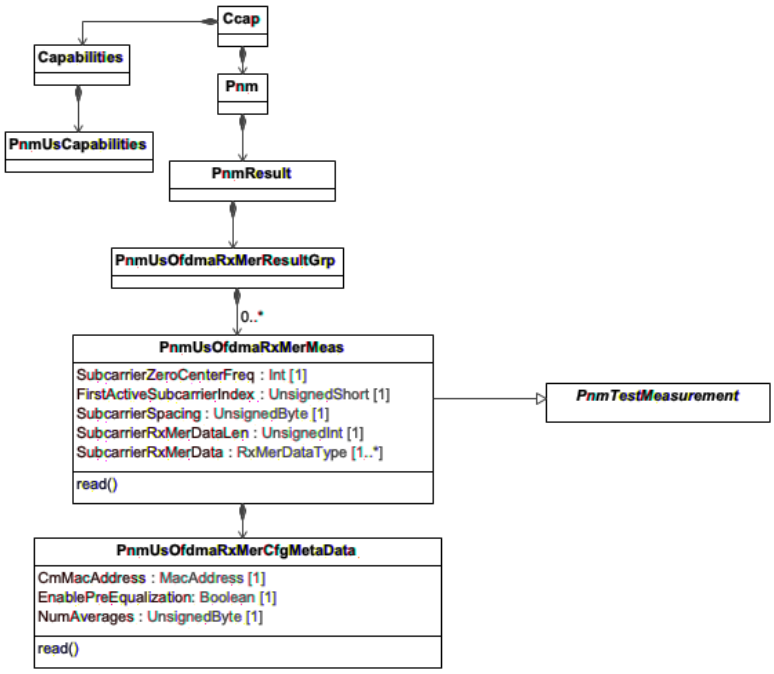


Figure 99 - PnmUsOfdmaRxMerResultGrp Class Diagram

10.3.2.5.1 PnmUsOfdmaRxMerResultGrp

This class represents a top-level container for the upstream OFDMA RxMER PNM test results.

10.3.2.5.2 PnmUsOfdmaRxMerMeas

This class contains the PNM measurements results for the upstream RxMER PNM test and inherits the attributes from the abstract class PnmTestMeasurement. This class refactors the RxMER File Format defined in Section 7.3.5.5.7.

Table 547 - PnmUsOfdmaRxMerMeas Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SubcarrierZeroCenterFreq	Int	Yes			
FirstActiveSubcarrierIndex	UnsignedShort	Yes			
SubcarrierSpacing	UnsignedByte	Yes			
SubcarrierRxMerDataLen	UnsignedInt	Yes			

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SubcarrierRxMerData	RxMerDataType	Yes			

Table 548 - PnmUsOfdmaRxMerMeas Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmUsOfdmaRxMerCfgMetaData	Directed composition to PnmUsOfdmaRxMerCfgMetaData	1	1	
PnmTestMeasurement	Specialization of PnmTestMeasurement	1	1	

10.3.2.5.2.1 SubcarrierZeroCenterFreq

This attribute reports the center frequency of subcarrier zero of the OFDMA channel.

10.3.2.5.2.2 FirstActiveSubcarrierIndex

This attribute is the subcarrier index of the lowest subcarrier in the Encompassed Spectrum of the OFDMA channel.

10.3.2.5.2.3 SubcarrierSpacing

This attribute reports the subcarrier spacing in kilohertz for the OFDMA channel.

10.3.2.5.2.4 SubcarrierRxMerDataLen

This attribute reports the number of bytes of RxMER measurement data which follow in the file.

10.3.2.5.2.5 SubcarrierRxMerData

This attribute contains sequence of received modulation error ratio values for an upstream OFDMA channel at the CM.

10.3.2.5.3 PnmUsOfdmaRxMerCfgMetaData

This class contains the PNM test configuration meta data for the upstream RxMER PNM test. This class refactors the UsOfdmaRxMerPerSubcarrier class defined in Section 7.3.5.5.

Table 549 - PnmUsOfdmaRxMerCfgMetaData Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
CmMacAddress	MacAddress	Yes			
EnablePreEqualization	Boolean	Yes			false
NumAverages	UnsignedByte	Yes			

10.3.2.5.3.1 CmMacAddress

This attribute is a copy of the PnmUsOfdmaRxMerPerSubcarrierCfg::CmMacAddress attribute.

10.3.2.5.3.2 EnablePreEqualization

This attribute is a copy of the UsOfdmaRxMerCfg::EnablePreEqualization attribute.

10.3.2.5.3.3 NumAverages

This attribute is a copy of the UsOfdmaRxMerPerSubcarrierCfg::NumAverages attribute.

10.3.2.6 Upstream OFDMA RxMER Component Diagram

The Upstream RxMER component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the Upstream RxMER PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.3.2.6.1 PnmUsOfdmaRxMerTestManagement Component Diagram

The PnmUsOfdmaRxMerTestManagement component diagram illustrates the CCAP and PNM Server components that execute the InitPnmUsOfdmaRxMerTest operation.

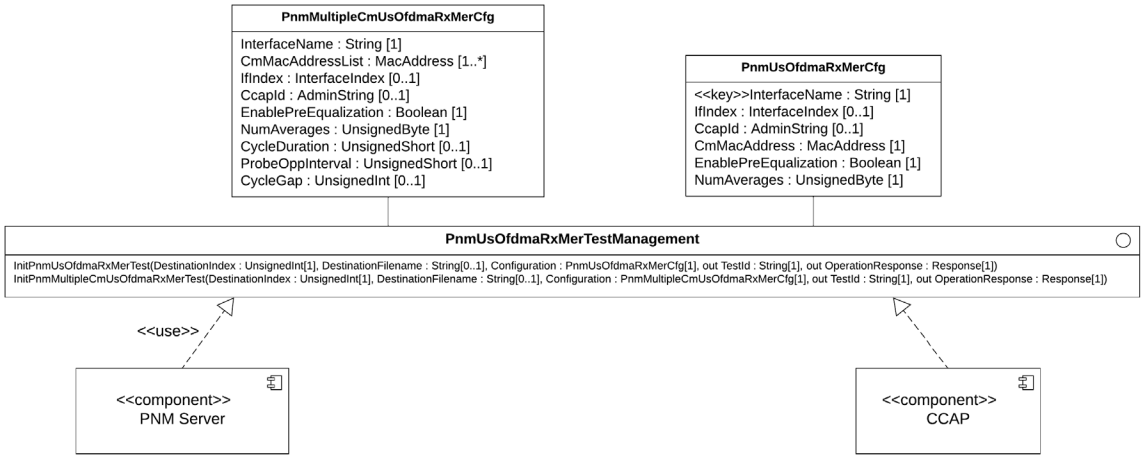


Figure 100 - PnmUsOfdmaRxMerTestManagement Component Diagram

10.3.2.6.1.1 InitPnmUsOfdmaRxMerTest Operation

The InitPnmUsOfdmaRxMerTest is a non-blocking asynchronous operation that initiates the Upstream OFDMA RxMER PNM test.

A successful operation will result in the CCAP starting the MER per subcarrier measurement collection. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

When the CCAP completes the test and measurements, the CCAP will then send the TestCompleteNotification signaling the test results have been uploaded.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsOfdmaRxMerTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 550 - InitPnmUsOfdmaRxMerTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsOfdmaRxMerCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.2.6.1.1.1 Parameter Definitions

10.3.2.6.1.1.1.1 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.2.6.1.1.1.2 DestinationFilename

This parameter defines the filename for the measurement data file.

10.3.2.6.1.1.1.3 Configuration

This parameter is the complex set of configuration parameters for the Upstream RxMER PNM test operation. Refer to the class definition PnmUsOfdmaRxMerCfg for details.

10.3.2.6.1.1.1.4 TestId

This parameter is a unique identifier for a PNM test instance.

10.3.2.6.1.1.1.5 OperationResponse

This parameter is the device response to the InitPnmUsOfdmaRxMerTest operation command. Refer to the definition of the common Response class for details.

10.3.2.6.1.1.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsOfdmaRxMerTest operation.

Table 551 - InitPnmUsOfdmaRxMerTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.2.6.1.2 InitPnmMultipleCmUsOfdmaRxMerTest Operation

The InitPnmMultipleCmUsOfdmaRxMerTest is a non-blocking asynchronous operation that initiates the Upstream OFDMA RxMER PNM test for multiple cable modems for a configurable length of time.

A successful operation will result in the CCAP starting the MER per subcarrier measurement collection for multiple cable modems in sequence. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

When the CCAP completes the test and measurements, the CCAP will then send the TestCompleteNotification signaling the test results have been uploaded.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmMultipleCmUsOfdmaRxMerTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 552 - InitPnmMultipleCmUsOfdmaRxMerTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	0..1		
DestinationFilename	String		In	0..1		
Configuration	PnmMultipleCmUsOfdmaRxMerCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.2.6.1.2.1 Parameter Definitions

10.3.2.6.1.2.1.1 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

If used, a separate result file will be created by the CCAP and transferred to the Destination, for each upstream RxMER per Subcarrier test, which are executed individually for each configured cable modem.

10.3.2.6.1.2.1.2 DestinationFilename

This parameter defines the filename for the measurement data file.

10.3.2.6.1.2.1.3 Configuration

This parameter is the complex set of configuration parameters for the Multiple Cable Modem Upstream RxMER PNM test operation. Refer to the class definition PnmMultipleCmUsOfdmaRxMerCfg for details.

10.3.2.6.1.2.1.4 TestId

This parameter is a unique identifier for a PNM test instance.

10.3.2.6.1.2.1.5 OperationResponse

This parameter is the device response to the InitPnmMultipleCmUsOfdmaRxMerTest operation command. Refer to the definition of the common Response class for details.

10.3.2.6.1.2.2 Error Conditions

The following table defines the possible error conditions for the InitPnmMultipleCmUsOfdmaRxMerTest operation.

Table 553 - InitPnmMultipleCmUsOfdmaRxMerTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.3 Capture Upstream OFDMA Symbols for Active and Quiet Probe Information Models

This section defines the Information Models for the Capture Upstream OFDMA Symbols for Active and Quiet Probe (AQP) Use Case.

Upstream OFDMA Symbols for Active and Quiet Probes is a PNM Test described in [PHYv3.1] Upstream Capture for Active and Quiet Probe section. The Capture Upstream OFDMA Symbols for Active and Quiet Probe information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Upstream OFDMA Symbols for Active and Quiet Probes test.

Refer to Section 7.3.5.1, UsOfdmaActiveAndQuietProbe for a description of the purpose and operation of the Upstream OFDMA Active and Quiet Probe PNM test.

10.3.3.1 Upstream OFDMA AQP Complex Data Type Definitions

This section defines classes/objects used in the PNM Upstream Active and Quiet Probe Information Models as complex data types.

10.3.3.1.1 PnmUsOfdmaAqpCfg

This class defines configuration parameters for the Upstream OFDMA Active and Quiet Probe PNM test. This class refactors the UsOfdmaActiveAndQuietProbe class defined in Section 7.3.5.1, UsOfdmaActiveAndQuietProbe.

Table 554 - PnmUsOfdmaAqpCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
InterfaceName	String	Yes			
IfIndex	InterfaceIndex	No			
CcapId	AdminString	No			
CmMacAddress	MacAddress	No			0x000000000000
UseIdleSid	Boolean	Yes			False
EnablePreEqualization	Boolean	No			True
Timeout	UnsignedShort	Yes		Seconds	1800
NumSymbolsToCapture	UnsignedShort	Yes		Symbols	1
EnableFrequencyDomainSamples	Boolean	Yes			True

10.3.3.1.1.1 InterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture symbols on the OFDMA channel.

10.3.3.1.1.2 IfIndex

This attribute represents the CCAP OFDMA upstream interface index for the Upstream OFDMA Active And Quiet Probe PNM test.

10.3.3.1.1.3 CcapId

This attribute represents a string identifying the CCAP serving the CM transmitting the OFDMA symbols captured during the Upstream OFDMA Active and Quiet Probe PNM test.

10.3.3.1.1.4 CmMacAddress

This attribute represents the MAC address of the CM transmitting the OFDMA symbols to be captured.

10.3.3.1.1.5 UseIdleSid

This attribute when enabled causes the CCAP to capture OFDMA symbols on the channel during a quiet period when no CM is transmitting.

10.3.3.1.1.6 EnablePreEqualization

This attribute when enabled causes the CCAP to enable pre-equalization in the Probe Information Element for the CM transmitting the OFDMA symbols to be captured.

10.3.3.1.1.7 Timeout

This attribute provides a timeout for the symbol capture if the CCAP is unable to perform the capture for some reason. A value of zero for the Timeout attribute means that the symbol capture continues to be active until the capture is complete.

10.3.3.1.1.8 NumSymbolsToCapture

This attribute represents the number of symbols the CCAP is to capture for the modem whose probe is being measured or the number of symbol times to measure for the idle Sid.

10.3.3.1.1.9 EnableFrequencyDomainSamples

This attribute indicates if the output samples are to be in the time domain or in the frequency domain. True means the samples are in the frequency domain. False means they are in the time domain.

10.3.3.2 Upstream OFDMA AQP Class Diagram

The following diagram defines the Upstream OFDMA Active and Quiet Probe PNM test measurement classes rooted from the PnmResult class.

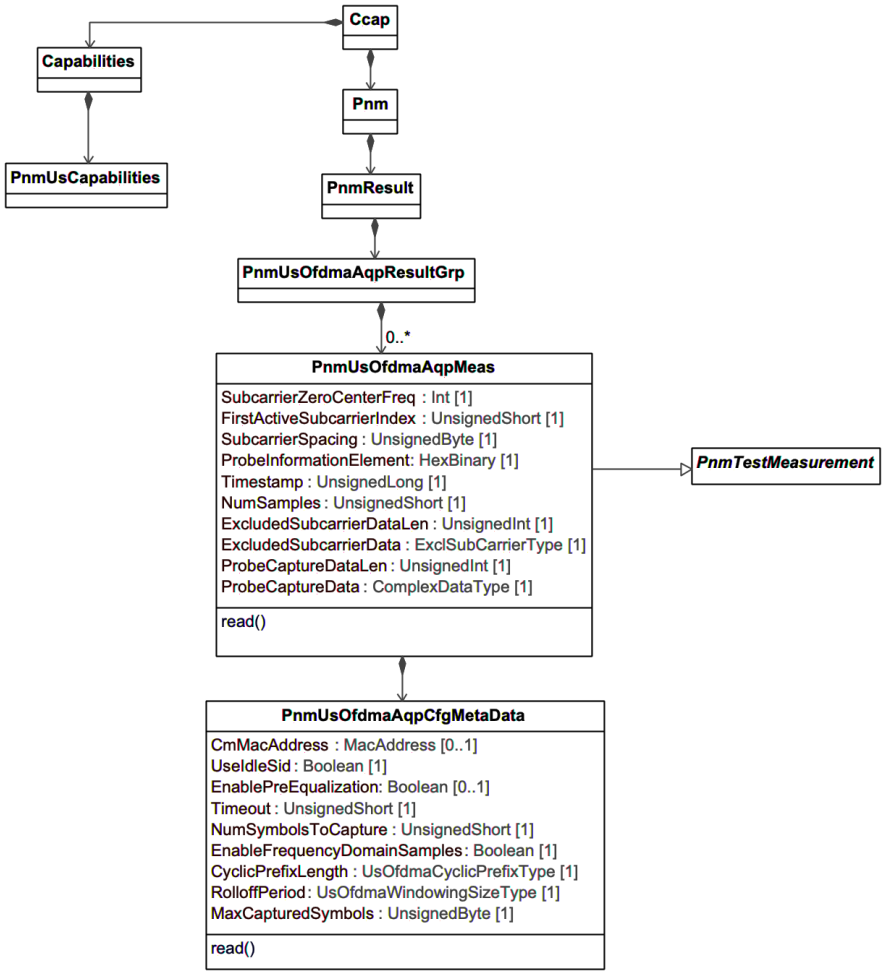


Figure 101 - PnmUsOfdmaAqpTestResultGrp Class Diagram

10.3.3.2.1 PnmUsOfdmaAqpResultGrp

This class represents a top-level container for the upstream OFDMA Active and Quiet Probe PNM test results.

10.3.3.2.2 PnmUsOfdmaAqpMeas

This class contains the PNM measurements results for the Upstream OFDMA Active and Quiet Probe PNM test and inherits the attributes from the abstract class PnmTestMeasurement. This class refactors the ActiveAndQuiet Probe File Format defined in Section 7.3.5.1, UsOfdmaActiveAndQuietProbe.

Table 555 - PnmUsOfdmaAqpMeas Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
SubcarrierZeroCenterFreq	Int	Yes		Hz	
FirstActiveSubcarrierIndex	UnsignedShort	Yes			
SubcarrierSpacing	UnsignedByte	Yes		kHz	
ProbeInformationElement	HexBinary	Yes	SIZE(4)		
Timestamp	UnsignedLong	Yes			
NumSamples	UnsignedShort	Yes		Samples	

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
ExcludedSubcarrierDataLen	UnsignedInt	Yes		Bytes	
ExcludedSubcarrierData	ExclSubCarrierType	Yes			
ProbeCaptureDataLen	UnsignedInt	Yes		Bytes	
ProbeCaptureData	ComplexData	Yes			

10.3.3.2.2.1 SubcarrierZeroCenterFreq

This attribute defines the center frequency of subcarrier zero of the OFDM channel.

10.3.3.2.2.2 FirstActiveSubcarrierIndex

This attribute is used to denote the subcarrier index of the lowest frequency of the Encompassed Spectrum for the OFDM channel.

10.3.3.2.2.3 SubcarrierSpacing

This attribute defines the subcarrier spacing configured on the OFDM downstream channel. If the SubcarrierSpacing is 50 kHz, then the FFT length is 4K. If the SubcarrierSpacing is 25 kHz, then the FFT length is 8K.

10.3.3.2.2.4 ProbeInformationElement

This attribute is a copy of the Probe Information Element (P-IE) sent in the P-MAP describing the Active or Quiet Probe that was captured.

10.3.3.2.2.5 Timestamp

This attribute is a copy of the Timestamp corresponding to the time when the Active or Quiet Probe was captured. If the Downstream Channel used for the P-MAP is an OFDM channel, then the Timestamp will be the 64-bit Extended Timestamp. If the Downstream Channel used for the P-MAP is an SC-QAM channel, then the Timestamp will be the 32-bit DOCSIS Timestamp and the 32 Most Significant Bits are set to zero.

10.3.3.2.2.6 NumSamples

For FrequencyDomainSamples set to True, this attribute represents the number of FFT samples present in the probe capture data. This corresponds to the Encompassed Spectrum of the OFDMA channel divided by the subcarrier spacing. For FrequencyDomainSamples set to False, this attribute represents the number of time-domain input samples (i.e. prior to the FFT engine) present in the probe capture data and includes the cyclic prefix, if configured. This is calculated as the sample rate (102.4 E6) divided by the subcarrier spacing plus the number of samples for the cyclic prefix (if enabled for the measurement). See [PHYv3.1]. For example, with 50 kHz subcarrier spacing this is 2048 samples plus 640 samples for the cyclic prefix (assuming the cyclic prefix is configured for 6.25 µs).

10.3.3.2.2.7 ExcludedSubcarrierDataLen

This element represents the length in bytes of the excluded subcarrier data which follows.

10.3.3.2.2.8 ExcludedSubcarrierData

This element contains the excluded subcarrier data as ExclSubCarType.

10.3.3.2.2.9 ProbeCaptureDataLen

This element represents the length in bytes of the probe capture data which follows.

10.3.3.2.2.10 ProbeCaptureData

This element refers to the I/Q values of the Probe Capture Data. The data is expressed as 16-bit signed values in s.15in s3.12 Fixed Point notation.

10.3.3.2.3 PnmUsOfdmaAqpCfgMetaData

This class contains the PNM test configuration meta data for the upstream Active and Quiet Probe PNM test. This class refactors the UsOfdmaActiveAndQuietProbe class defined in Section 7.3.5.1.

Table 556 - PnmUsOfdmaAqpCfgMetaData Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
CmMacAddress	MacAddress	R/W	No			0x000000000000
UseIdleSid	Boolean	R/W	Yes			False
EnablePreEqualization	Boolean	R/W	No			True
Timeout	UnsignedShort	R/W	Yes		Seconds	1800
NumSymbolsToCapture	UnsignedShort	R/W	Yes		Symbols	1
EnableFrequencyDomainSamples	Boolean	R/W	Yes			True
CyclicPrefixLength	UsOfdmaCyclicPrefixType	R/W	Yes		Samples	
RolloffPeriod	UsOfdmaWindowingSizeType	R/W	Yes		Samples	
MaxCapturedSymbols	UnsignedByte	R/O	Yes			

10.3.3.2.3.1 CmMacAddress

This attribute represents the MAC address of the CM transmitting the probe to be measured.

10.3.3.2.3.2 UseIdleSid

This attribute when enabled causes the CCAP to measure the channel during a quiet period when no CM is transmitting.

10.3.3.2.3.3 PreEqualizationOn

This attribute when enabled causes the CCAP to enable pre-equalization in the Probe Information Element for the CM transmitting the probe to be measured.

10.3.3.2.3.4 Timeout

This attribute provides a timeout for the measurement if the CCAP is unable to perform the measurement for some reason. A value of zero for the Timeout attribute means that the measurement continues to be active until the measurement is complete or until the Enable attribute is cleared.

10.3.3.2.3.5 NumSymbolsToCapture

This attribute represents the number of symbols the CCAP is to capture for the modem whose probe is being measured or the number of symbol times to measure for the idle Sid.

10.3.3.2.3.6 EnableFrequencyDomainSamples

This Boolean attribute configures the collection of output samples in the time domain or in the frequency domain. True means the samples are in the frequency domain. False means they are in the time domain.

10.3.3.2.3.7 CyclicPrefixLength

This attribute is the allowed values for applying cyclic prefix for mitigating interference due to microreflections.

10.3.3.2.3.8 RolloffPeriod

This attribute provides the allowed values for applying windowing to maximize the capacity of the upstream channel.

10.3.3.2.3.9 MaxCapturedSymbols

This attribute represents the number of symbols the CCAP can capture for one measurement and is reported based on the channel's configuration. Typically, for 50 kHz Subcarrier Spacing, the CCAP can capture two symbols, and for 25 kHz, the CCAP can capture one symbol. In order to capture more than one symbol, the CCAP would need to schedule multiple probe opportunities for the CM whose probe is being measured.

10.3.3.3 Upstream OFDMA AQP Component Diagram

The Upstream OFDMA Capture for Active and Quiet Probe component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the Upstream Active and Quiet Probe PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.3.3.3.1 PnmUsOfdmaAqpTestManagement Component Diagram

The PnmUsOfdmaAqpTestManagement component diagram illustrates the CCAP and PNM Server components that execute the InitPnmUsOfdmaAqpTest operation.

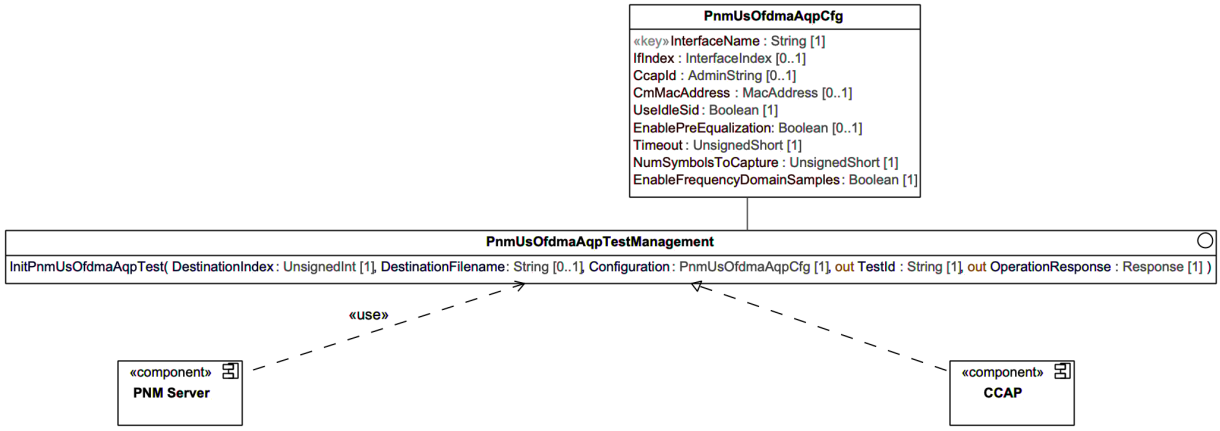


Figure 102 - PnmUsOfdmaAqpTestManagement Component Diagram

10.3.3.3.1.1 InitPnmUsOfdmaAqpTest Operation

The InitPnmUsOfdmaAqpTest is a non-blocking asynchronous operation that initiates the Upstream OFDMA Active And Quiet Probe PNM test.

A successful operation will result in the CCAP starting the collection of one or more OFDMA symbol(s) during a scheduled active or quiet probe. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

When the CCAP completes the test and measurements, the CCAP will then send the TestCompleteNotification signaling the test results have been uploaded.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsOfdmaAqpTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 557 - InitPnmUsOfdmaAqpTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsOfdmaAqpCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.3.3.1.1.1 Parameter Definitions

10.3.3.3.1.1.1.1 DestinationIndex

This attribute allows the operator to optionally define a destination for the result file or files to be sent when they are available. If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.3.3.1.1.1.2 DestinationFilename

This parameter defines the filename for the measurement data file.

10.3.3.3.1.1.1.3 Configuration

This parameter is the complex set of configuration parameters for the upstream OFDMA Active and Quiet Probe PNM test operation. Refer to the class definition PnmUsOfdmaAqpCfg for details.

10.3.3.3.1.1.1.4 TestId

This parameter is a unique identifier for a PNM test instance.

10.3.3.3.1.1.1.5 OperationResponse

This parameter is the device response to the InitPnmUsOfdmaAqpTest operation command. Refer to the definition of the common Response class for details.

10.3.3.3.1.1.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsOfdmaAqpTest operation.

Table 558 - InitPnmUsOfdmaAqpTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.4 Measure Upstream OFDMA Receive Power Information Models

This section defines the Information Models for the Measure Upstream OFDMA Receive Power Use Case.

Upstream OFDMA Receive Power is a PNM Test described in [PHYv3.1] Upstream Channel Power section. The Measure Upstream Receive Power information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Upstream OFDMA Receive Power test.

When executing the Measure Upstream OFDMA Receive Power test, the CCAP MUST provide probe opportunities and make measurements over the number of averages configured by attribute PnmUsOfdmaRxPowerCfgMetaData::NumAverages.

Refer to section 7.3.5.4 *UsOfdmaRxPower* for a description of the purpose and operation of the Upstream OFDMA Receive Power PNM test.

10.3.4.1 Upstream OFDMA Receive Power Complex Data Type Definitions

This section defines classes/objects used in the PNM Upstream OFDMA Receive Power Information Models as complex data types.

10.3.4.1.1 PnmUsOfdmaRxPowerCfg

This object contains configuration parameters for the Upstream OFDMA Receive Power PNM test. This class refactors the UsOfdmaRxPower class defined in section 7.3.5.4 *UsOfdmaRxPower*. The table below defines the class.

Table 559 - PnmUsOfdmaRxPowerCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
InterfaceName	String	Yes			
IfIndex	InterfaceIndex	No			
CcapId	AdminString	No			
CmMacAddress	MacAddress	Yes			0x000000000000
EnablePreEqualization	Boolean	Yes			True
NumAverages	UnsignedByte	Yes			1

10.3.4.1.1.1 InterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will measure power on the OFDMA channel.

10.3.4.1.1.2 IfIndex

This attribute represents the CCAP OFDMA upstream interface index for the Upstream OFDMA Receive Power PNM test. This is an optional parameter.

10.3.4.1.1.3 CcapId

This attribute represents a string identifying the CCAP serving the CM transmitting on the OFDMA channel on which power is measured during the Upstream OFDMA Receive Power PNM test. This is an optional parameter.

10.3.4.1.1.4 CmMacAddress

This attribute represents the MAC address of the CM transmitting on the OFDMA channel on which the receive power is measured.

10.3.4.1.1.5 EnablePreEqualization

This attribute when enabled causes the CCAP to enable pre-equalization in the Probe Information Element for the CM transmitting on the OFDMA channel on which power will be measured.

10.3.4.1.1.6 NumAverages

This attribute controls the time average over the number of probes the CCAP will use to calculate the RxPower. The average is simply the sum of the RxPower values divided by the NumAverages.

10.3.4.2 Upstream OFDMA Receive Power Class Diagram

The following diagram defines the Upstream OFDMA Receive Power PNM test measurement classes rooted from the PnmResult class.

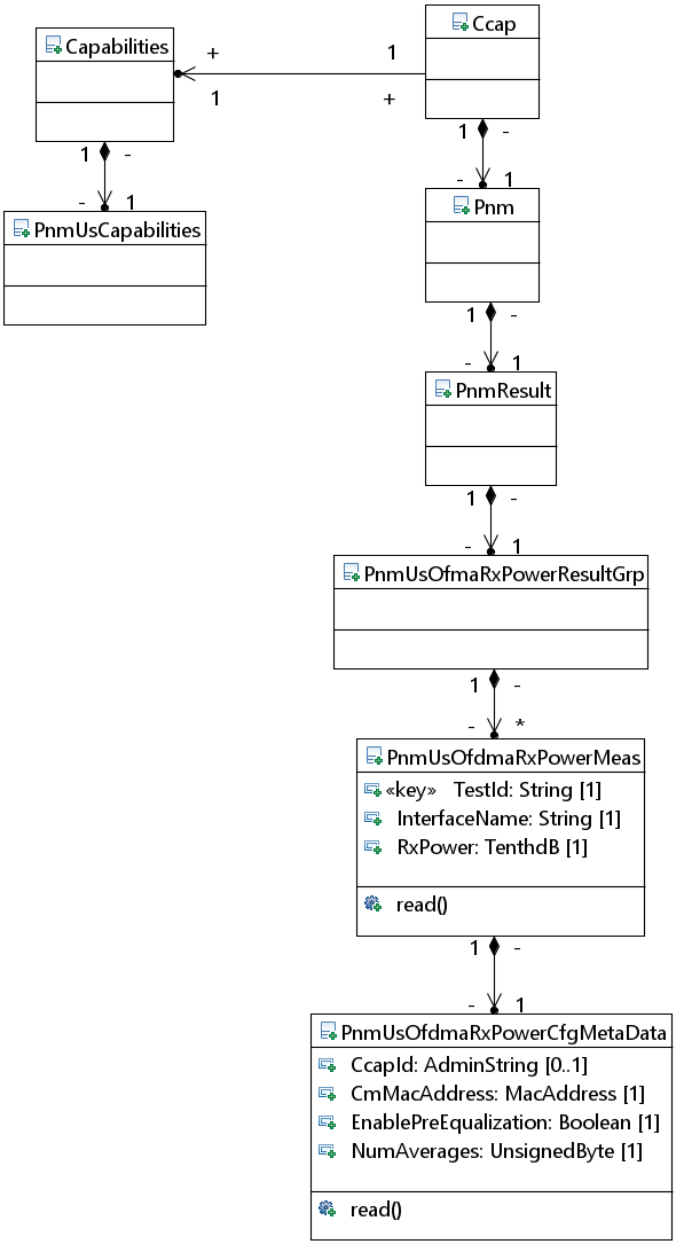


Figure 103 - CCAP PnmUsOfdmaRxPowerResultGrp Class Diagram

10.3.4.2.1 PnmUsOfdmaRxPowerResultGrp

This object represents a top-level container for the upstream OFDMA Receive Power PNM test results.

10.3.4.2.2 PnmUsOfdmaRxPowerMeas

This object contains the PNM test measurement data for the upstream OFDMA Receive Power PNM test.

Table 560 - PnmUsOfdmaRxPowerMeas Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units
TestId	String	Key	Yes (Key)		
InterfaceName	String	R/O	Yes		
RxPower	TenthdB	R/O	Yes		TenthdB

10.3.4.2.2.1 TestId

This key attribute is a string uniquely identifying a PNM test instance.

10.3.4.2.2.2 InterfaceName

This attribute contains the CCAP interface name for the OFDMA upstream channel on which the CCAP will measure receive power.

10.3.4.2.2.3 RxPower

This attribute represents the average power of the probe measured by the CCAP, reported as the Power Spectral Density in an equivalent 1.6 MHz spectrum, for the CM whose MAC address was specified in the CmMacAddress parameter. If the NumAverages parameter was greater than one, then this attribute represents the accumulated average 1.6 MHz PSD.

10.3.4.2.3 PnmUsOfdmaRxPowerCfgMetaData

This object contains the PNM test configuration meta data for the upstream OFDMA Receive Power PNM test. This data represents the configured input parameters when the InitRxPowerTest was started.

Table 561 - PnmUsOfdmaRxPowerCfgMetaData Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
CcapId	AdminString	R/O	No			
CmMacAddress	MacAddress	R/O	Yes			0x000000000000
EnablePreEqualization	Boolean	R/O	Yes			True
NumAverages	UnsignedShort	R/O	Yes		Seconds	1800

10.3.4.2.3.1 CcapId

This attribute represents a string identifying the CCAP serving the CM transmitting on the OFDMA channel on which power is measured during the Upstream OFDMA Receive Power PNM test.

10.3.4.2.3.2 CmMacAddress

This attribute represents the MAC address of the CM for which the received upstream channel power was measured.

10.3.4.2.3.3 EnablePreEqualization

This attribute indicates whether pre-equalization of the probe is enabled or disabled.

10.3.4.2.3.4 NumAverages

This attribute configures the number of measurements over which the CCAP averages Upstream OFDMA Receive Power. The average is simply the sum of the RxPower values divided by the NumAverages.

10.3.4.3 Upstream OFDMA Receive Power Component Diagram

The CCAP Upstream OFDMA Receive Power component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the Upstream Receive Power PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.3.4.3.1 PnmUsOfdmaRxPowerTestManagement Component Diagram

The CCAP Pnm*UsOfdmaRxPowerTestManagement* component diagram illustrates the operations defined between a CCAP and a PNM Server.

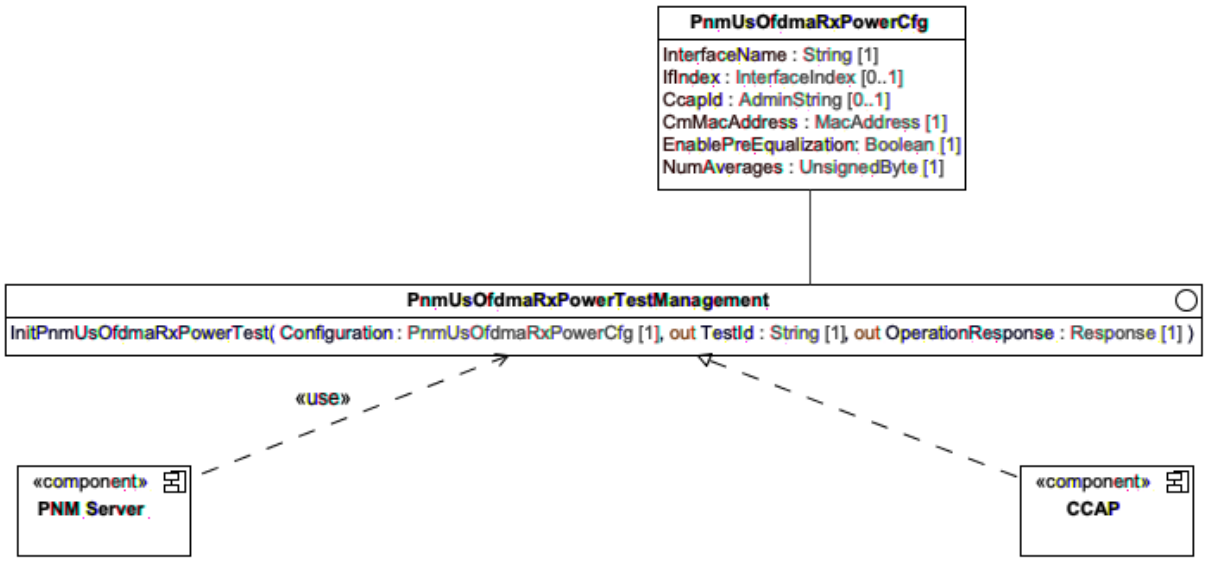


Figure 104 - CCAP PnmUsOfdmaRxPowerTestManagement Component Diagram

10.3.4.3.1.1 InitPnmUsOfdmaRxPowerTest Operation

The InitPnmUsOfdmaRxPowerTest is a non-blocking asynchronous operation that initiates the Upstream OFDMA Receive Power PNM test.

A successful operation will result in the CCAP starting the measurement of upstream power on the configured upstream OFDMA channel.

Table 562 - InitPnmUsOfdmaRxPowerTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
Configuration	PnmUsOfdmaRxPowerCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.4.3.1.1.1 Parameter Definitions

10.3.4.3.1.1.1.1 Configuration

This parameter is the complex set of configurations for the upstream OFDMA Receive Power PNM test operation.

10.3.4.3.1.1.1.2 TestId

This parameter is a string uniquely identifying a PNM test instance.

10.3.4.3.1.1.1.3 OperationResponse

This parameter is the device response to the InitRxPowerTest operation command. Refer to the definition of the common Response class for details.

10.3.4.3.1.1.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsOfdmaRxPowerTest operation.

Table 563 - InitPnmUsOfdmaRxPowerTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5 Capture Upstream Triggered Spectrum Information Models

This section defines the Information Models for the Capture Upstream Spectrum Use Case.

Upstream Triggered Spectrum Capture is a PNM Test described in [PHYv3.1] Upstream Triggered Spectrum Analysis section. The Capture Upstream Triggered Spectrum information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Upstream Triggered Spectrum Capture test.

Refer to Section 7.3.5.6, Upstream Triggered Spectrum Capture Information Model for a description of the purpose and operation of the Upstream Triggered Spectrum Capture (UTSC) PNM test.

10.3.5.1 Upstream Triggered Spectrum Capture Data Type Definitions

This section defines required data type definitions used in the Upstream Triggered Spectrum Capture Information Model.

Table 564 - Upstream Triggered Spectrum Capture Data Types

Data Type Name	Base Type	Permitted Values	Reference
WindowType	Enum	other(1), rectangular(2), hann(3), blackmanHarris(4), hamming(5), flatTop(6), gaussian(7), chebyshev(8)	PnmUsTrigSpectCaptCommonCfg::Window

Data Type Name	Base Type	Permitted Values	Reference
OutputFormatType	Enum	other(0) timeIQ(1), fftPower(2), rawAdc(3), fftIQ(4), fftAmplitude(5), fftDb(6)	PnmUsTrigSpectCaptCommonCfg::OutputFormat
BurstIucType	Enum	other(1), Iuc1(2), Iuc2(3), Iuc3(4), Iuc4(5), Iuc5(6), Iuc6(7), Iuc9(8), Iuc10(9), Iuc11(10), Iuc12(11), Iuc13(12)	PnmUsTrigSpectCaptBurstIucCfg::BurstIuc

10.3.5.1.1 WindowType

This data type represents the windowing function that will be used when performing the discrete Fourier transform for the upstream spectrum analysis. Use of "modern" windowing functions not yet defined will likely be specified as 'other'.

10.3.5.1.2 OutputFormatType

This data type represents the format of the data returned in the upstream spectrum sample capture file and in the Output attribute of the Results object.

10.3.5.1.3 BurstIucType

This data type represents the Interval Usage Code (IUC) on which the Upstream Spectrum Capture is triggered.

Reference: [MULPIv4.0] Upstream Bandwidth Allocation Map (MAP) section.

10.3.5.2 Upstream Triggered Spectrum Capture Complex Data Type Definitions

This section defines classes/objects used in the PNM UTSC Information Models as complex data types.

10.3.5.2.1 PnmUsTrigSpectCaptCommonCfg

This object contains configuration parameters that are common to all PNM UTSC test trigger-specific operations. This class refactors the UsTriggeredSpectrumCaptureCfg class defined in section 7.3.5.6 *Upstream Triggered Spectrum Capture Information Model*. Table 554 - PnmUsTrigSpectCaptCommonCfg Object Attributes below defines the class.

Table 565 - PnmUsTrigSpectCaptCommonCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
InterfaceName	String	Key	Yes			
IfIndex	InterfaceIndex	R/W	No			
CcapId	AdminString	R/W	No			
Averaging	UnsignedByte	R/W	No	0|2..255		0

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
QualifyCenterFreq	UnsignedInt	R/W	No		Hertz	0
QualifyBw	UnsignedInt	R/W	No		Hertz	5120000
QualifyThrshld	TenthdB	R/W	No		TenthdB	-100
Window	WindowType	R/W	No			rectangular(2)
OutputFormat	OutputFormatType	R/W	No			fftPower(2)
TriggerCount	UnsignedInt	R/W	No			0
Filename	AdminString	R/W	No			""
MaxResultsPerFile	UnsignedInt	R/W	No	0..N		0
CenterFreq	UnsignedInt	R/W	Yes		Hertz	
FreqSpan	UnsignedInt	R/W	Yes		Hertz	
NumBins	UnsignedShort	R/W	Yes			

10.3.5.2.1.1 InterfaceName

This key attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.1.2 IfIndex

This attribute represents the CCAP OFDMA upstream interface index for the UTSC PNM test. This is an optional parameter.

10.3.5.2.1.3 CcapId

This attribute represents a string identifying the CCAP serving the CM transmitting on the OFDMA channel on which the upstream spectrum is captured during the UTSC PNM test. This is an optional parameter.

10.3.5.2.1.4 Averaging

Refer to the description for *Averaging* in Section 7.3.5.6.3.12.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.12 *Averaging* also apply to the Model Driven PNM Information Model.

10.3.5.2.1.5 QualifyCenterFreq

Refer to the description for *QualifyCenterFreq* in Section 7.3.5.6.3.14.

10.3.5.2.1.6 QualifyBw

Refer to the description for *QualifyBw* in Section 7.3.5.6.3.15.

10.3.5.2.1.7 QualifyThrshld

Refer to the description for *QualifyThrshld* in Section 7.3.5.6.3.16.

10.3.5.2.1.8 Window

Refer to the description for *Window* in Section 7.3.5.6.3.17.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.17 also apply to the Model Driven PNM Information Model.

10.3.5.2.1.9 OutputFormat

Refer to the description for *OutputFormat* in Section 7.3.5.6.3.18.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.18 *OutputFormat* also apply to the Model Driven PNM Information Model.

10.3.5.2.1.10 TriggerCount

Refer to the description for *TriggerCount* in Section 7.3.5.6.3.21.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.21 *TriggerCount* also apply to the Model Driven PNM Information Model.

10.3.5.2.1.11 Filename

Refer to the description for *Filename* in Section 7.3.5.6.3.13.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.13 *Filename* also apply to the Model Driven PNM Information Model.

10.3.5.2.1.12 MaxResultsPerFile

Refer to the description for *MaxResultsPerFile* in Section 7.3.5.6.3.23.

10.3.5.2.1.13 CenterFreq

Refer to the description for *CenterFreq* in Section 7.3.5.6.3.9.

10.3.5.2.1.14 FreqSpan

Refer to the description for *Span* in Section 7.3.5.6.3.10.

10.3.5.2.1.15 NumBins

Refer to the description for *NumBins* in Section 7.3.5.6.3.11.

10.3.5.2.2 PnmUsTrigSpectCaptFreeRunningCfg

This object contains configuration parameters specific to the PNM UTSC test operation *InitPnmUsTrigSpectCaptFreeRunningTest*, for which the Free Running trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 555 - PnmUsTrigSpectCaptFreeRunningCfg Object Attributes below defines the class.

Table 566 - PnmUsTrigSpectCaptFreeRunningCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
FreeRunDuration	UnsignedInt	R/W	Yes		msec	1000
RepeatPeriod	UnsignedInt	R/W	Yes		usec	100000

10.3.5.2.2.1 FreeRunDuration

Refer to the description for *FreeRunDuration* in Section 7.3.5.6.3.20.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.20 *FreeRunDuration* also apply to the Model Driven PNM Information Model.

10.3.5.2.2.2 RepeatPeriod

Refer to the description for *RepeatPeriod* in section 7.3.5.6.3.19.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.19 *RepeatPeriod* also apply to the Model Driven PNM Information Model.

10.3.5.2.3 PnmUsTrigSpectCaptMinislotCountCfg

This object contains configuration parameters specific to the PNM UTSC test operation *InitPnmUsTrigSpectCaptMinislotCountTest*, for which the Minislot Count trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 556 - PnmUsTrigSpectCaptMinislotCountCfg Object Attributes below defines the class.

Table 567 - PnmUsTrigSpectCaptMinislotCountCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			
MinislotCount	UnsignedInt	R/W	Yes			0
FreeRunDuration	UnsignedInt	R/W	Yes		msec	1000
RepeatPeriod	UnsignedInt	R/W	Yes		usec	100000

10.3.5.2.3.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.3.2 MinislotCount

Refer to the description for *MinislotCount* in Section 7.3.5.6.3.5.

10.3.5.2.3.3 FreeRunDuration

Refer to the description for *FreeRunDuration* in Section 7.3.5.6.3.20.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.20 *FreeRunDuration* also apply to the Model Driven PNM Information Model.

10.3.5.2.4 PnmUsTrigSpectCaptSidCfg

This object contains configuration parameters specific to the PNM UTSC test operation *InitPnmUsTrigSpectCaptSidTest*, for which the SID trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 557 - PnmUsTrigSpectCaptSidCfg Object Attributes below defines the class.

Table 568 - PnmUsTrigSpectCaptSidCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			
Sid	UnsignedInt	R/W	Yes			0

10.3.5.2.4.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.4.2 Sid

Refer to the description for *Sid* in Section 7.3.5.6.3.6.

10.3.5.2.5 PnmUsTrigSpectCaptIdleSidCfg

This object contains configuration parameters specific to the PNM UTSC test operation InitPnmUsTrigSpectCaptIdleSidTest, for which the Idle SID trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 558 - PnmUsTrigSpectCaptIdleSidCfg Object Attributes below defines the class.

Table 569 - PnmUsTrigSpectCaptIdleSidCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			

10.3.5.2.5.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.6 PnmUsTrigSpectCaptCmMacAddressSidCfg

This object contains configuration parameters specific to the PNM UTSC test operation InitPnmUsTrigSpectCaptCmMacAddressSidTest, for which the CM MAC Address SID trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 559 - PnmUsTrigSpectCaptCmMacAddressSidCfg Object Attributes below defines the class.

Table 570 - PnmUsTrigSpectCaptCmMacAddressSidCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			
CmMacAddr	MacAddress	R/W	Yes			'000000000000'H

10.3.5.2.6.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.6.2 CmMacAddr

Refer to the description for *CmMacAddr* in Section 7.3.5.6.3.7.

10.3.5.2.7 PnmUsTrigSpectCaptActiveProbeSymbolCfg

This object contains configuration parameters specific to the PNM UTSC test operation InitPnmUsTrigSpectCaptActiveProbeSymbolTest, for which the Active Probe Symbol trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 560 - PnmUsTrigSpectCaptActiveProbeSymbolCfg Object Attributes below defines the class.

Table 571 - PnmUsTrigSpectCaptActiveProbeSymbolCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			
Sid	UnsignedInt	R/W	Yes			0

10.3.5.2.7.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.7.2 Sid

Refer to the description for *Sid* in Section 7.3.5.6.3.6.

10.3.5.2.8 PnmUsTrigSpectCaptQuietProbeSymbolCfg

This object contains configuration parameters specific to the PNM UTSC test operation InitPnmUsTrigSpectCaptQuietProbeSymbolTest, for which the Quiet Probe Symbol trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 561 - PnmUsTrigSpectCaptQuietProbeSymbolCfg Object Attributes below defines the class.

Table 572 - PnmUsTrigSpectCaptQuietProbeSymbolCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			
Sid	UnsignedInt	R/W	Yes			0

10.3.5.2.8.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.8.2 Sid

Refer to the description for *Sid* in Section 7.3.5.6.3.6.

10.3.5.2.9 PnmUsTrigSpectCaptBurstIucCfg

This object contains configuration parameters specific to the PNM UTSC test operation *InitPnmUsTrigSpectCaptBurstIucTest*, for which the Burst IUC trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 562 - PnmUsTrigSpectCaptBurstIucCfg Object Attributes below defines the class.

Table 573 - PnmUsTrigSpectCaptBurstIucCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
LogicalChInterfaceName	String	R/W	Yes			
CmMacAddr	MacAddress	R/W	Yes			'000000000000'H
BurstIuc	BurstIucType	R/W	Yes			other

10.3.5.2.9.1 LogicalChInterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.2.9.2 CmMacAddr

Refer to the description for CmMacAddr in Section 7.3.5.6.3.7.

10.3.5.2.9.3 BurstIuc

Refer to the description for *BurstIuc* in Section 7.3.5.6.3.22.

10.3.5.2.10 PnmUsTrigSpectCaptTimestampCfg

This object contains configuration parameters specific to the PNM UTSC test operation *InitPnmUsTrigSpectCaptBurstIucTest*, for which the Timestamp trigger mode is used. This object is a specialization of PnmUsTrigSpectCaptCommonCfg. Table 563 - PnmUsTrigSpectCaptTimestampCfg Object Attributes below defines the class.

Table 574 - PnmUsTrigSpectCaptTimestampCfg Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
Timestamp	TimeStamp	R/W	Yes			0
FreeRunDuration	UnsignedInt	R/W	Yes		msec	1000
RepeatPeriod	UnsignedInt	R/W	Yes		usec	100000

10.3.5.2.10.1 Timestamp

Refer to the description for *Timestamp* in Section 7.3.5.6.3.8.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.8 *Timestamp* also apply to the Model Driven PNM Information Model.

10.3.5.2.10.2 FreeRunDuration

Refer to the description for *FreeRunDuration* in Section 7.3.5.6.3.20.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.20 *FreeRunDuration* also apply to the Model Driven PNM Information Model.

10.3.5.2.10.3 RepeatPeriod

Refer to the description for *RepeatPeriod* in Section 7.3.5.6.3.19.

Requirements specified in Upstream Triggered Spectrum Capture Information Model Section 7.3.5.6.3.19 *RepeatPeriod* also apply to the Model Driven PNM Information Model.

10.3.5.3 Upstream Triggered Spectrum Capture Class Diagram

The following diagram defines the Upstream Triggered Spectrum Capture Capabilities class rooted from the PnmUsCapabilities class and Upstream Triggered Spectrum Capture PNM test measurement classes rooted from the PnmResult class.

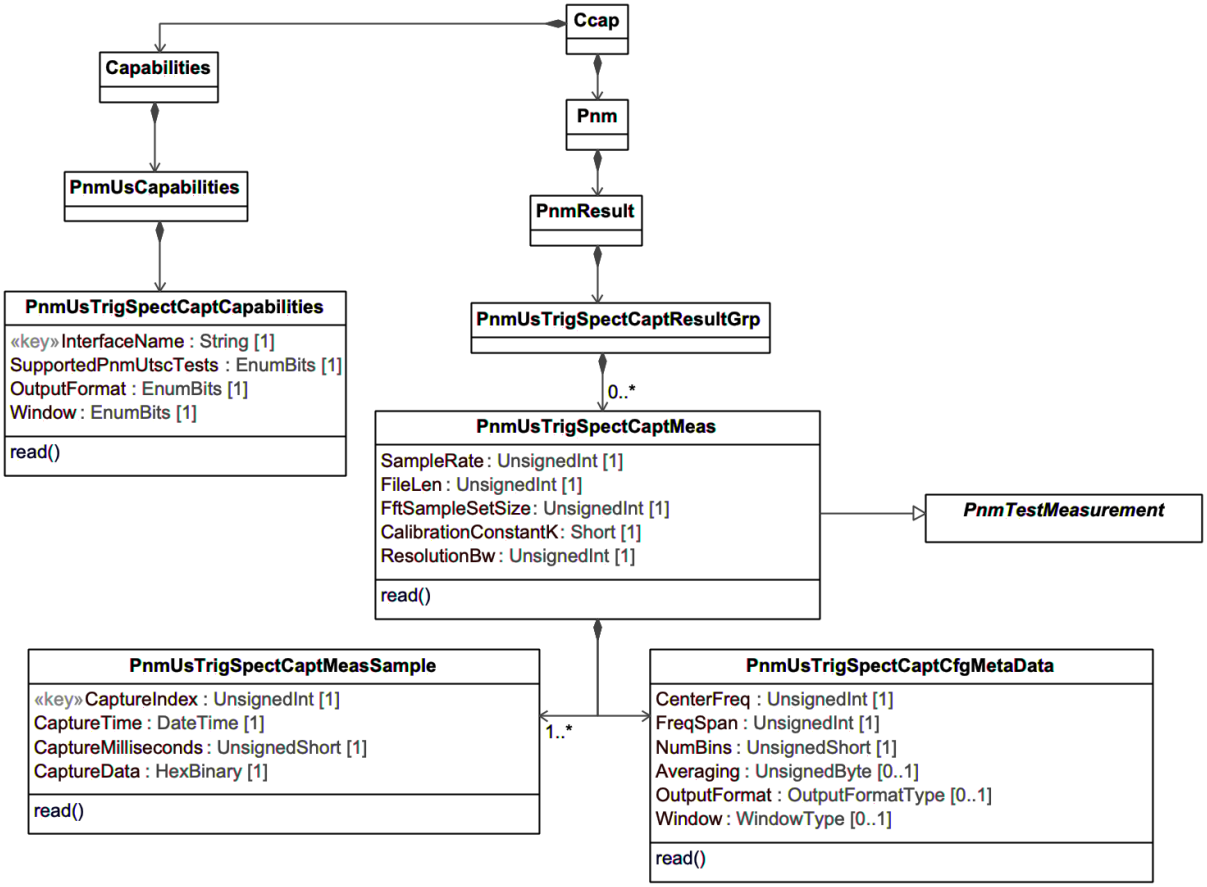


Figure 105 - CCAP PnmUsTrigSpectCaptResultGrp Class Diagram

10.3.5.3.1 PnmUsCapabilities

This object is the container for PNM Upstream capabilities objects. PnmUsCapabilities is a specialization of the Capabilities class for a CCAP.

Table 575 - PnmUsCapabilities Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmUsTrigSpectCaptCapabilities	Directed Association to PnmUsTrigSpectCaptCapabilities	1	1	

10.3.5.3.2 PnmUsTrigSpectCaptCapabilities

Refer to the description for *UsTriggeredSpectrumCaptureCapab* in Section 7.3.5.6.1. This object is a specialization of PnmUsCapabilities object.

Table 576 - PnmUsTrigSpectCaptCapabilities

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units
InterfaceName	String	Key	Yes		

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units
SupportedPnmUtscTests	EnumBits	R/O	Yes	other(0), freeRunning(1), miniSlotCount(2), sid(3), idleSid(4), cmMac(5), quietProbeSymbol(6), burstIuc(7), timestamp(8), activeProbeSymbol(9)	
OutputFormat	EnumBits	R/O	Yes	other(0) timeIQ(1), fftPower(2), rawAdc(3), fftIQ(4), fftAmplitude(5), fftDb(6)	
Window	EnumBits	R/O	Yes	other(0), rectangular(1), hann(2), blackmanHarris(3), hamming(4), flatTop(5), gaussian(6), chebyshev(7)	

10.3.5.3.2.1 InterfaceName

This key attribute contains the CCAP interface name for the upstream interface on which the CCAP will capture the upstream spectrum on the OFDMA channel.

10.3.5.3.2.2 SupportedPnmUtscTests

This attribute reports the UTSC Trigger Type(s) the CCAP supports for the PNM UTSC test.

Refer to the description for *TriggerMode* in Section 7.3.5.6.1.1.

10.3.5.3.2.3 OutputFormat

Refer to the description for *OutputFormat* in Section 7.3.5.6.1.2.

10.3.5.3.2.4 Window

Refer to the description for *Window* in Section 7.3.5.6.1.3.

10.3.5.3.3 PnmUsTrigSpectCaptResultGrp

This object is a container for the Upstream Triggered Spectrum Capture PNM test results.

Table 577 - PnmUsTrigSpectCaptResultGrp Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmUsTrigSpectCaptMeas	Directed Association to PnmUsTrigSpectCaptMeas	0	*	

10.3.5.3.4 PnmUsTrigSpectCaptMeas

This object contains the PNM test measurement data for the Upstream Triggered Spectrum Capture PNM test and inherits the attributes from the abstract class PnmTestMeasurement. This class refactors the UsTriggeredSpectrumCaptureFile class defined in Section 7.3.5.6.6 *UsTriggeredSpectrumCaptureResult*. Table 568 - PnmUsTrigSpectCaptMeas Object Attributes below defines the class.

Table 578 - PnmUsTrigSpectCaptResultGrp Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmUsTrigSpectCaptMeasSample	Directed Composition	1	1..*	
PnmUsTrigSpectCaptCfgMetaData	Directed Composition	1	1	

Table 579 - PnmUsTrigSpectCaptMeas Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units
SampleRate	UnsignedInt	R/O	Yes	SIZE(4)	Samples per second
FileLen	UnsignedInt	R/O	Yes	SIZE(4)	Bytes
FftSampleSetSize	UnsignedInt	R/O	Yes	SIZE(4)	Bytes
CalibrationConstantK	Short	R/O	Yes	SIZE(2)	HundredthsdB
ResolutionBw	UnsignedInt	R/O	Yes	SIZE(4)	Hertz

10.3.5.3.4.1 SampleRate

Refer to the description for *SamplingRate* in Section 7.3.5.6.2.6.

10.3.5.3.4.2 FileLen

Refer to the description for *FileLen* in Section 7.3.5.6.2.9.

10.3.5.3.4.3 FftSampleSetSize

Refer to the description for *FftSampleSetSize* in Section 7.3.5.6.2.10.

10.3.5.3.4.4 CalibrationConstantK

Refer to the description for *CalibrationConstantK* in Section 7.3.5.6.6.6.

10.3.5.3.4.5 ResolutionBw

Refer to the description for *ResolutionBw* in Section 7.3.5.6.6.4.

10.3.5.3.5 PnmUsTrigSpectCaptMeasSample

This object contains UTSC sample capture data and the timestamp for the capture. This object is a specialization of PnmUsTrigSpectCaptMeas object.

Table 580 - PnmUsTrigSpectCaptMeasSample Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
CaptureIndex	UnsignedInt	Key	Yes			
CaptureTime	DateTime	R/O	Yes			
CaptureMilliseconds	UnsignedShort	R/O	Yes			

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
CaptureData	Binary	R/O	Yes			

10.3.5.3.5.1 CaptureIndex

This key attribute is a unique identifier for a specific UTSC sample.

10.3.5.3.5.2 CaptureTime

This attribute reports the Date and Time the UTSC sample was taken.

10.3.5.3.5.3 CaptureMilliseconds

Refer to the description for *SampleCaptureMilliseconds* in Section 7.3.5.6.2.14.

10.3.5.3.5.4 CaptureData

Refer to the description for *Output* in Section 7.3.5.6.6.5.

10.3.5.3.6 PnmUsTrigSpectCaptCfgMetaData

This object contains metadata for a UTSC sample. This object is a specialization of PnmUsTrigSpectCaptMeas object.

Table 581 - PnmUsTrigSpectCaptCfgMetaData Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units
CenterFreq	UnsignedInt	R/O	Yes		Hertz
FreqSpan	UnsignedInt	R/O	Yes		Hertz
NumBins	UnsignedShort	R/O	Yes		
Averaging	UnsignedByte	R/O	No	0|2..255	
OutputFormat	OutputFormatType	R/O	No		
Window	WindowType	R/O	No		

10.3.5.3.6.1 CenterFreq

Refer to the description for *CenterFreq* in Section 7.3.5.6.2.2.

10.3.5.3.6.2 FreqSpan

Refer to the description for *FreqSpan* in Section 7.3.5.6.2.3.

10.3.5.3.6.3 NumBins

Refer to the description for *NumBins* in Section 7.3.5.6.2.4.

10.3.5.3.6.4 Averaging

Refer to the description for *Averaging* in Section 7.3.5.6.2.5.

10.3.5.3.6.5 OutputFormat

Refer to the description for *OutputFormat* in Section 7.3.5.6.2.7.

10.3.5.3.6.6 Window

Refer to the description for *Window* in Section 7.3.5.6.2.12.

10.3.5.4 Upstream Triggered Spectrum Capture Component Diagram

The Upstream Triggered Spectrum Capture component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the Upstream Triggered Spectrum Capture PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.3.5.4.1 PnmUsTrigSpectCaptTestManagement Component Diagram

The CCAP PnmUsTrigSpectCaptTestManagement component diagram illustrates the operations defined between a CCAP and a PNM Server.

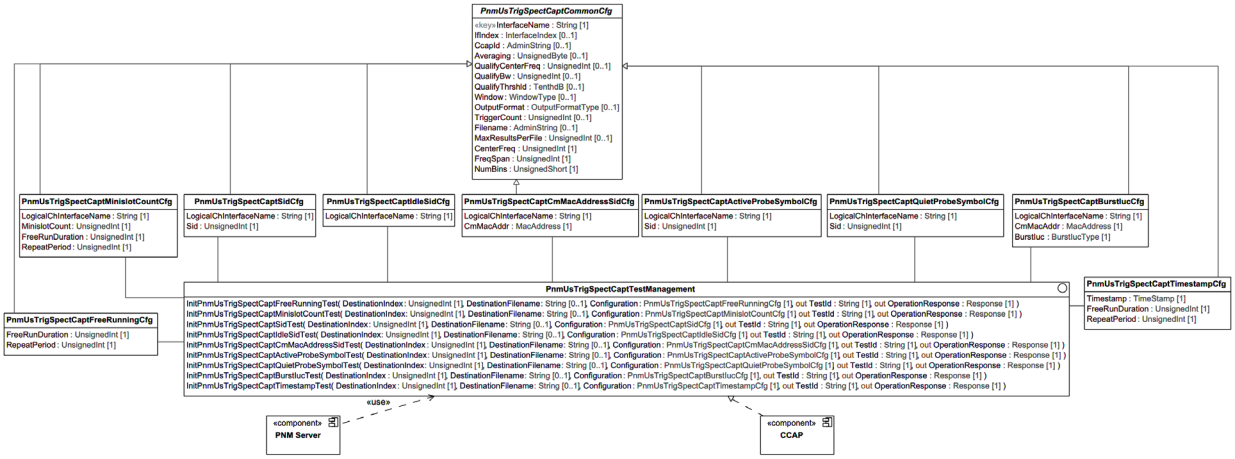


Figure 106 - CCAP PnmUsTrigSpectCaptTestManagement Component Diagram

10.3.5.4.1.1 InitPnmUsTrigSpectCaptFreeRunningTest Operation

The InitPnmUsTrigSpectCaptFreeRunningTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Free Running trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Free Running trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptFreeRunningTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 582 - InitPnmUsTrigSpectCaptFreeRunningTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptFreeRunningCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.1.1 Parameter Definitions

10.3.5.4.1.1.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.1.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.1.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Free Running trigger mode.

10.3.5.4.1.1.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.1.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptFreeRunningTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.1.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptFreeRunningTest operation.

Table 583 - InitPnmUsTrigSpectCaptFreeRunningTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.2 InitPnmUsTrigSpectCaptMinislotCountTest Operation

The InitPnmUsTrigSpectCaptMinislotCountTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Minislot Count trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Minislot Count trigger mode.

Table 584 - InitPnmUsTrigSpectCaptMinislotCountTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptMinislotCountCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.2.1 Parameter Definitions

10.3.5.4.1.2.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

10.3.5.4.1.2.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.2.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Minislot Count trigger mode.

10.3.5.4.1.2.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.2.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptMinislotCountTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.2.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptMinislotCountTest operation.

Table 585 - InitPnmUsTrigSpectCaptMinislotCountTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.3 InitPnmUsTrigSpectCaptSidTest Operation

The InitPnmUsTrigSpectCaptSidTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the SID trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the SID trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptSidTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 586 - InitPnmUsTrigSpectCaptSidTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptSidCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.3.1 Parameter Definitions

10.3.5.4.1.3.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.3.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.3.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the SID trigger mode.

10.3.5.4.1.3.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.3.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptSidTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.3.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptSidTest operation.

Table 587 - InitPnmUsTrigSpectCaptSidTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter

ErrorTag	ErrorMessage
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.4 InitPnmUsTrigSpectCaptIdleSidTest Operation

The InitPnmUsTrigSpectCaptIdleSidTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Idle SID trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Idle SID trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptIdleSidTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 588 - InitPnmUsTrigSpectCaptIdleSidTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptIdleSidCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.4.1 Parameter Definitions

10.3.5.4.1.4.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.4.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.4.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Idle SID trigger mode.

10.3.5.4.1.4.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.4.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptIdleSidTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.4.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptIdleSidTest operation.

Table 589 - InitPnmUsTrigSpectCaptIdleSidTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.5 InitPnmUsTrigSpectCaptCmMacAddressSidTest Operation

The InitPnmUsTrigSpectCaptCmMacAddressSidTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Cable Modem MAC Address SID trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Cable Modem MAC Address SID trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptCmMacAddressSidTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 590 - InitPnmUsTrigSpectCaptCmMacAddressSidTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptCmMacAddressSidCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.5.1 Parameter Definitions

10.3.5.4.1.5.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.5.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.5.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Cable Modem MAC Address SID trigger mode.

10.3.5.4.1.5.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.5.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptCmMacAddressSidTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.5.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptCmMacAddressSidTest operation.

Table 591 - InitPnmUsTrigSpectCaptCmMacAddressSidTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.6 InitPnmUsTrigSpectCaptActiveProbeSymbolTest Operation

The InitPnmUsTrigSpectCaptActiveProbeSymbolTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Active Probe Symbol trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Active Probe Symbol trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptActiveProbeSymbolTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 592 - InitPnmUsTrigSpectCaptActiveProbeSymbolTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptActiveProbeSymbolCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.6.1 Parameter Definitions

10.3.5.4.1.6.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.6.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.6.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Active Probe Symbol trigger mode.

10.3.5.4.1.6.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.6.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptActiveProbeSymbolTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.6.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptActiveProbeSymbolTest operation.

Table 593 - InitPnmUsTrigSpectCaptActiveProbeSymbolTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.7 InitPnmUsTrigSpectCaptQuietProbeSymbolTest Operation

The InitPnmUsTrigSpectCaptQuietProbeSymbolTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Quiet Probe Symbol trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Quiet Probe Symbol trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptQuietProbeSymbolTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 594 - InitPnmUsTrigSpectCaptQuietProbeSymbolTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptQuietProbeSymbolCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.7.1 Parameter Definitions

10.3.5.4.1.7.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.7.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.7.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Quiet Probe Symbol trigger mode.

10.3.5.4.1.7.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.7.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptQuietProbeSymbolTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.7.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptQuietProbeSymbolTest operation.

Table 595 - InitPnmUsTrigSpectCaptQuietProbeSymbolTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.8 InitPnmUsTrigSpectCaptBurstIucTest Operation

The InitPnmUsTrigSpectCaptBurstIucTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Burst IUC trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Burst IUC trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptBurstIucTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 596 - InitPnmUsTrigSpectCaptBurstIucTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptBurstIucCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.8.1 Parameter Definitions

10.3.5.4.1.8.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.8.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.8.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Burst IUC trigger mode.

10.3.5.4.1.8.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.8.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptBurstIucTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.8.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptBurstIucTest operation.

Table 597 - InitPnmUsTrigSpectCaptBurstIucTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device

ErrorTag	ErrorMessage
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.5.4.1.9 InitPnmUsTrigSpectCaptTimestampTest Operation

The InitPnmUsTrigSpectCaptTimestampTest is a non-blocking asynchronous operation that initiates the Upstream Triggered Spectrum Capture PNM Test using the Timestamp trigger mode.

A successful operation will result in the CCAP starting the capture of samples of the spectrum on the configured upstream OFDMA channel using the Timestamp trigger mode.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsTrigSpectCaptTimestampTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 598 - InitPnmUsTrigSpectCaptTimestampTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsTrigSpectCaptTimestampCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.5.4.1.9.1 Parameter Definitions

10.3.5.4.1.9.1.1 DestinationIndex

This parameter is the index of the configured destination for the captured spectrum results data.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.5.4.1.9.1.2 DestinationFilename

This optional parameter is a string with the name for the UTSC sample data file provisioned by the operator via the PNM Server.

10.3.5.4.1.9.1.3 Configuration

This parameter is the complex set of configurations for the Upstream Triggered Spectrum Capture PNM test operation using the Timestamp trigger mode.

10.3.5.4.1.9.1.4 TestId

This parameter is a string uniquely identifying a UTSC PNM test instance.

10.3.5.4.1.9.1.5 OperationResponse

This parameter is the CCAP response to the InitPnmUsTrigSpectCaptTimestampTest operation command. Refer to the definition of the common Response class.

10.3.5.4.1.9.2 Error Conditions

The following table defines the possible error conditions for the InitPnmUsTrigSpectCaptTimestampTest operation.

Table 599 - InitPnmUsTrigSpectCaptTimestampTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.6 Measure Upstream Histogram Information Models

This section defines the Information Models for the Measure Upstream Histogram Use Case.

Upstream Histogram is a PNM Test described in [PHYv3.1] Upstream Histogram section. The Measure Upstream Histogram information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Upstream Histogram test.

Refer to Section 7.3.5.3, UpstreamHistogram, for a description of the purpose and operation of the Upstream Histogram PNM test.

10.3.6.1 Upstream Histogram Data Type Definitions

This section defines any required data type definitions used in the Information Model. There are no specific data types defined for Upstream Histogram PNM Test.

10.3.6.2 Upstream Histogram Complex Data Type Definitions

This section defines classes/objects used in the PNM Upstream Histogram Information Models as complex data types.

10.3.6.2.1 PnmUsHistogramCfg

This class defines the configuration parameters for the Upstream Histogram PNM test. This class refactors the UpstreamHistogram class defined in Section 7.3.5.3, UpstreamHistogram.

Table 600 - PnmUsHistogramCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
InterfaceName	String	Yes			
IfIndex	InterfaceIndex	No			
Timeout	UnsignedShort	No		Seconds	1800

10.3.6.2.1.1 InterfaceName

This attribute contains the CCAP interface name for the upstream interface on which the CCAP will perform the required measurements.

10.3.6.2.1.2 IfIndex

This attribute represents the CCAP upstream interface index for the Upstream Histogram test.

10.3.6.2.1.3 Timeout

This attribute sets a seconds time-out timer for capturing histogram data. If Timeout is not included or specified, the CCAP collects data until the timeout value is updated, the test is stopped, or until any dwell counter reaches its 32-bit rollover value. When the dwell count reaches its 32-bit maximum, the CCAP ends the test and reports counts accumulated to that point. If the Timeout attribute is updated while a test is in progress, the CCAP restarts the timeout timer with the new Timeout value and continue collecting data.

When the Timeout expires, the CCAP will stop the capture. When this happens, the data collected up to this point will be saved, and the value of 'MeasStatus' will be set to 'sampleReady'.

10.3.6.3 Upstream Histogram Class Diagram

The following diagram defines the Upstream Histogram PNM test measurement classes rooted from the PnmResult class.

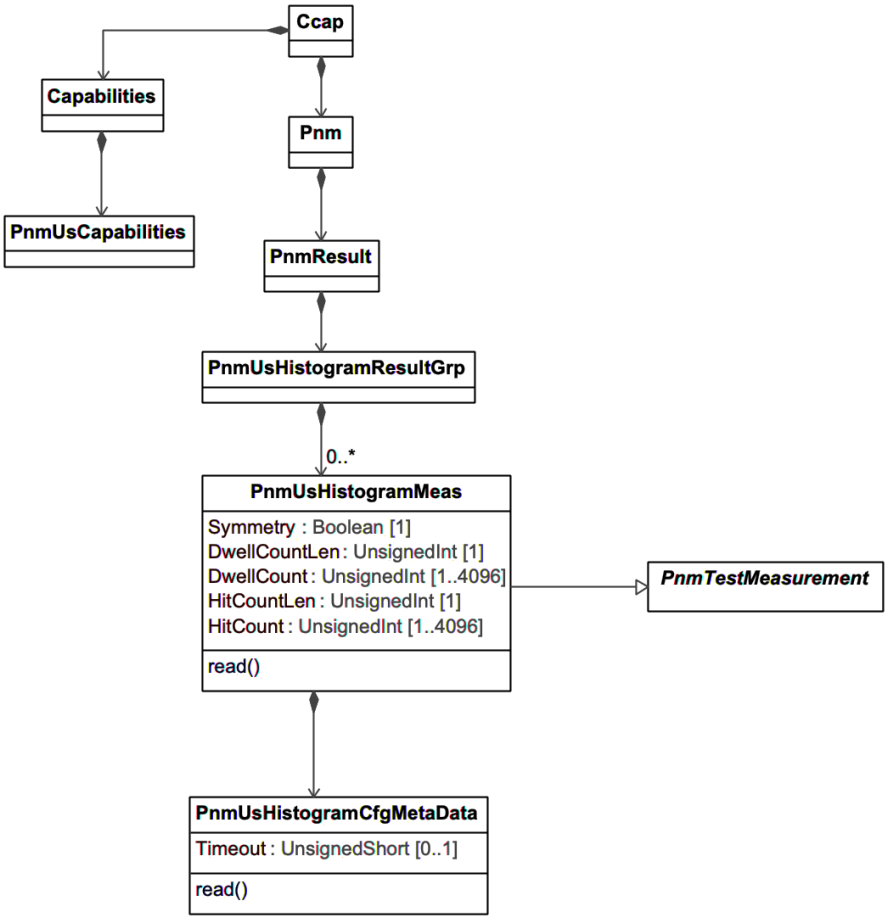


Figure 107 - PnmUsHistogramResultGrp Class Diagram

10.3.6.3.1 PnmUsHistogramResultGrp

This class represents a top-level container for the Upstream Histogram PNM test results.

10.3.6.3.2 PnmUsHistogramMeas

This class contains the PNM measurements results for the upstream Histogram PNM test and inherits the attributes from the abstract class PnmTestMeasurement. This class refactors the upstream Histogram File Format defined in Section 7.3.5.3.5.

Table 601 - PnmUsHistogramMeas Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Symmetry	Boolean	Yes			'false'
DwellCountLen	UnsignedInt	Yes			
DwellCount	UnsignedInt	Yes	1-4096 sequences		
HitCountLen	UnsignedInt	Yes			
HitCount	UnsignedInt	Yes	1-4096 sequences		

Table 602 - PnmUsHistogramMeas Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmUsHistogramCfgMetaData	Directed composition to PnmUsHistogramCfgMetaData	1	1	
PnmTestMeasurement	Specialization of PnmTestMeasurement	1	1	

10.3.6.3.2.1 Symmetry

This attribute indicates whether 256 or 255 bins were used for the measurement.

'false' = Even Symmetry

The histogram has even symmetry about the origin. There is no bin center lying directly at the origin; rather, two bin centers straddle the origin at 0.5. All bins with indices 0-255 contain valid hit-count data. The histogram bin centers are offset from the corresponding 8-bit two's-complement integer values by 1/2, that is, bin center = two's complement value + 0.5.

'true' = Odd Symmetry

The histogram has odd symmetry about the origin. There is a bin center lying at the origin. The bin with index 0 is not used and returns the value 0. The bins with indices 1 to 255 contain valid hit-count data. The histogram bin centers are located on the corresponding 8-bit two's-complement integer values.

The following table shows the defined histogram bin centers for the cases of even and odd symmetry.

Table 603 - Histogram Bin Centers

Bin Index	Bin Center Even Symmetry	Bin Center Odd Symmetry
0	-127.5	not used
1	-126.5	-127
2	-125.5	-126
...	...	...
127	-0.5	-1

Bin Index	Bin Center Even Symmetry	Bin Center Odd Symmetry
128	0.5	0
129	1.5	1
...	...	...
253	125.5	125
254	126.5	126
255	127.5	127

10.3.6.3.2.2 DwellCountLen

This attribute reports the number of bytes of DwellCount measurement data which follow in the file.

10.3.6.3.2.3 DwellCount

This attribute contains the Dwell Counts for each bin for the "Current" capture. The value is a sequence of 4-byte values. If the dwell count for all bins is the same, then only a single value is reported. The value for each bin is reported as a 32-bit value.

10.3.6.3.2.4 HitCountLen

This attribute reports the number of bytes of HitCount measurement data which follow in the file.

10.3.6.3.2.5 HitCount

This attribute contains the Hit Counts for each bin for the "Current" capture. The value represents a sequence of 4-byte values. If odd symmetry is used, then there will be 255 bins. The value for each bin is reported as a 32-bit value.

10.3.6.3.3 PnmUsHistogramCfgMetaData

This class contains the PNM test configuration meta data for the upstream Histogram PNM test. This class refactors the upstream Histogram File Format defined in Section 7.3.5.3.5.

Table 604 - PnmUsHistogramCfgMetaData Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
Timeout	UnsignedShort	No		Seconds	1800

10.3.6.3.3.1 Timeout

This attribute is a copy of the PnmUsHistogramCfg::Timeout attribute.

10.3.6.4 Upstream Histogram Component Diagram

The Upstream Histogram component diagram illustrates the CCAP (Server) and PNM Server (Client) components for the Upstream Histogram PNM test operations. The CCAP Server component provides an operations/methods interface that contains operations that are invoked by the PNM Server Client to perform the actions.

10.3.6.4.1 PnmUsHistogramTestManagement Component Diagram

The PnmUsHistogramTestManagement component diagram illustrates the CCAP and PNM Server components that execute the InitPnmUsHistogramTest and UpdatePnmUsHistogramTest operations.

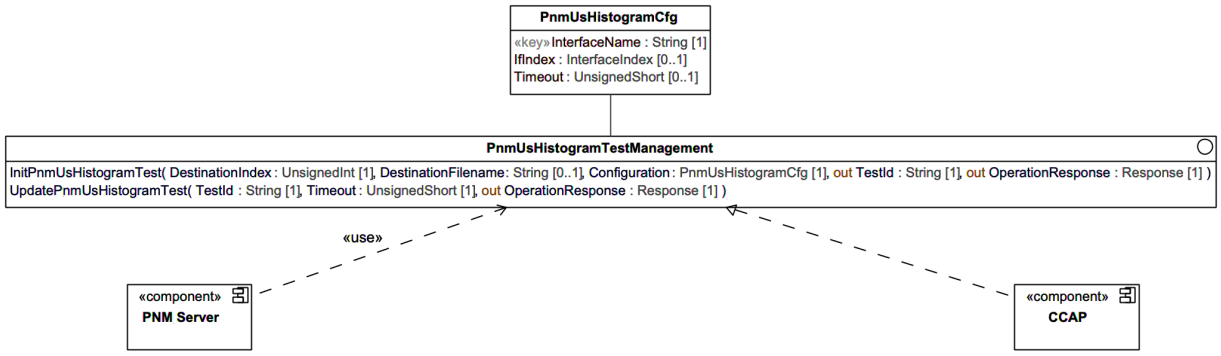


Figure 108 - PnmUsHistogramTestManagement Component Diagram

10.3.6.4.1.1 InitPnmUsHistogramTest Operation

The InitPnmUsHistogramTest is a non-blocking asynchronous operation that initiates the Upstream Histogram PNM test.

A successful operation will result in the CCAP starting the histogram measurement collection. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

If Timeout is not included or specified in the test configuration, the CCAP collects data until the timeout value is updated, the test is stopped, or until any dwell counter reaches its 32-bit rollover value. When the dwell count reaches its 32-bit maximum, the CCAP ends the test and reports counts accumulated to that point.

If Timeout is included or specified in the test configuration, the CCAP will stop the capture when the Timeout expires and save the data collected up to this point. The Timeout can be updated while a test is in progress using the UpdatePnmUsHistogramTest operation.

When the CCAP stops or completes the test and measurements, the CCAP will then send the TestCompleteNotification signaling the test results have been stored locally and/or uploaded.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsHistogramTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 605 - InitPnmUsHistogramTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsHistogramCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.6.4.1.2 Parameter Definitions

10.3.6.4.1.2.1 DestinationIndex

This parameter is the index of the configured destination for the captured histogram.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.6.4.1.2.2 DestinationFilename

This parameter defines the filename for the measurement data file.

10.3.6.4.1.2.3 Configuration

This parameter is the complex set of configuration parameters for the Upstream Histogram PNM test operation. Refer to the class definition PnmUsHistogramCfg for details.

10.3.6.4.1.2.4 TestId

This parameter is a unique identifier for a PNM test instance.

10.3.6.4.1.2.5 OperationResponse

This parameter is the device response to the InitPnmUsHistogramTest operation command. Refer to the definition of the common Response class for details.

10.3.6.4.1.3 Error Conditions

The following table defines the possible error conditions for the InitPnmUsHistogramTest operation.

Table 606 - InitPnmUsHistogramTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.6.4.1.4 UpdatePnmUsHistogramTest Operation

The UpdatePnmUsHistogramTest is a non-blocking asynchronous operation that updates the Timeout value for an active Upstream Histogram PNM test as specified by TestId.

A successful operation will result in the CCAP restarting the timer, using the specified Timeout parameter, for the actively running upstream Histogram PNM Test referenced by TestId. The CCAP will continue to collect histogram data until the configured timer expires, the timer is subsequently updated, the test is stopped, or until any dwell counter reaches its 32-bit rollover value.

Table 607 - UpdatePnmUsHistogramTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
TestId	String		In	1		
Timeout	UnsignedShort		In	1		
OperationResponse	Response		Out	1		

10.3.6.4.1.5 Parameter Definitions

10.3.6.4.1.5.1 TestId

This parameter is the unique identifier for the upstream Histogram in-progress PNM test instance.

10.3.6.4.1.5.2 Timeout

This parameter is Timeout value for the Upstream Histogram PNM test operation. Refer to PnmUsHistogramCfg::Timeout attribute for details.

10.3.6.4.1.5.3 OperationResponse

This parameter is the device response to the UpdatePnmUsHistogramTest operation command. Refer to the definition of the common Response class for details.

10.3.6.4.1.6 Error Conditions

The following table defines the possible error conditions for the UpdatePnmUsHistogramTest operation.

Table 608 - UpdatePnmUsHistogramTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	TestId does not exist on the device
Not In Valid State	No test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

10.3.7 Measure Upstream Impulse Noise Information Models

This section defines the Information Models for the Measure Upstream Impulse Noise Use Case.

Upstream Impulse Noise is a PNM Test described in [PHYv3.1] Upstream Impulse Noise Statistics section. The Measure Upstream Impulse Noise information model defines the Streaming Telemetry management interface for the operator to configure, execute, and monitor the Upstream Impulse Noise test.

Refer to Section 7.3.5.2, UsImpulseNoise for a description of the purpose and operation of the Upstream Impulse Noise PNM test.

10.3.7.1 Upstream Impulse Noise Data Type Definitions

This section defines any required data type definitions used in the Information Model. There are no specific data types defined for Upstream Impulse Noise PNM Test.

10.3.7.2 Upstream Impulse Noise Complex Data Type Definitions

This section defines classes/objects used in the PNM Upstream Impulse Noise Information Models as complex data types.

10.3.7.2.1 PnmUsImpulseNoiseCfg

This class defines the configuration parameters for the Upstream Impulse Noise PNM test. This class refactors the UpstreamImpulseNoise class defined in Section 7.3.5.2, UsImpulseNoise.

Table 609 - PnmUsImpulseNoiseCfg Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
InterfaceName	String	Yes			
IfIndex	InterfaceIndex	No			
FreeRunDuration	UnsignedShort	No		seconds	60

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default
StartTriggerLevel	UnsignedInt	No		microvolts	300
EndTriggerLevel	UnsignedInt	No		microvolts	150
CenterFreq	UnsignedInt	Yes		Hertz	7000000
MeasurementBandwidth	UnsignedShort	Yes	160 | 320 | 640 | 1280 | 2560 | 5120	Kilohertz	2560

10.3.7.2.1.1 InterfaceName

This attribute contains the CCAP interface name for the upstream RF port interface on which the CCAP will perform the required Upstream Impulse Noise measurements.

10.3.7.2.1.2 IfIndex

This attribute represents the CCAP upstream RF port interface index for the Upstream Impulse Noise test.

10.3.7.2.1.3 FreeRunDuration

This attribute, when configured with a nonzero value, configures the length of time to perform the Upstream Impulse Noise measurement when the InitPnmUsImpulseNoiseTest operation is invoked on the CCAP.

10.3.7.2.1.4 StartTriggerLevel

This attribute, when configured with a nonzero value, is the burst noise threshold which, when exceeded after the InitPnmUsImpulseNoiseTest is invoked on the CCAP and FreeRunDuration is configured with value zero, starts the Impulse Noise measurement. If the InitPnmUsImpulseNoiseTest is invoked on the CCAP with a nonzero value configured for StartTriggerLevel and a zero value configured for FreeRunDuration, an individual burst event starts when the burst noise exceeds the StartTriggerLevel.

10.3.7.2.1.5 EndTriggerLevel

This attribute, when configured with a nonzero value, is the lower burst noise threshold for the Upstream Impulse Noise measurement which terminates the measurement after it is started. Measurement of an individual burst event ends when the burst noise falls below the EndTriggerLevel. If the EndTriggerLevel and the FreeRunDuration are both set to zero and StartTriggerLevel is configured with a nonzero value, at most a single Impulse Noise Event will be recorded when triggered by a burst event exceeding the StartTriggerLevel.

10.3.7.2.1.6 CenterFreq

This attribute defines the center frequency for the noise power measurement.

10.3.7.2.1.7 MeasurementBandwidth

This attribute defines the bandwidth for the noise power measurement. The MeasurementBandwidth is the -3 dB bandwidth; the occupied bandwidth is typically 1.25 times the measurement bandwidth.

10.3.7.3 Upstream Impulse Noise Class Diagram

The following diagram defines the Upstream Impulse Noise PNM test measurement classes rooted from the PnmResult class.

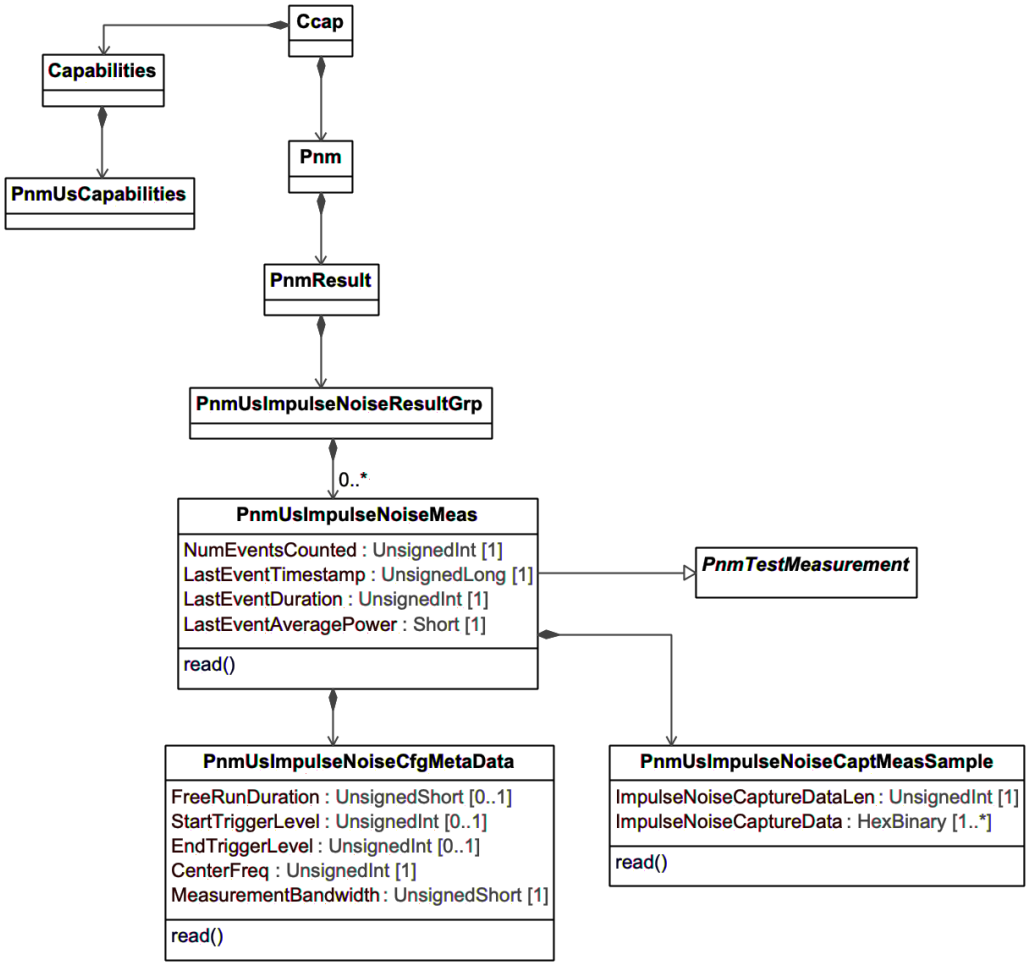


Figure 109 - PnmUsImpulseNoiseResultGrp Class Diagram

10.3.7.3.1 PnmUsImpulseNoiseResultGrp

This class represents a top-level container for the Upstream Impulse Noise PNM test results.

10.3.7.3.2 PnmUsImpulseNoiseMeas

This class contains the PNM measurement results for the Upstream Impulse Noise PNM test and inherits the attributes from the abstract class PnmTestMeasurement. This class refactors the Impulse Noise File Format defined in Section 7.3.5.2.13.

Table 610 - PnmUsImpulseNoiseMeas Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
NumEventsCounted	UnsignedInt	Yes			
LastEventTimestamp	UnsignedLong	Yes			
LastEventDuration	UnsignedInt	Yes		ns	
LastEventAveragePower	Short	Yes		dBmV	

Table 611 - PnmUsImpulseNoiseMeas Object Associations

Associated Object Name	Type	Near-end Multiplicity	Far-end Multiplicity	Label
PnmUsImpulseNoiseCfgMetaData	Directed composition to PnmUsImpulseNoiseCfgMetaData	1	1	
PnmUsImpulseNoiseCaptMeasSample	Directed composition to PnmUsImpulseNoiseCaptMeasSample	1	1	
PnmTestMeasurement	Specialization of PnmTestMeasurement	1	1	

10.3.7.3.2.1 NumEventsCounted

This attribute reports the count of impulse noise events recorded since the test was initiated. This value will be 1024 in steady state, after the ring buffer has filled with measurements. If the StartTriggerLevel is set to zero, then the NumEventsCounted will be set to 1 when the FreeRunDuration has expired and the measurement ends.

10.3.7.3.2.2 LastEventTimestamp

This attribute reports the timestamp corresponding to the start of the last recorded event. The measurement is time-stamped using the 64-bit extended timestamp. If the CMTS is not using the 64-bit Extended Timestamp, then the 8-byte value is constructed from the 32-bit DOCSIS 3.0 Timestamp as follows:

Bits 63 through 41 = 0

Bits 40 through 9 = 32-bit DOCSIS 3.0 Timestamp

Bits 8 through 0 = 0

10.3.7.3.2.3 LastEventDuration

This attribute reports the time corresponding to the duration of the last recorded event. LastEventDuration is expressed in ns.

10.3.7.3.2.4 LastEventAveragePower

This attribute reports the average power measured during the last recorded event. The LastEventAveragePower is expressed in units of dBmV with 16-bit fixed point, fractional, two's complement notation encoded using the S6.9 format.

10.3.7.3.3 PnmUsImpulseNoiseCfgMetaData

This class contains the PNM test configuration meta data for the Upstream Impulse Noise PNM test. This class refactors the Upstream Impulse Noise File Format defined in Section 7.3.5.2.13.

Table 612 - PnmUsImpulseNoiseCfgMetaData Object Attributes

Attribute Name	Type	Required Attribute	Type Constraints	Units	Default Value
FreeRunDuration	UnsignedShort	No		Seconds	1800
StartTriggerLevel	UnsignedInt	No		Microvolts	300
EndTriggerLevel	UnsignedInt	No		Microvolts	150
CenterFreq	UnsignedInt	Yes		Hertz	7000000
MeasurementBandwidth	UnsignedShort	Yes	160 | 320 | 640 | 1280 | 2560 | 5120	Kilohertz	2560

10.3.7.3.3.1 FreeRunDuration

This attribute is a copy of the PnmUsImpulseNoiseCfg::FreeRunDuration attribute.

10.3.7.3.3.2 StartTriggerLevel

This attribute is a copy of the PnmUsImpulseNoiseCfg::StartTriggerLevel attribute.

10.3.7.3.3.3 EndTriggerLevel

This attribute is a copy of the PnmUsImpulseNoiseCfg::EndTriggerLevel attribute.

10.3.7.3.3.4 CenterFreq

This attribute is a copy of the PnmUsImpulseNoiseCfg::CenterFreq attribute.

10.3.7.3.3.5 MeasurementBandwidth

This attribute is a copy of the PnmUsImpulseNoiseCfg::MeasurementBandwidth attribute.

10.3.7.3.4 PnmUsImpulseNoiseCaptMeasSample

This class contains Upstream Impulse Noise sample capture data and the length of the capture data. This class is a specialization of PnmUsImpulseNoiseMeas class.

Table 613 - PnmUsImpulseNoiseCaptMeasSample Object Attributes

Attribute Name	Type	Access	Required Attribute	Type Constraints	Units	Default Value
ImpulseNoiseCaptureDataLen	UnsignedInt	R/O	Yes			
ImpulseNoiseCaptureData	HexBinary	R/O	Yes			

10.3.7.3.4.1 ImpulseNoiseCaptureDataLen

This attribute reports the length of the impulse event data which follows. The length is equal to NumEventsCounted * 14.

10.3.7.3.4.2 ImpulseNoiseCaptureData

This attribute is the set of NumEventsCounted number of samples of impulse noise power in microvolts, measured in the configured measurement bandwidth.

10.3.7.4 Upstream Impulse Noise Component Diagram

The Upstream Impulse Noise component diagram illustrates the CCAP (server) and PNM Server (client) components for the Upstream Impulse Noise PNM test operations. The CCAP server component provides an operations/methods interface that contains operations that are invoked by the PNM Server client to perform the actions.

10.3.7.4.1 PnmUsImpulseNoiseTestManagement Component Diagram

The PnmUsImpulseNoiseTestManagement component diagram illustrates the CCAP and PNM Server components that execute the InitPnmUsImpulseNoiseTest operation.

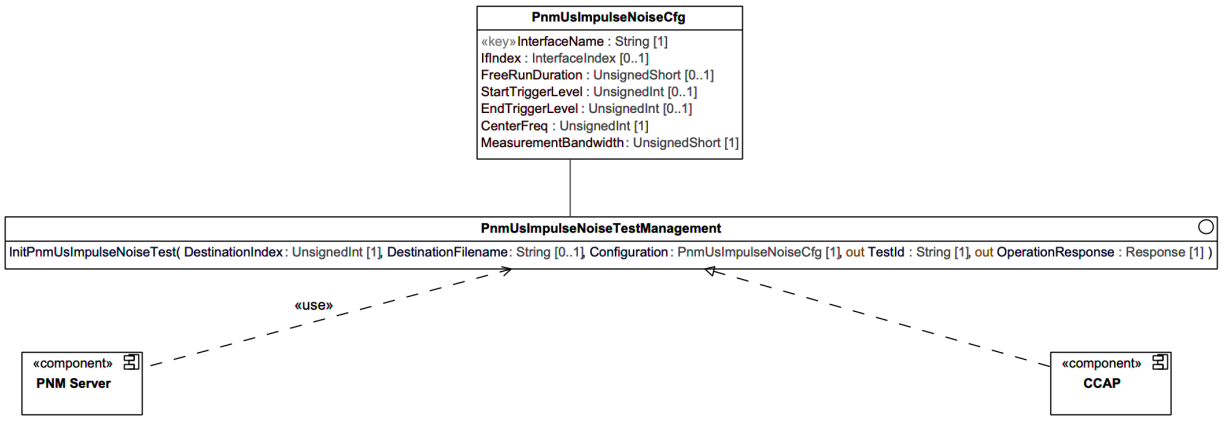


Figure 110 - PnmUsImpulseNoiseTestManagement Component Diagram

10.3.7.4.1.1 InitPnmUsImpulseNoiseTest Operation

The InitPnmUsImpulseNoiseTest is a non-blocking asynchronous operation that initiates the Upstream Impulse Noise PNM test.

A successful operation will result in the CCAP starting the impulse noise measurement collection. The CCAP will return a Test Identifier which uniquely identifies the specific test that was started.

Initiation and termination of impulse noise samples collection is controlled by configured values for PnmUsImpulseNoiseCfg attributes FreeRunDuration, StartTriggerLevel, and EndTriggerLevel.

The CCAP MUST collect Upstream Impulse Noise samples when InitPnmUsImpulseNoiseTest operation is invoked on the CCAP and FreeRunDuration is configured for a nonzero value, regardless of the values configured for StartTriggerLevel and EndTriggerLevel. The CCAP MUST stop collecting Upstream Impulse Noise samples and terminate the Upstream Impulse Noise test when the time corresponding to the value of FreeRunDuration expires.

If the configured value of FreeRunDuration is nonzero, the CCAP will capture at most one impulse noise event.

The CCAP MUST collect Upstream Impulse Noise samples when InitPnmUsImpulseNoiseTest operation is invoked on the CCAP, FreeRunDuration is configured with zero, StartTriggerLevel is configured with a nonzero value, and the burst noise on the upstream RF port exceeds the value configured for StartTriggerLevel. The CCAP MUST stop collection of Upstream Impulse Noise samples for a burst noise event when FreeRunDuration is configured with zero, StartTriggerLevel and EndTriggerLevel are configured with a nonzero value, and the burst noise on the RF port falls below the configured value for EndTriggerLevel.

If the configured value of FreeRunDuration is zero, the configured value of StartTriggerLevel is nonzero, and the configured value of EndTriggerLevel is nonzero, the CCAP could capture multiple burst noise events before the sample capture is terminated with the PnmStopTest operation.

If the configured values of FreeRunDuration and EndTriggerLevel are zero and the configured value of StartTriggerLevel is nonzero, the CCAP will capture at most one impulse noise event before the sample capture is terminated with the PnmStopTest operation.

The CCAP MUST measure average power in the band when InitPnmUsImpulseNoiseTest operation is invoked on the CCAP and configured values for FreeRunDuration and StartTriggerLevel are zero, and the configured value for EndTriggerLevel is zero or nonzero. The average power in the band will be measured until sample collection is terminated when the PnmStopTest operation is invoked on the CCAP.

The CCAP MUST reject the configuration as invalid if InterfaceName and IfIndex are not referring to the same interface on the CCAP.

Upstream Impulse Noise test sample collection initiation and termination conditions described above are summarized in Table 603.

Table 614 - Upstream Impulse Noise Sample Collection Control Configuration Attributes

FreeRunDuration	StartTriggerLevel	EndTriggerLevel	CCAP Sample Collection
Nonzero	Zero or nonzero	Zero or nonzero	Sample collection begins when the InitPnmUsImpulseNoiseTest operation is invoked on the CCAP. Sample collection ends and the test terminates when the time equal to the value of FreeRunDuration expires. StartTriggerLevel and EndTriggerLevel are ignored. Sample collection occurs for one event and NumEventsCounted will be reported as 1 unless the test is aborted. If sample collection is terminated by invocation of PnmStopTest operation on the CCAP before FreeRunDuration time expires, NumEventsCounted will be reported as 0 and no results will be returned.
Zero	Nonzero	Nonzero	Sample collection for an individual burst event begins when the InitPnmUsImpulseNoiseTest operation is invoked on the CCAP and the burst noise on the upstream RF port exceeds the value configured for StartTriggerLevel. Sample collection ends for an individual burst event when the burst noise on the upstream RF port falls below the value configured for EndTriggerLevel. Sample collection may occur for multiple burst events. The test terminates when the PnmStopTest operation is invoked on the CCAP.
Zero	Nonzero	Zero	Sample collection begins when the InitPnmUsImpulseNoiseTest operation is invoked on the CCAP and the burst noise on the upstream RF port exceeds the value configured for StartTriggerLevel. Sample collection ends and the test terminates when the PnmStopTest operation is invoked on the CCAP. At most a single impulse noise event will be recorded.
Zero	Zero	Zero or nonzero	Sample collection begins when InitPnmUsImpulseNoiseTest operation is invoked on the CCAP. The average power in the band will be measured until sample collection is terminated when the PnmStopTest operation is invoked on the CCAP. A single event will be recorded.

When the CCAP stops or completes the test and the measurements, the CCAP will then send the TestCompleteNotification signaling the test results have been stored locally and/or uploaded.

The CCAP MUST reject configuring a value for the DestinationIndex of the InitPnmUsImpulseNoiseTest object if that value does not exist in the corresponding DestinationIndex attribute of the DataTransferCfg instance.

Table 615 - InitPnmUsImpulseNoiseTest Operation Parameters

Parameter Name	Type	Type Constraints	Direction	Multiplicity	Units	Default
DestinationIndex	UnsignedInt		In	1		
DestinationFilename	String		In	0..1		
Configuration	PnmUsImpulseNoiseCfg		In	1		
TestId	String		Out	1		
OperationResponse	Response		Out	1		

10.3.7.4.1.2 Parameter Definitions

10.3.7.4.1.2.1 DestinationIndex

This parameter is the index of the configured destination for the captured impulse noise samples.

If this attribute is not populated or set to zero, the device will create a local file or files for the results. If the attribute is set to a non-zero value, the device uses the instance of DataTransferCfg defined by the DestinationIndex to determine how to handle the results file or files. Note that the DestinationIndex attribute of the DataTransferCfg object is required to exist before provisioning the corresponding value in this attribute.

10.3.7.4.1.2.2 DestinationFilename

This parameter defines the filename for the measurement data file.

10.3.7.4.1.2.3 Configuration

This parameter is the complex set of configuration parameters for the Upstream Impulse Noise PNM test operation. Refer to the class definition PnmUsImpulseNoiseCfg for details.

10.3.7.4.1.2.4 TestId

This parameter is a unique identifier for a PNM test instance.

10.3.7.4.1.2.5 OperationResponse

This parameter is the device response to the InitPnmUsImpulseNoiseTest operation command. Refer to the definition of the common Response class for details.

10.3.7.4.1.3 Error Conditions

The following table defines the possible error conditions for the InitPnmUsImpulseNoiseTest operation.

Table 616 - InitPnmUsImpulseNoiseTest Operation Errors

ErrorTag	ErrorMessage
Entity Not Found	InterfaceName does not exist on the device
Not In Valid State	Test is in progress
Internal Error	The device had an error and could not process the request
Invalid Input	Invalid input parameter
Access denied	The operation request is not authorized
Operation Not Supported	The device does not support the operation or feature

11 YANG MODULE IMPLEMENTATION REQUIREMENTS

This section defines the CCAP's normative requirements for YANG module support. Unless otherwise specified in this section or elsewhere in this specification, the CCAP MUST implement all nodes in a required YANG module.

11.1 External YANG Modules

This section defines the CCAP normative requirements for YANG modules released by external organizations (e.g., IETF).

11.1.1 IETF YANG Modules

This section defines IETF Data Types used in external YANG modules.

11.1.1.1 IETF Data Types Module

The CCAP MUST implement the IETF general YANG Data Types module ietf-yang-types@2020-07-06.yang [RFC 6991].

The CCAP MUST implement the IETF Internet Protocol YANG Data Types module ietf-inet-types@2020-07-06.yang [RFC 6991].

11.2 CableLabs YANG Modules

This section defines the CCAP normative requirements for YANG modules released CableLabs.

11.2.1 CableLabs Common Types Module

The CCAP MUST implement the CableLabs Common Types YANG module cablelabs-common-yang-types.yang [CL-COMMON-YANG]. This module defines data types used by all CableLabs YANG modules.

11.2.2 DOCSIS Common Types Module

The CCAP MUST implement the DOCSIS Common Types YANG module cablelabs-docsis-yang-types.yang [DOCSIS-COMMON-YANG]. This module defines data types used by DOCSIS-specific YANG modules.

11.2.3 CCAP Device Module

The CCAP MUST implement the DOCSIS 4.0 CCAP Device YANG module cablelabs-ccap-docsis40.yang [CCAP-COMMON-YANG]. This module defines the top-level root CCAP container for the complete CCAP Device YANG tree.

11.2.4 CCAP DOCSIS Module

The CCAP MUST implement the CCAP DOCSIS YANG module cablelabs-ccap-docsis.yang [CCAP-COMMON-YANG]. This module defines the top-level DOCSIS grouping for the DOCSIS-related YANG nodes.

11.2.5 CCAP DOCSIS QoS Module

The CCAP MUST implement the CCAP DOCSIS QoS YANG module cablelabs-ccap-docsis-qos.yang [CCAP-COMMON-YANG]. This module defines the top-level DOCSIS QoS container for the QoS-related YANG nodes.

11.2.6 DOCSIS Common QoS Module

The CCAP MUST implement the DOCSIS Common QoS YANG module cablelabs-yang-docsis-qos.yang [CCAP-COMMON-YANG]. This module defines the common DOCSIS QoS nodes which can be used by DOCSIS devices for QoS-related features.

11.2.7 DOCSIS Common QoS Submodule

The CCAP MUST implement the DOCSIS Common QoS YANG submodule cablelabs-yang-docsis-qos-sub.yang [CCAP-COMMON-YANG]. This submodule defines additional DOCSIS QoS nodes which can be used by DOCSIS devices for QoS-related features.

Annex A Detailed MIB Requirements (Normative)

This Annex defines the SNMP MIB modules and MIB variables required for DOCSIS 4.0 CMTS and CCAP devices. Refer to Section 2.1 Normative References for the associated MIB files.

Table 617 - MIB Implementation Support

Requirement Type	Table Notation	Description
Deprecated	D	Deprecated objects are optional. If a vendor chooses to implement the object, the object is expected to be implemented correctly according to the MIB definition. If a vendor chooses not to implement the object, an agent is expected to respond with the appropriate error/exception condition (e.g., 'noSuchObject' for SNMPv2c).
Mandatory	M	The object is required to be implemented correctly according to the MIB definition.
Not Applicable	NA	Not applicable to the device.
Not Supported	N-Sup	An agent is expected to respond with the appropriate error/exception condition (e.g., 'noSuchObject' for SNMPv2c).
Optional	O	A vendor can choose to implement or not implement the object. If a vendor chooses to implement the object, the object is expected to be implemented correctly according to the MIB definition. If a vendor chooses not to implement the object, an agent is expected to respond with the appropriate error/exception condition (e.g., 'noSuchObject' for SNMPv2c).
Obsolete	Ob	In SNMP convention, obsolete objects should not be implemented. This specification allows vendors to implement or not implement obsolete objects. If a vendor chooses to implement an obsoleted object, the object is expected to be implemented correctly according to the MIB definition. If a vendor chooses not to implement the obsoleted object, the SNMP agent is expected to respond with the appropriate error/exception condition (e.g., 'noSuchObject' for SNMPv2c).

Table 618 - SNMP Access Requirements

SNMP Access Type	Table Notation	Description
Not Accessible	N-Acc	The object is not accessible and is usually an index in a table
Read Create	RC	The access of the object is implemented as Read-Create
Read Write	RW	The access of the object is implemented as Read-Write
Read Only	RO	The access of the object is implemented as Read-Only
Read Create or Read Only	RC/RO	The access of the object is implemented as either Read-Create or Read-Only as described in the MIB definition
Read Create or Read Write	RC/RW	The access of the object is implemented as either Read-Create or Read-Write as described in the MIB definition
Read Write or Read Only	RW/RO	The access of the object is implemented as either Read-Write or Read-Only as described in the MIB definition
Accessible for SNMP Notifications	Acc-FN	These objects are used for SNMP Notifications by the CMTS and CM SNMP Agents

A.1 MIB Object Details

The CMTS and CCAP instantiates SNMP MIB objects based on its configuration and operational parameters.

The CMTS and CCAP upstream channel types can be categorized as "TDMA/ATDMA upstream" and "SCDMA upstream" and "OFDMA upstream".

Table 619 - MIB Object Details

DOCS-IF-MIB [RFC 4546]		
Object	**CMTS**	**Access**
docsIfDownstreamChannelTable	M	N-Acc
docsIfDownstreamChannelEntry	M	N-Acc
docsIfDownChannelId	M	RO
docsIfDownChannelFrequency	M	RW/RO
docsIfDownChannelWidth	M	RO
docsIfDownChannelModulation	M	RW
docsIfDownChannelInterleave	M	RW
docsIfDownChannelPower	M	RW/RO
docsIfDownChannelAnnex	M	RO
docsIfDownChannelStorageType	M	RO
docsIfUpstreamChannelTable	M	N-Acc
docsIfUpstreamChannelEntry	M	N-Acc
docsIfUpChannelId	M	RO
docsIfUpChannelFrequency	M	RC
docsIfUpChannelWidth	M	RC
docsIfUpChannelModulationProfile	M	RC
docsIfUpChannelSlotSize	M	RC/RO
docsIfUpChannelTxTimingOffset	M	RO
docsIfUpChannelRangingBackoffStart	M	RC
docsIfUpChannelRangingBackoffEnd	M	RC
docsIfUpChannelTxBackoffStart	M	RC
docsIfUpChannelTxBackoffEnd	M	RC
docsIfUpChannelScdmaActiveCodes	M	RC
docsIfUpChannelScdmaCodesPerSlot	M	RC
docsIfUpChannelScdmaFrameSize	M	RC
docsIfUpChannelScdmaHoppingSeed	M	RC
docsIfUpChannelType	M	RC
docsIfUpChannelCloneFrom	M	RC
docsIfUpChannelUpdate	M	RC
docsIfUpChannelStatus	M	RC
docsIfUpChannelPreEqEnable	M	RC
docsIfQosProfileTable	D	N-Acc
docsIfQosProfileEntry	D	N-Acc
docsIfQosProfIndex	D	N-Acc
docsIfQosProfPriority	D	RC/RO
docsIfQosProfMaxUpBandwidth	D	RC/RO
docsIfQosProfGuarUpBandwidth	D	RC/RO
docsIfQosProfMaxDownBandwidth	D	RC/RO

DOCS-IF-MIB [RFC 4546]		
Object	**CMTS**	**Access**
docsIfQosProfMaxTxBurst	D	RC/RO
docsIfQosProfBaselinePrivacy	D	RC/RO
docsIfQosProfStatus	D	RC/RO
docsIfQosProfMaxTransmitBurst	D	RC/RO
docsIfQosProfStorageType	D	RO
docsIfSignalQualityTable	M	N-Acc
docsIfSignalQualityEntry	M	N-Acc
docsIfSigQIncludesContention	M	RO
docsIfSigQUnerroreds	M	RO
docsIfSigQCorrecteds	M	RO
docsIfSigQUncorrectables	M	RO
docsIfSigQSignalNoise	D	RO
docsIfSigQMicroreflections	M	RO
docsIfSigQEqualizationData	D	RO
docsIfSigQExtUnerroreds	M	RO
docsIfSigQExtCorrecteds	M	RO
docsIfSigQExtUncorrectables	M	RO
docsIfDocsisBaseCapability	D	RO
docsIfCmtsMacTable	M	N-Acc
docsIfCmtsMacEntry	M	N-Acc
docsIfCmtsCapabilities	M	RO
docsIfCmtsSyncInterval	M	RW
docsIfCmtsUcdInterval	M	RW/RO
docsIfCmtsMaxServiceIds	M	RO
docsIfCmtsInsertionInterval	Ob	RW/RO
docsIfCmtsInvitedRangingAttempts	M	RW/RO
docsIfCmtsInsertInterval	M	RW/RO
docsIfCmtsMacStorageType	M	RW/RO
docsIfCmtsStatusTable	D	N-Acc
docsIfCmtsStatusEntry	D	N-Acc
docsIfCmtsStatusInvalidRangeReqs	D	RO
docsIfCmtsStatusRangingAborteds	D	RO
docsIfCmtsStatusInvalidRegReqs	D	RO
docsIfCmtsStatusFailedRegReqs	D	RO
docsIfCmtsStatusInvalidDataReqs	D	RO
docsIfCmtsStatusT5Timeouts	D	RO
docsIfCmtsCmStatusTable	D	N-Acc
docsIfCmtsCmStatusEntry	D	N-Acc
docsIfCmtsCmStatusIndex	D	N-Acc
docsIfCmtsCmStatusMacAddress	D	RO
docsIfCmtsCmStatusIpAddress	D	RO
docsIfCmtsCmStatusDownChannelIfIndex	D	RO
docsIfCmtsCmStatusUpChannelIfIndex	D	RO
docsIfCmtsCmStatusRxPower	D	RO
docsIfCmtsCmStatusTimingOffset	D	RO

DOCS-IF-MIB [RFC 4546]		
Object	**CMTS**	**Access**
docsIfCmtsCmStatusEqualizationData	D	RO
docsIfCmtsCmStatusValue	D	RO
docsIfCmtsCmStatusUnerroreds	D	RO
docsIfCmtsCmStatusCorrecteds	D	RO
docsIfCmtsCmStatusUncorrectables	D	RO
docsIfCmtsCmStatusSignalNoise	D	RO
docsIfCmtsCmStatusMicroreflections	D	RO
docsIfCmtsCmStatusExtUnerroreds	D	RO
docsIfCmtsCmStatusExtCorrecteds	D	RO
docsIfCmtsCmStatusExtUncorrectables	D	RO
docsIfCmtsCmStatusDocsisRegMode	D	RO
docsIfCmtsCmStatusModulationType	D	RO
docsIfCmtsCmStatusInetAddressType	D	RO
docsIfCmtsCmStatusInetAddress	D	RO
docsIfCmtsCmStatusValueLastUpdate	D	RO
docsIfCmtsCmStatusHighResolutionTimingOffset	D	RO
docsIfCmtsServiceTable	M/O	N-Acc
docsIfCmtsServiceEntry	M/O	N-Acc
docsIfCmtsServiceId	M/O	N-Acc
docsIfCmtsServiceCmStatusIndex	D	RO
docsIfCmtsServiceAdminStatus	D	RW/RO
docsIfCmtsServiceQosProfile	M/O	RO
docsIfCmtsServiceCreateTime	D	RO
docsIfCmtsServiceInOctets	D	RO
docsIfCmtsServiceInPackets	D	RO
docsIfCmtsServiceNewCmStatusIndex	D	RO
docsIfCmtsModulationTable	M	N-Acc
docsIfCmtsModulationEntry	M	N-Acc
docsIfCmtsModIndex	M	N-Acc
docsIfCmtsModIntervalUsageCode	M	N-Acc
docsIfCmtsModControl	M	RC
docsIfCmtsModType	M	RC
docsIfCmtsModPreambleLen	M	RC
docsIfCmtsModDifferentialEncoding	M	RC
docsIfCmtsModFECErrorCorrection	M	RC
docsIfCmtsModFECCodewordLength	M	RC
docsIfCmtsModScramblerSeed	M	RC
docsIfCmtsModMaxBurstSize	M	RC
docsIfCmtsModGuardTimeSize	M	RO
docsIfCmtsModLastCodewordShortened	M	RC
docsIfCmtsModScrambler	M	RC
docsIfCmtsModByteInterleaverDepth	M	RC
docsIfCmtsModByteInterleaverBlockSize	M	RC
docsIfCmtsModPreambleType	M	RC
docsIfCmtsModTcmErrorCorrectionOn	M	RC

DOCS-IF-MIB [RFC 4546]		
Object	**CMTS**	**Access**
docsIfCmtsModScdmaInterleaverStepSize	M	RC
docsIfCmtsModScdmaSpreaderEnable	M	RO
docsIfCmtsModScdmaSubframeCodes	M	RC
docsIfCmtsModChannelType	M	RC
docsIfCmtsModStorageType	M	RC
docsIfCmtsQosProfilePermissions	M	RW /RO
docsIfCmtsMacToCmTable	M	N-Acc
docsIfCmtsMacToCmEntry	M	N-Acc
docsIfCmtsCmMac	M	N-Acc
docsIfCmtsCmPtr	M	RO
docsIfCmtsChannelUtilizationInterval	M	RW
docsIfCmtsChannelUtilizationTable	M	N-Acc
docsIfCmtsChannelUtilizationEntry	M	N-Acc
docsIfCmtsChannelUtIfType	M	N-Acc
docsIfCmtsChannelUtId	M	N-Acc
docsIfCmtsChannelUtUtilization	M	RO
docsIfCmtsDownChannelCounterTable	M	N-Acc
docsIfCmtsDownChannelCounterEntry	M	N-Acc
docsIfCmtsDownChnlCtrId	M	RO
docsIfCmtsDownChnlCtrTotalBytes	M	RO
docsIfCmtsDownChnlCtrUsedBytes	M	RO
docsIfCmtsDownChnlCtrExtTotalBytes	M	RO
docsIfCmtsDownChnlCtrExtUsedBytes	M	RO
docsIfCmtsUpChannelCounterTable	M	N-Acc
docsIfCmtsUpChannelCounterEntry	M	N-Acc
docsIfCmtsUpChnlCtrId	M	RO
docsIfCmtsUpChnlCtrTotalMslots	M	RO
docsIfCmtsUpChnlCtrUcastGrantedMslots	M	RO
docsIfCmtsUpChnlCtrTotalCntnMslots	M	RO
docsIfCmtsUpChnlCtrUsedCntnMslots	M	RO
docsIfCmtsUpChnlCtrExtTotalMslots	M	RO
docsIfCmtsUpChnlCtrExtUcastGrantedMslots	M	RO
docsIfCmtsUpChnlCtrExtTotalCntnMslots	M	RO
docsIfCmtsUpChnlCtrExtUsedCntnMslots	M	RO
docsIfCmtsUpChnlCtrCollCntnMslots	M	RO
docsIfCmtsUpChnlCtrTotalCntnReqMslots	M	RO
docsIfCmtsUpChnlCtrUsedCntnReqMslots	M	RO
docsIfCmtsUpChnlCtrCollCntnReqMslots	M	RO
docsIfCmtsUpChnlCtrTotalCntnReqDataMslots	M	RO
docsIfCmtsUpChnlCtrUsedCntnReqDataMslots	M	RO
docsIfCmtsUpChnlCtrCollCntnReqDataMslots	M	RO
docsIfCmtsUpChnlCtrTotalCntnInitMaintMslots	M	RO
docsIfCmtsUpChnlCtrUsedCntnInitMaintMslots	M	RO
docsIfCmtsUpChnlCtrCollCntnInitMaintMslots	M	RO
docsIfCmtsUpChnlCtrExtCollCntnMslots	M	RO

DOCS-IF-MIB [RFC 4546]		
Object	**CMTS**	**Access**
docsIfCmtsUpChnlCtrExtTotalCntnReqMslots	M	RO
docsIfCmtsUpChnlCtrExtUsedCntnReqMslots	M	RO
docsIfCmtsUpChnlCtrExtCollCntnReqMslots	M	RO
docsIfCmtsUpChnlCtrExtTotalCntnReqDataMslots	M	RO
docsIfCmtsUpChnlCtrExtUsedCntnReqDataMslots	M	RO
docsIfCmtsUpChnlCtrExtCollCntnReqDataMslots	M	RO
docsIfCmtsUpChnlCtrExtTotalCntnInitMaintMslots	M	RO
docsIfCmtsUpChnlCtrExtUsedCntnInitMaintMslots	M	RO
docsIfCmtsUpChnlCtrExtCollCntnInitMaintMslots	M	RO

DOCS-IF31-MIB		
Object	**CMTS**	**Access**
docsIf31DocsisBaseCapability	M	RO
docsIf31RxChStatusTable	M	N-Acc
docsIf31RxChStatusEntry	M	N-Acc
docsIf31RxChStatusPrimaryDsIndicator	M	RO
docsIf31RxChStatusOfdmProfiles	M	RO
docsIf31CmtsCmRegStatusTable	M	N-Acc
docsIf31CmtsCmRegStatusEntry	M	N-Acc
docsIf31CmtsCmRegStatusAssignedEmIds	M	RO
docsIf31CmtsCmRegStatusDsProfileIdList	M	RO
docsIf31CmtsCmRegStatusUsProfileIucList	M	RO
docsIf31CmtsCmRegStatusTcsPhigh	M	RO
docsIf31CmtsCmRegStatusTcsDrwTop	M	RO
docsIf31CmtsCmRegStatusMinUsableDsFreq	M	RO
docsIf31CmtsCmRegStatusMaxUsableDsFreq	M	RO
docsIf31CmtsCmRegStatusMaxUsableUsFreq	M	RO
docsIf31CmtsCmRegStatusPartialSvcState	M	RO
docsIf31CmtsCmRegStatusPartialChanState	M	RO
docsIf31CmtsCmUsOfdmaChannelStatusTable	M	N-Acc
docsIf31CmtsCmUsOfdmaChannelStatusEntry	M	N-Acc
docsIf31CmtsCmUsOfdmaChannelRxPower	M	RO
docsIf31CmtsCmUsOfdmaChannelMeanRxMer	M	RO
docsIf31CmtsCmUsOfdmaChannelStdDevRxMer	M	RO
docsIf31CmtsCmUsOfdmaChannelRxMerThreshold	M	RW
docsIf31CmtsCmUsOfdmaChannelThresholdRxMerValue	M	RO
docsIf31CmtsCmUsOfdmaChannelThresholdRxMerHighestFreq	M	RO
docsIf31CmtsCmUsOfdmaChannelMicroreflections	M	RO
docsIf31CmtsCmUsOfdmaChannelHighResolutionTimingOffset	M	RO
docsIf31CmtsCmUsOfdmaChannelIsMuted	M	RO
docsIf31CmtsCmUsOfdmaChannelRangingStatus	M	RO
docsIf31CmtsCmUsOfdmaChannelCurPartialSvcReasonCode	M	RO
docsIf31CmtsCmUsOfdmaChannelLastPartialSvcTime	M	RO
docsIf31CmtsCmUsOfdmaChannelLastPartialSvcReasonCode	M	RO
docsIf31CmtsCmUsOfdmaChannelNumPartialSvcIncidents	M	RO

DOCS-IF31-MIB		
Object	**CMTS**	**Access**
docsIf31CmtsCmUsOfdmaProfileStatusTable	M	N-Acc
docsIf31CmtsCmUsOfdmaProfileStatusEntry	M	N-Acc
docsIf31CmtsCmUsOfdmaProfileTotalCodewords	M	RO
docsIf31CmtsCmUsOfdmaProfileCorrectedCodewords	M	RO
docsIf31CmtsCmUsOfdmaProfileUnreliableCodewords	M	RO
docsIf31CmtsCmDsOfdmChannelStatusTable	M	N-Acc
docsIf31CmtsCmDsOfdmChannelStatusEntry	M	N-Acc
docsIf31CmtsCmDsOfdmChannelCurPartialSvcReasonCode	M	RO
docsIf31CmtsCmDsOfdmChannelLastPartialSvcTime	M	RO
docsIf31CmtsCmDsOfdmChannelLastPartialSvcReasonCode	M	RO
docsIf31CmtsCmDsOfdmChannelNumPartialSvcIncidents	M	RO
docsIf31CmtsCmDsOfdmChannelNumPartialChanIncidents	M	RO
docsIf31CmtsCmDsOfdmChannelPreferredProfile	M	RO
docsIf31CmtsCmDsOfdmProfileStatusTable	M	N-Acc
docsIf31CmtsCmDsOfdmProfileStatusEntry	M	N-Acc
docsIf31CmtsCmDsOfdmProfilePartialChanReasonCode	M	RO
docsIf31CmtsCmDsOfdmProfileLastPartialChanTime	M	RO
docsIf31CmtsCmDsOfdmProfileLastPartialChanReasonCode	M	RO
docsIf31CmtsCmEmStatsTable	M	N-Acc
docsIf31CmtsCmEmStatsEntry	M	N-Acc
docsIf31CmtsCmEmStatsEm1x1ModeTotalDuration	M	RO
docsIf31CmtsCmEmStatsDlsModeTotalDuration	M	RO
docsIf31CmtsCmEmStatsLastDlsTime	M	RO
docsIf31CmtsCmEmStatsDlsWakeupEvents	M	RO
docsIf31CmtsDsOfdmChanTable	M	N-Acc
docsIf31CmtsDsOfdmChanEntry	M	N-Acc
docsIf31CmtsDsOfdmChanChannelId	M	RO
docsIf31CmtsDsOfdmChanLowerBdryFreq	M	RO
docsIf31CmtsDsOfdmChanUpperBdryFreq	M	RO
docsIf31CmtsDsOfdmChanLowerBdryEncompSpectrum	M	RO
docsIf31CmtsDsOfdmChanUpperBdryEncompSpectrum	M	RO
docsIf31CmtsDsOfdmChanPlcFreq	M	RO
docsIf31CmtsDsOfdmChanSubcarrierZeroFreq	M	RO
docsIf31CmtsDsOfdmChanFirstActiveSubcarrierNum	M	RO
docsIf31CmtsDsOfdmChanLastActiveSubcarrierNum	M	RO
docsIf31CmtsDsOfdmChanNumActiveSubcarriers	M	RO
docsIf31CmtsDsOfdmChanSubcarrierSpacing	M	RO
docsIf31CmtsDsOfdmChanLowerGuardbandWidth	M	RO
docsIf31CmtsDsOfdmChanUpperGuardbandWidth	M	RO
docsIf31CmtsDsOfdmChanCyclicPrefix	M	RO
docsIf31CmtsDsOfdmChanRollOffPeriod	M	RO
docsIf31CmtsDsOfdmChanTimeInterleaverDepth	M	RO
docsIf31CmtsDsOfdmChanNumPilots	M	RO
docsIf31CmtsDsOfdmChanPilotScaleFactor	M	RO
docsIf31CmtsDsOfdmChanNcpModulation	M	RO

DOCS-IF31-MIB		
Object	**CMTS**	**Access**
docsIf31CmtsDsOfdmChanUtilization	M	RO
docsIf31CmtsDsOfdmChanPowerAdjust	M	RO
docsIf31CmtsDsOfdmSubcarrierTypeTable	M	N-Acc
docsIf31CmtsDsOfdmSubcarrierTypeEntry	M	N-Acc
docsIf31CmtsDsOfdmSubcarrierTypeStartSubcarrierId	M	RO
docsIf31CmtsDsOfdmSubcarrierTypeEndSubcarrierId	M	RO
docsIf31CmtsDsOfdmSubcarrierTypeSubcarrierType	M	RO
docsIf31CmtsDsOfdmProfileStatsTable	M	N-Acc
docsIf31CmtsDsOfdmProfileStatsEntry	M	N-Acc
docsIf31CmtsDsOfdmProfileStatsProfileId	M	N-Acc
docsIf31CmtsDsOfdmProfileStatsConfigChangeCt	M	RO
docsIf31CmtsDsOfdmProfileStatsFullChannelSpeed	M	RO
docsIf31CmtsDsOfdmProfileStatsOutOctets	M	RO
docsIf31CmtsDsOfdmProfileStatsOutUnicastOctets	M	RO
docsIf31CmtsDsOfdmProfileStatsOutMulticastOctets	M	RO
docsIf31CmtsDsOfdmProfileStatsOutFrames	M	RO
docsIf31CmtsDsOfdmProfileStatsOutUnicastFrames	M	RO
docsIf31CmtsDsOfdmProfileStatsOutMulticastFrames	M	RO
docsIf31CmtsDsOfdmProfileStatsCtrDiscontinuityTime	M	RO
docsIf31CmtsDsOfdmProfileStatsAssignedCmCt	M	RO
docsIf31CmtsDsOfdmSubcarrierStatusTable	M	N-Acc
docsIf31CmtsDsOfdmSubcarrierStatusEntry	M	N-Acc
docsIf31CmtsDsOfdmSubcarrierStatusStartId	M	N-Acc
docsIf31CmtsDsOfdmSubcarrierStatusEndId	M	RO
docsIf31CmtsDsOfdmSubcarrierStatusMainModulation	M	RO
docsIf31CmtsDsOfdmSubcarrierStatusSkip	M	RO
docsIf31CmtsDsOfdmSubcarrierStatusSkipModulation	M	RO
docsIf31CmtsDsOfdmChanPowerTable	M	N-Acc
docsIf31CmtsDsOfdmChanPowerEntry	M	N-Acc
docsIf31CmtsDsOfdmChanPowerBandIndex	M	N-Acc
docsIf31CmtsDsOfdmChanPowerCenterFrequency	M	RO
docsIf31CmtsDsOfdmChanPowerTxPower	M	RO
docsIf31CmtsUsOfdmaChanTable	M	N-Acc
docsIf31CmtsUsOfdmaChanEntry	M	N-Acc
docsIf31CmtsUsOfdmaChanTemplateIndex	M	RO
docsIf31CmtsUsOfdmaChanConfigChangeCt	M	RO
docsIf31CmtsUsOfdmaChanTargetRxPower	M	RO
docsIf31CmtsUsOfdmaChanLowerBdryFreq	M	RO
docsIf31CmtsUsOfdmaChanUpperBdryFreq	M	RO
docsIf31CmtsUsOfdmaChanSubcarrierSpacing	M	RO
docsIf31CmtsUsOfdmaChanCyclicPrefix	M	RO
docsIf31CmtsUsOfdmaChanNumSymbolsPerFrame	M	RO
docsIf31CmtsUsOfdmaChanRollOffPeriod	M	RO
docsIf31CmtsUsOfdmaChanFineRngGuardband	M	RO
docsIf31CmtsUsOfdmaChanFineRngNumSubcarriers	M	RO

DOCS-IF31-MIB		
Object	**CMTS**	**Access**
docsIf31CmtsUsOfdmaChanFineRngPreambleLen	M	RO
docsIf31CmtsUsOfdmaChanInitRngGuardband	M	RO
docsIf31CmtsUsOfdmaChanInitRngNumSubcarriers	M	RO
docsIf31CmtsUsOfdmaChanInitRngPreambleLen	M	RO
docsIf31CmtsUsOfdmaChanProvAttribMask	M	RO
docsIf31CmtsUsOfdmaChanTxBackoffStart	M	RO
docsIf31CmtsUsOfdmaChanTxBackoffEnd	M	RO
docsIf31CmtsUsOfdmaChanRangingBackoffStart	M	RO
docsIf31CmtsUsOfdmaChanRangingBackoffEnd	M	RO
docsIf31CmtsUsOfdmaChanUtilization	M	RO
docsIf31CmtsUsOfdmaChanId	M	RO
docsIf31CmtsUsOfdmaChanSubcarrierZeroFreq	M	RO
docsIf31CmtsUsOfdmaChanTargetMapInterval	M	RO
docsIf31CmtsUsOfdmaChanUpChannelTotalCms	M	RO
docsIf31CmtsUsOfdmaSubcarrierTypeTable	M	N-Acc
docsIf31CmtsUsOfdmaSubcarrierTypeEntry	M	N-Acc
docsIf31CmtsUsOfdmaSubcarrierTypeStartSubcarrierId	M	RO
docsIf31CmtsUsOfdmaSubcarrierTypeEndSubcarrierId	M	RO
docsIf31CmtsUsOfdmaSubcarrierTypeSubcarrierType	M	RO
docsIf31CmtsCmMdStatsTable	M	N-Acc
docsIf31CmtsCmMdStatsEntry	M	N-Acc
docsIf31CmtsCmMdStatsCmMacAddr	M	N-Acc
docsIf31CmtsCmMdStatsUsMacStatsFrameCount	M	RO
docsIf31CmtsCmMdStatsUsMacStatsCrcFailureCount	M	RO
docsIf31CmtsCmMdStatsUsMacStatsTimestamp	M	RO
docsIf31CmtsUsOfdmaOverlapChannelStatusTable	M	N-Acc
docsIf31CmtsUsOfdmaOverlapChannelStatusEntry	M	N-Acc
docsIf31CmtsUsOfdmaOverlapChannelStatusIndex	M	N-Acc
docsIf31CmtsUsOfdmaOverlapChannelStatusDocsisChanId	M	RO
docsIf31CmtsUsOfdmaOverlapChannelStatusUpperBdryFreq	M	RO
docsIf31CmtsUsOfdmaDatalucStatsTable	M	N-Acc
docsIf31CmtsUsOfdmaDatalucStatsEntry	M	N-Acc
docsIf31CmtsUsOfdmaDatalucStatsDataluc	M	N-Acc
docsIf31CmtsUsOfdmaDatalucStatsMinislotPilotPattern	M	RO
docsIf31CmtsUsOfdmaDatalucStatsMinislotModulation	M	RO
docsIf31CmtsUsOfdmaDatalucStatsTotalCodewords	M	RO
docsIf31CmtsUsOfdmaDatalucStatsCorrectedCodewords	M	RO
docsIf31CmtsUsOfdmaDatalucStatsUnreliableCodewords	M	RO
docsIf31CmtsUsOfdmaDatalucStatsInOctets	M	RO
docsIf31CmtsUsOfdmaDatalucStatsCtrDiscontinuityTime	M	RO
docsIf31CmtsUsOfdmaDatalucStatsAssignedCmCt	M	RO
docsIf31CmtsUsOfdmaDatalucDetailStatusTable	M	N-Acc
docsIf31CmtsUsOfdmaDatalucDetailStatusEntry	M	N-Acc
docsIf31CmtsUsOfdmaDatalucDetailStatusLowerFreq	M	N-Acc
docsIf31CmtsUsOfdmaDatalucDetailStatusUpperFreq	M	RO

DOCS-IF31-MIB		
Object	**CMTS**	**Access**
docsIf31CmtsUsOfdmaDataIucDetailStatusMinislotPilotPattern	M	RO
docsIf31CmtsUsOfdmaDataIucDetailStatusMinislotModulation	M	RO
docsIf31CmtsUsOfdmaRangingIucStatusTable	M	N-Acc
docsIf31CmtsUsOfdmaRangingIucStatusEntry	M	N-Acc
docsIf31CmtsUsOfdmaRangingIucStatusIuc	M	N-Acc
docsIf31CmtsUsOfdmaRangingIucStatusGuardband	M	RO
docsIf31CmtsUsOfdmaRangingIucStatusNumSubcarriers	M	RO

DOCS-IF40-MIB	D4.0 CMTS Compliance		
Object	**FDD**	**FDX**	**Access**
docsIf40CmtsCmRegStatusTable	M	M	N-Acc
docsIf40CmtsCmRegStatusEntry	M	M	N-Acc
docsIf40CmtsCmRegStatusAdvBandPlanCapability	M	M	RO

DOCS-FDX-MIB	D4.0 CMTS Compliance		
Object	**FDD**	**FDX**	**Access**
docsFdxCmtsCmUsOfdmaChannelStatusTable	M	M	N-Acc
docsFdxCmtsCmUsOfdmaChannelStatusEntry	M	M	N-Acc
docsFdxCmtsCmUsOfdmaChannelStatusFdxEnabled	M	M	RO
docsFdxCmtsCmDsOfdmChannelStatusTable	M	M	N-Acc
docsFdxCmtsCmDsOfdmChannelStatusEntry	M	M	N-Acc
docsFdxCmtsCmDsOfdmChannelStatusFdxEnabled	M	M	RO
docsFdxCmtsCmFdxStatusTable	NA	M	N-Acc
docsFdxCmtsCmFdxStatusEntry	NA	M	N-Acc
docsFdxCmtsCmFdxStatusTransmissionGroupId	NA	M	RO
docsFdxCmtsCmFdxStatusRbaSubbandDirectionSet	NA	M	RO
docsFdxCmtsCmFdxStatusEcTrainingStatus	NA	M	RO
docsFdxCmtsUsOfdmaChannelStatusTable	M	M	N-Acc
docsFdxCmtsUsOfdmaChannelStatusEntry	M	M	N-Acc
docsFdxCmtsUsOfdmaChannelStatusFdxEnabled	M	M	RO
docsFdxCmtsDsOfdmChannelStatusTable	M	M	N-Acc
docsFdxCmtsDsOfdmChannelStatusEntry	M	M	N-Acc
docsFdxCmtsDsOfdmChannelStatusFdxEnabled	M	M	RO
docsFdxCmtsTransmissionGroupStatusTable	NA	M	N-Acc
docsFdxCmtsTransmissionGroupStatusEntry	NA	M	N-Acc
docsFdxCmtsTransmissionGroupStatusMacDomainName	NA	M	N-Acc
docsFdxCmtsTransmissionGroupStatusTransmissionGroupId	NA	M	N-Acc
docsFdxCmtsTransmissionGroupStatusCmMacIndex	NA	M	N-Acc
docsFdxCmtsTransmissionGroupStatusCmMacAddr	NA	M	RO

DOCS-FDD-MIB	D4.0 CMTS Compliance		
Object	**FDD**	**FDX**	**Access**
docsFddCmFddSystemCfgStateDiplexerDsLowerBandEdgeCfg	M	M	RO
docsFddCmFddSystemCfgStateDiplexerDsUpperBandEdgeCfg	M	M	RO
docsFddCmFddSystemCfgStateDiplexerUsUpperBandEdgeCfg	M	M	RO

DOCS-FDD-MIB	D4.0 CMTS Compliance		
docsFddDiplexerUsUpperBandEdgeCapabilityTable	M	M	N-Acc
docsFddDiplexerUsUpperBandEdgeCapabilityEntry	M	M	N-Acc
docsFddDiplexerUsUpperBandEdgeCapability	M	M	RO
docsFddDiplexerDsLowerBandEdgeCapabilityTable	M	M	N-Acc
docsFddDiplexerDsLowerBandEdgeCapabilityEntry	M	M	N-Acc
docsFddDiplexerDsLowerBandEdgeCapability	M	M	RO
docsFddDiplexerDsUpperBandEdgeCapabilityTable	M	M	N-Acc
docsFddDiplexerDsUpperBandEdgeCapabilityEntry	M	M	N-Acc
docsFddDiplexerDsUpperBandEdgeCapability	M	M	RO
docsFddCmUsOfdmaChannelTable	M	M	N-Acc
docsFddCmUsOfdmaChannelEntry	M	M	N-Acc
docsFddCmUsOfdmaChannelIsExtendedUsChannel	M	M	RO

DOCS-DRF-MIB [M-OSSI]		
Object	**CMTS**	**Access**
docsDrfDownstreamTable	M	N-Acc
docsDrfDownstreamEntry	M	N-Acc
docsDrfDownstreamPhyDependencies	M	RO
docsDrfDownstreamCapabilitiesTable	M	N-Acc
docsDrfDownstreamCapabilitiesEntry	M	N-Acc
docsDrfDownstreamCapabFrequency	M	RO
docsDrfDownstreamCapabBandwidth	M	RO
docsDrfDownstreamCapabPower	M	RO
docsDrfDownstreamCapabModulation	M	RO
docsDrfDownstreamCapabInterleaver	M	RO
docsDrfDownstreamCapabJ83Annex	M	RO
docsDrfDownstreamCapabConcurrentServices	NA	
docsDrfDownstreamCapabServicesTransport	NA	
docsDrfDownstreamCapabMuting	M	RO
docsDrfGroupDependencyTable	M	N-Acc
docsDrfGroupDependencyEntry	M	N-Acc
docsDrfGroupDependencyPhyParam	M	N-Acc
docsDrfGroupDependencyPhysicalIndex	M	N-Acc
docsDrfGroupDependencyGroupID	O	RO
docsDrfGroupDependencyType	M	RO
docsDrfChannelBlockTable	M	N-Acc
docsDrfChannelBlockEntry	M	N-Acc
docsDrfChannelBlockPhysicalIndex	M	N-Acc
docsDrfChannelBlockNumberChannels	M	RO
docsDrfChannelBlockCfgNumberChannels	M	RW
docsDrfChannelBlockMute	M	RW
docsDrfChannelBlockTestType	M	RW
docsDrfChannelBlockTestIfIndex	M	RW

IF-MIB [RFC 2863]		
Object	**CMTS**	**Access**
ifNumber	M	RO
ifTableLastChange	M	RO
ifTable **Note: The ifTable Counter32 objects are not reflected here; refer to Table 337 for details on these objects.**	M	N-Acc
ifEntry	M	N-Acc
ifIndex	M	RO
ifDescr	M	RO
ifType	M	RO
ifMtu	M	RO
ifSpeed	M	RO
ifPhysAddress	M	RO
ifAdminStatus	M	RW
ifOperStatus	M	RO
ifLastChange	M	RO
ifOutQLen	D	RO
ifSpecific	D	RO
ifXTable **Note: The ifXTable Counter32 and Counter64 objects are not reflected here; refer to Table 337 for details on these objects.**	M	N-Acc
ifXEntry	M	N-Acc
ifName	M	RO
ifLinkUpDownTrapEnable	M	RW
ifHighSpeed	M	RO
ifPromiscuousMode	M	RW/RO
ifConnectorPresent	M	RO
ifAlias	M	RW/RO
ifCounterDiscontinuityTime	M	RO
ifStackTable	M	N-Acc
ifStackEntry	M	N-Acc
ifStackHigherLayer	M	N-Acc
ifStackLowerLayer	M	N-Acc
ifStackStatus	M	RC/RO
ifStackLastChange	M	RC/RO
ifRcvAddressTable	O	N-Acc
ifRcvAddressEntry	O	N-Acc
ifRcvAddressAddress	O	N-Acc
ifRcvAddressStatus	O	RC
IfRcvAddressType	O	RC
Notification		
linkUp	M	Acc-FN
linkDown	M	Acc-FN
ifTestTable	D	N-Acc
ifTestEntry	D	N-Acc
ifTestId	D	RW
ifTestStatus	D	RW

IF-MIB [RFC 2863]		
Object	**CMTS**	**Access**
ifTestType	D	RW
ifTestResult	D	RO
ifTestCode	D	RO
ifTestOwner	D	RW

BRIDGE-MIB [RFC 4188] **Note: Implementation of BRIDGE-MIB is required ONLY if device is a bridging device.**		
Object	**CMTS**	**Access**
dot1dBase		
dot1dBaseBridgeAddress	M	RO
dot1dBaseNumPorts	M	RO
dot1dBaseType	M	RO
dot1dBasePortTable	M	N-Acc
dot1dBasePortEntry	M	N-Acc
dot1dBasePort	M	RO
dot1dBasePortIfIndex	M	RO
dot1dBasePortCircuit	M	RO
dot1dBasePortDelayExceededDiscards	M	RO
dot1dBasePortMtuExceededDiscards	M	RO
dot1dStp		
dot1dStpProtocolSpecification	M	RO
dot1dStpPriority	M	RW
dot1dStpTimeSinceTopologyChange	M	RO
dot1dStpTopChanges	M	RO
dot1dStpDesignatedRoot	M	RO
dot1dStpRootCost	M	RO
dot1dStpRootPort	M	RO
dot1dStpMaxAge	M	RO
dot1dStpHelloTime	M	RO
dot1dStpHoldTime	M	RO
dot1dStpForwardDelay	M	RO
dot1dStpBridgeMaxAge	M	RW
dot1dStpBridgeHelloTime	M	RW
dot1dStpBridgeForwardDelay	M	RW
dot1dStpPortTable **Note: This table is required ONLY if STP is implemented.**	O	N-Acc
dot1dStpPortEntry	O	N-Acc
dot1dStpPort	O	RO
dot1dStpPortPriority	O	RW
dot1dStpPortState	O	RO
dot1dStpPortEnable	O	RW
dot1dStpPortPathCost	O	RW
dot1dStpPortDesignatedRoot	O	RO
dot1dStpPortDesignatedCost	O	RO
dot1dStpPortDesignatedBridge	O	RO

BRIDGE-MIB [RFC 4188] **Note: Implementation of BRIDGE-MIB is required ONLY if device is a bridging device.**		
Object	**CMTS**	**Access**
dot1dStpPortDesignatedPort	O	RO
dot1dStpPortForwardTransitions	O	RO
dot1dStpPortPathCost32	O	RO
dot1dTp **Note: This group is required ONLY if transparent bridging is implemented.**		
dot1dTpLearnedEntryDiscards	M	RO
dot1dTpAgingTime	M	RW
dot1dTpFdbTable	M	N-Acc
dot1dTpFdbEntry	M	N-Acc
dot1dTpFdbAddress	M	RO
dot1dTpFdbPort	M	RO
dot1dTpFdbStatus	M	RO
dot1dTpPortTable	M	N-Acc
dot1dTpPortEntry	M	N-Acc
dot1dTpPort	M	RO
dot1dTpPortMaxInfo	M	RO
dot1dTpPortInFrames	M	RO
dot1dTpPortOutFrames	M	RO
dot1dTpPortInDiscards	M	RO
dot1dStaticTable **Note: Implementation of dot1dStaticTable is OPTIONAL.**	O	N-Acc
dot1dStaticEntry	O	N-Acc
dot1dStaticAddress	O	RW
dot1dStaticReceivePort	O	RW
dot1dStaticAllowedToGoTo	O	RW
dot1dStaticStatus	O	RW
Notification		
newRoot	O	Acc-FN
topologyChange	O	Acc-FN

DOCS-CABLE-DEVICE-MIB [RFC 2669]		
Object	**CMTS**	**Access**
docsDevBase		
docsDevRole	O	RO
docsDevDateTime	M	RW
docsDevResetNow	O	RW
docsDevSerialNumber	O	RO
docsDevSTPControl	O	RW/RO
docsDevNmAccessTable	O	N-Acc
docsDevNmAccessEntry	O	N-Acc
docsDevNmAccessIndex	O	N-Acc
docsDevNmAccessIp	O	RC
docsDevNmAccessIpMask	O	RC
docsDevNmAccessCommunity	O	RC

DOCS-CABLE-DEVICE-MIB [RFC 2669]		
Object	**CMTS**	**Access**
docsDevNmAccessControl	O	RC
docsDevNmAccessInterfaces	O	RC
docsDevNmAccessStatus	O	RC
docsDevNmAccessTrapVersion	O	RC
docsDevSoftware		
docsDevSwServer	D	RW
docsDevSwFilename	O	RW
docsDevSwAdminStatus	O	RW
docsDevSwOperStatus	O	RO
docsDevSwCurrentVers	O	RO
docsDevSwServerAddressType	O	RO
docsDevSwServerAddress	O	RO
docsDevSwServerTransportProtocol	O	RO
docsDevEvent		
docsDevEvControl	M	RW
docsDevEvSyslog	D	RW
docsDevEvThrottleAdminStatus	M	RW
docsDevEvThrottleInhibited	D	RO
docsDevEvThrottleThreshold	M	RW
docsDevEvThrottleInterval	M	RW
docsDevEvControlTable	M	N-Acc
docsDevEvControlEntry	M	N-Acc
docsDevEvPriority	M	N-Acc
docsDevEvReporting	M	RW
docsDevEventTable	M	N-Acc
docsDevEventEntry	M	N-Acc
docsDevEvIndex	M	N-Acc
docsDevEvent		
docsDevEvFirstTime	M	RO
docsDevEvLastTime	M	RO
docsDevEvCounts	M	RO
docsDevEvLevel	M	RO
docsDevEvId	M	RO
docsDevEvText	M	RO
docsDevEvSyslogAddressType	M	RW
docsDevEvSyslogAddress	M	RW
docsDevEvThrottleThresholdExceeded	M	RO
docsDevFilter		
docsDevFilterLLCUnmatchedAction	O	RW
docsDevFilterLLCTable	O	N-Acc
docsDevFilterLLCEntry	O	N-Acc
docsDevFilterLLCIndex	O	N-Acc
docsDevFilterLLCStatus	O	RC
docsDevFilterLLCIfIndex	O	RC
docsDevFilterLLCProtocolType	O	RC

DOCS-CABLE-DEVICE-MIB [RFC 2669]		
Object	**CMTS**	**Access**
docsDevFilterLLCProtocol	O	RC
docsDevFilterLLCMatches	O	RO
docsDevFilterIpDefault	O	RW
docsDevFilterIpTable	D	N-Acc
docsDevFilterIpEntry	D	N-Acc
docsDevFilterIpIndex	D	N-Acc
docsDevFilterIpStatus	D	RC
docsDevFilterIpControl	D	RC
docsDevFilterIpIfIndex	D	RC
docsDevFilterIpDirection	D	RC
docsDevFilterIpBroadcast	D	RC
docsDevFilterIpSaddr	D	RC
docsDevFilterIpSmask	D	RC
docsDevFilterIpDaddr	D	RC
docsDevFilterIpDmask	D	RC
docsDevFilterIpProtocol	D	RC
docsDevFilterIpSourcePortLow	D	RC
docsDevFilterIpSourcePortHigh	D	RC
docsDevFilterIpDestPortLow	D	RC
docsDevFilterIpDestPortHigh	D	RC
docsDevFilterIpMatches	D	RO
docsDevFilterIpTos	D	RC
docsDevFilterIpTosMask	D	RC
docsDevFilterIpContinue	D	RC
docsDevFilterIpPolicyId	D	RC
docsDevFilterPolicyTable	D	N-Acc
docsDevFilterPolicyEntry	D	N-Acc
docsDevFilterPolicyIndex	D	N-Acc
docsDevFilterPolicyId	D	RC
docsDevFilterPolicyStatus	D	RC
docsDevFilterPolicyPtr	D	RC
docsDevFilterTosTable	D	N-Acc
docsDevFilterTosEntry	D	N-Acc
docsDevFilterTosIndex	D	N-Acc
docsDevFilterTosStatus	D	RC
docsDevFilterTosAndMask	D	RC
docsDevFilterTosOrMask	D	RC

IP-MIB [RFC 4293]		
Object	**CMTS**	**Access**
ipv4GeneralGroup		
ipForwarding	M	RW
ipDefaultTTL	M	RW
ipReasmTimeout	M	RW

IP-MIB [RFC 4293]		
Object	**CMTS**	**Access**
ipv6GeneralGroup2		
ipv6IpForwarding	M	RW
ipv6IpDefaultHopLimit	M	RW
ipv4InterfaceTableLastChange	M	RO
ipv4InterfaceTable	M	N-Acc
ipv4InterfaceEntry	M	N-Acc
ipv4InterfaceIfIndex	M	N-Acc
ipv4InterfaceReasmMaxSize	M	RO
ipv4InterfaceEnableStatus	M	RW
ipv4InterfaceRetransmitTime	M	RO
ipv6InterfaceTableLastChange	M	RO
ipv6InterfaceTable	M	N-Acc
ipv6InterfaceEntry	M	N-Acc
ipv6InterfaceIfIndex	M	N-Acc
ipv6InterfaceReasmMaxSize	M	RO
ipv6InterfaceIdentifier	M	RO
ipv6InterfaceEnableStatus	M	RW
ipv6InterfaceReachableTime	M	RO
ipv6InterfaceRetransmitTime	M	RO
ipv6InterfaceForwarding	M	RW
ipSystemStatsTable	O	N-Acc
ipSystemStatsEntry	O	N-Acc
ipSystemStatsIPVersion	O	N-Acc
ipSystemStatsInReceives	O	RO
ipSystemStatsHCInReceives	O	RO
ipSystemStatsInOctets	O	RO
ipSystemStatsHCInOctets	O	RO
ipSystemStatsInHdrErrors	O	RO
ipSystemStatsInNoRoutes	O	RO
ipSystemStatsInAddrErrors	O	RO
ipSystemStatsInUnknownProtos	O	RO
ipSystemStatsInTruncatedPkts	O	RO
ipSystemStatsInForwDatagrams	O	RO
ipSystemStatsHCInForwDatagrams	O	RO
ipSystemStatsReasmReqds	O	RO
ipSystemStatsReasmOKs	O	RO
ipSystemStatsReasmFails	O	RO
ipSystemStatsInDiscards	O	RO
ipSystemStatsInDelivers	O	RO
ipSystemStatsHCInDelivers	O	RO
ipSystemStatsOutRequests	O	RO
ipSystemStatsHCOutRequests	O	RO
ipSystemStatsOutNoRoutes	O	RO
ipSystemStatsOutForwDatagrams	O	RO
ipSystemStatsHCOutForwDatagrams	O	RO

IP-MIB [RFC 4293]		
Object	**CMTS**	**Access**
ipSystemStatsOutDiscards	O	RO
ipSystemStatsOutFragReqds	O	RO
ipSystemStatsOutFragOKs	O	RO
ipSystemStatsOutFragFails	O	RO
ipSystemStatsOutFragCreates	O	RO
ipSystemStatsOutTransmits	O	RO
ipSystemStatsHCOutTransmits	O	RO
ipSystemStatsOutOctets	O	RO
ipSystemStatsHCOutOctets	O	RO
ipSystemStatsInMcastPkts	O	RO
ipSystemStatsHCInMcastPkts	O	RO
ipSystemStatsInMcastOctets	O	RO
ipSystemStatsHCInMcastOctets	O	RO
ipSystemStatsOutMcastPkts	O	RO
ipSystemStatsHCOutMcastPkts	O	RO
ipSystemStatsOutMcastOctets	O	RO
ipSystemStatsHCOutMcastOctets	O	RO
ipSystemStatsInBcastPkts	O	RO
ipSystemStatsHCInBcastPkts	O	RO
ipSystemStatsOutBcastPkts	O	RO
ipSystemStatsHCOutBcastPkts	O	RO
ipSystemStatsDiscontinuityTime	O	RO
ipSystemStatsRefreshRate	O	RO
ipIfStatsTableLastChange	O	RO
ipIfStatsTable **Note: This table is required ONLY if routing is implemented.**	M	N-Acc
ipIfStatsEntry	M	N-Acc
ipIfStatsIPVersion	M	N-Acc
ipIfStatsIfIndex	M	N-Acc
ipIfStatsInReceives	M	RO
ipIfStatsHCInReceives	M	RO
ipIfStatsInOctets	M	RO
ipIfStatsHCInOctets	M	RO
ipIfStatsInHdrErrors	M	RO
ipIfStatsInNoRoutes	M	RO
ipIfStatsInAddrErrors	M	RO
ipIfStatsInUnknownProtos	M	RO
ipIfStatsInTruncatedPkts	M	RO
ipIfStatsInForwDatagrams	M	RO
ipIfStatsHCInForwDatagrams	M	RO
ipIfStatsReasmReqds	M	RO
ipIfStatsReasmOKs	M	RO
ipIfStatsReasmFails	M	RO
ipIfStatsInDiscards	M	RO
ipIfStatsInDelivers	M	RO

IP-MIB [RFC 4293]		
Object	**CMTS**	**Access**
ipIfStatsHCInDelivers	M	RO
ipIfStatsOutRequests	M	RO
ipIfStatsHCOutRequests	M	RO
ipIfStatsOutForwDatagrams	M	RO
ipIfStatsHCOutForwDatagrams	M	RO
ipIfStatsOutDiscards	M	RO
ipIfStatsOutFragReqds	M	RO
ipIfStatsOutFragOKs	M	RO
ipIfStatsOutFragFails	M	RO
ipIfStatsOutFragCreates	M	RO
ipIfStatsOutTransmits	M	RO
ipIfStatsHCOutTransmits	M	RO
ipIfStatsOutOctets	M	RO
ipIfStatsHCOutOctets	M	RO
ipIfStatsInMcastPkts	M	RO
ipIfStatsHCInMcastPkts	M	RO
ipIfStatsInMcastOctets	M	RO
ipIfStatsHCInMcastOctets	M	RO
ipIfStatsOutMcastPkts	M	RO
ipIfStatsHCOutMcastPkts	M	RO
ipIfStatsOutMcastOctets	M	RO
ipIfStatsHCOutMcastOctets	M	RO
ipIfStatsInBcastPkts	M	RO
ipIfStatsHCInBcastPkts	M	RO
ipIfStatsOutBcastPkts	M	RO
ipIfStatsHCOutBcastPkts	M	RO
ipIfStatsDiscontinuityTime	M	RO
ipIfStatsRefreshRate	M	RO
ipAddressPrefixTable **Note: This table is required ONLY if routing is implemented.**	M	N-Acc
ipAddressPrefixEntry	M	N-Acc
ipAddressPrefixIfIndex	M	N-Acc
ipAddressPrefixType	M	N-Acc
ipAddressPrefixPrefix	M	N-Acc
ipAddressPrefixLength	M	N-Acc
ipAddressPrefixOrigin	M	RO
ipAddressPrefixOnLinkFlag	M	RO
ipAddressPrefixAutonomousFlag	M	RO
ipAddressPrefixAdvPreferredLifetime	M	RO
ipAddressPrefixAdvValidLifetime	M	RO
ipAddressSpinLock	M	RW
ipAddressTable	M	N-Acc
ipAddressEntry	M	N-Acc
ipAddressAddrType	M	N-Acc
ipAddressAddr	M	N-Acc

IP-MIB [RFC 4293]		
Object	**CMTS**	**Access**
ipAddressIfIndex	M	RO
ipAddressType	M	RO
ipAddressPrefix	M	RO
ipAddressOrigin	M	RO
ipAddressStatus	M	RO
ipAddressCreated	M	RO
ipAddressLastChanged	M	RO
ipAddressRowStatus	M	RO
ipAddressStorageType	M	RO
ipNetToPhysicalTable **Note: This table is required ONLY if routing is implemented.**	M	N-Acc
ipNetToPhysicalEntry	M	N-Acc
ipNetToPhysicalIfIndex	M	N-Acc
ipNetToPhysicalNetAddressType	M	N-Acc
ipNetToPhysicalNetAddress	M	N-Acc
ipNetToPhysicalPhysAddress	M	RC
ipNetToPhysicalLastUpdated	M	RO
ipNetToPhysicalType	M	RC
ipNetToPhysicalState	M	RO
ipNetToPhysicalRowStatus	M	RC
ipDefaultRouterTable **Note: This table is required ONLY if routing is implemented.**	M	N-Acc
ipDefaultRouterEntry	M	N-Acc
ipDefaultRouterAddressType	M	N-Acc
ipDefaultRouterAddress	M	N-Acc
ipDefaultRouterIfIndex	M	N-Acc
ipDefaultRouterLifetime	M	RC
ipDefaultRouterPreference	M	RO
ipv6RouterAdvertGroup		
ipv6RouterAdvertSpinLock	O	RW
ipv6RouterAdvertTable **Note: This table is required ONLY if routing is implemented.**	M	N-Acc
ipv6RouterAdvertEntry	M	N-Acc
ipv6RouterAdvertIfIndex	M	N-Acc
ipv6RouterAdvertSendAdverts	M	RC
ipv6RouterAdvertMaxInterval	M	RC
ipv6RouterAdvertMinInterval	M	RC
ipv6RouterAdvertManagedFlag	M	RC
ipv6RouterAdvertOtherConfigFlag	M	RC
ipv6RouterAdvertLinkMTU	M	RC
ipv6RouterAdvertReachableTime	M	RC
ipv6RouterAdvertRetransmitTime	M	RC
ipv6RouterAdvertCurHopLimit	M	RC
ipv6RouterAdvertDefaultLifetime	M	RC
ipv6RouterAdvertRowStatus	M	RC

IP-MIB [RFC 4293]		
Object	**CMTS**	**Access**
icmpStatsTable	M	N-Acc
icmpStatsEntry	M	N-Acc
icmpStatsIPVersion	M	N-Acc
icmpStatsInMsgs	M	RO
icmpStatsInErrors	M	RO
icmpStatsOutMsgs	M	RO
icmpStatsOutErrors	M	RO
icmpMsgStatsTable	M	N-Acc
icmpMsgStatsEntry	M	N-Acc
icmpMsgStatsIPVersion	M	N-Acc
icmpMsgStatsType	M	N-Acc
icmpMsgStatsInPkts	M	RO
icmpMsgStatsOutPkts	M	RO

UDP-MIB [RFC 4113]		
Object	**CMTS**	**Access**
UDPGroup		
udpInDatagrams	O	RO
udpNoPorts	O	RO
udpInErrors	O	RO
udpOutDatagrams	O	RO
udpEndpointTable	O	N-Acc
udpEndpointEntry	O	N-Acc
udpEndpointLocalAddressType	O	N-Acc
udpEndpointLocalAddress	O	N-Acc
udpEndpointLocalPort	O	N-Acc
udpEndpointRemoteAddressType	O	N-Acc
udpEndpointRemoteAddress	O	N-Acc
udpEndpointRemotePort	O	N-Acc
udpEndpointInstance	O	N-Acc
udpEndpointProcess	O	RO

TCP-MIB [RFC 4022]		
Object	**CMTS**	**Access**
tcpBaseGroup		
tcpRtoAlgorithm	O	RO
tcpRtoMin	O	RO
tcpRtoMax	O	RO
tcpMaxConn	O	RO
tcpActiveOpens	O	RO
tcpPassiveOpens	O	RO
tcpAttemptFails	O	RO
tcpEstabResets	O	RO
tcpCurrEstab	O	RO
tcpInSegs	O	RO

TCP-MIB [RFC 4022]		
Object	**CMTS**	**Access**
tcpOutSegs	O	RO
tcpRetransSegs	O	RO
tcpInErrs	O	RO
tcpOutRsts	O	RO
tcpHCGroup		
tcpHCInSegs	O	RO
tcpHCOutSegs	O	RO
tcpConnectionTable	O	N-Acc
tcpConnectionEntry	O	N-Acc
tcpConnectionLocalAddressType	O	N-Acc
tcpConnectionLocalAddress	O	N-Acc
tcpConnectionLocalPort	O	N-Acc
tcpConnectionRemAddressType	O	N-Acc
tcpConnectionRemAddress	O	N-Acc
tcpConnectionRemPort	O	N-Acc
tcpConnectionState	O	RW
tcpConnectionProcess	O	RO
tcpListenerTable	O	N-Acc
tcpListenerEntry	O	N-Acc
tcpListenerLocalAddressType	O	N-Acc
tcpListenerLocalAddress	O	N-Acc
tcpListenerLocalPort	O	N-Acc
tcpListenerProcess	O	RO

SNMPv2-MIB [RFC 3418]		
Object	**CMTS**	**Access**
SystemGroup		
sysDescr	M	RO
sysObjectID	M	RO
sysUpTime	M	RO
sysContact	M	RW
sysName	M	RW
sysLocation	M	RW
sysServices	M	RO
sysORLastChange	M	RO
sysORTable	M	N-Acc
sysOREntry	M	N-Acc
sysORIndex	M	N-Acc
sysORID	M	RO
sysORDescr	M	RO
sysORUpTime	M	RO
SNMPGroup		
snmpInPkts	M	RO
snmpInBadVersions	M	RO
snmpOutPkts	Ob	RO

SNMPv2-MIB [RFC 3418]		
Object	**CMTS**	**Access**
snmpInBadCommunityNames	M	RO
snmpInBadCommunityUses	M	RO
snmpInASNParseErrs	M	RO
snmpInTooBigs	Ob	RO
snmpInNoSuchNames	Ob	RO
snmpInBadValues	Ob	RO
snmpInReadOnlys	Ob	RO
snmpInGenErrs	Ob	RO
snmpInTotalReqVars	Ob	RO
snmpInTotalSetVars	Ob	RO
snmpInGetRequests	Ob	RO
snmpInGetNexts	Ob	RO
snmpInSetRequests	Ob	RO
snmpInGetResponses	Ob	RO
snmpInTraps	Ob	RO
snmpOutTooBigs	Ob	RO
snmpOutNoSuchNames	Ob	RO
snmpOutBadValues	Ob	RO
snmpOutGenErrs	Ob	RO
snmpOutGetRequests	Ob	RO
snmpOutGetNexts	Ob	RO
snmpOutSetRequests	Ob	RO
snmpOutGetResponses	Ob	RO
snmpOutTraps	Ob	RO
snmpEnableAuthenTraps	M	RW
snmpSilentDrops	M	RO
snmpProxyDrops	M	RO
snmpTrapsGroup		
coldStart	M	Acc-FN
warmStart	O	Acc-FN
authenticationFailure	M	Acc-FN
snmpSetGroup		
snmpSetSerialNo	M	RW

Etherlike-MIB [RFC 3635]		
Object	**CMTS**	**Access**
dot3StatsTable	M	N-Acc
dot3StatsEntry	M	N-Acc
dot3StatsIndex	M	RO
dot3StatsAlignmentErrors	M	RO
dot3StatsFCSErrors	M	RO
dot3StatsInternalMacTransmitErrors	M	RO
dot3StatsFrameTooLongs	M	RO
dot3StatsInternalMacReceiveErrors	M	RO
dot3StatsSymbolErrors	M	RO

Etherlike-MIB [RFC 3635]		
Object	**CMTS**	**Access**
dot3StatsSingleCollisionFrames	O	RO
dot3StatsMultipleCollisionFrames	O	RO
dot3StatsDeferredTransmissions	O	RO
dot3StatsLateCollisions	O	RO
dot3StatsExcessiveCollisions	O	RO
dot3StatsCarrierSenseErrors	O	RO
dot3StatsDuplexStatus	O	RO
dot3StatsSQETestErrors	N-Sup	
dot3CollTable	O	N-Acc
dot3CollEntry	O	N-Acc
dot3CollCount	O	NA
dot3CollFrequencies	O	RO
dot3ControlTable	O	N-Acc
dot3ControlEntry	O	N-Acc
dot3ControlFunctionsSupported	O	RO
dot3ControlInUnknownOpcodes	O	RO
dot3PauseTable	O	N-Acc
dot3PauseEntry	O	N-Acc
dot3PauseAdminMode	O	RW
dot3PauseOperMode	O	RO
dot3InPauseFrames	O	RO
dot3OutPauseFrames	O	RO

DOCS-IETF-BPI2-MIB [RFC 4131]		
Object	**CMTS**	**Access**
docsBpi2CmtsBaseEntryTable	M	N-Acc
docsBpi2CmtsBaseEntryEntry	M	N-Acc
docsBpi2CmtsDefaultAuthLifetime	M	RW
docsBpi2CmtsDefaultTEKLifetime	M	RW
docsBpi2CmtsDefaultSelfSignedManufCertTrust	M	RW
docsBpi2CmtsCheckCertValidityPeriods	M	RW
docsBpi2CmtsAuthentInfos	M	RO
docsBpi2CmtsAuthRequests	M	RO
docsBpi2CmtsAuthReplies	M	RO
docsBpi2CmtsAuthRejects	M	RO
docsBpi2CmtsAuthInvalids	M	RO
docsBpi2CmtsSAMapRequests	M	RO
docsBpi2CmtsSAMapReplies	M	RO
docsBpi2CmtsSAMapRejects	M	RO
docsBpi2CmtsAuthEntryTable	M	N-Acc
docsBpi2CmtsAuthEntryEntry	M	N-Acc
docsBpi2CmtsAuthCmMacAddress	M	N-Acc
docsBpi2CmtsAuthCmBpiVersion	M	RO
docsBpi2CmtsAuthCmPublicKey	M	RO
docsBpi2CmtsAuthCmKeySequenceNumber	M	RO

DOCS-IETF-BPI2-MIB [RFC 4131]		
Object	**CMTS**	**Access**
docsBpi2CmtsAuthCmExpiresOld	M	RO
docsBpi2CmtsAuthCmExpiresNew	M	RO
docsBpi2CmtsAuthCmLifetime	M	RW
docsBpi2CmtsAuthCmReset	M	RW
docsBpi2CmtsAuthCmInfos	M	RO
docsBpi2CmtsAuthCmRequests	M	RO
docsBpi2CmtsAuthCmReplies	M	RO
docsBpi2CmtsAuthCmRejects	M	RO
docsBpi2CmtsAuthCmInvalids	M	RO
docsBpi2CmtsAuthRejectErrorCode	M	RO
docsBpi2CmtsAuthRejectErrorString	M	RO
docsBpi2CmtsAuthInvalidErrorCode	M	RO
docsBpi2CmtsAuthInvalidErrorString	M	RO
docsBpi2CmtsAuthPrimarySAId	M	RO
docsBpi2CmtsAuthBpkmCmCertValid	M	RO
docsBpi2CmtsAuthBpkmCmCert	M	RO
docsBpi2CmtsAuthCACertIndexPtr	M	RO
docsBpi2CmtsTEKTable	M	N-Acc
docsBpi2CmtsTEKEntry	M	N-Acc
docsBpi2CmtsTEKSAId	M	N-Acc
docsBpi2CmtsTEKSAType	M	RO
docsBpi2CmtsTEKDataEncryptAlg	M	RO
docsBpi2CmtsTEKDataAuthentAlg	M	RO
docsBpi2CmtsTEKLifetime	M	RW
docsBpi2CmtsTEKKeySequenceNumber	M	RO
docsBpi2CmtsTEKExpiresOld	M	RO
docsBpi2CmtsTEKExpiresNew	M	RO
docsBpi2CmtsTEKReset	M	RW
docsBpi2CmtsKeyRequests	M	RO
docsBpi2CmtsKeyReplies	M	RO
docsBpi2CmtsKeyRejects	M	RO
docsBpi2CmtsTEKInvalids	M	RO
docsBpi2CmtsKeyRejectErrorCode	M	RO
docsBpi2CmtsKeyRejectErrorString	M	RO
docsBpi2CmtsTEKInvalidErrorCode	M	RO
docsBpi2CmtsTEKInvalidErrorString	M	RO
docsBpi2CmtsIpMulticastMapTable	M	N-Acc
docsBpi2CmtsIpMulticastMapEntry	M	N-Acc
docsBpi2CmtsIpMulticastIndex	M	N-Acc
docsBpi2CmtsIpMulticastAddressType	M	RO
docsBpi2CmtsIpMulticastAddress	M	RO
docsBpi2CmtsIpMulticastMask	M	RO
docsBpi2CmtsIpMulticastSAId	M	RO
docsBpi2CmtsIpMulticastSAType	M	RO
docsBpi2CmtsIpMulticastDataEncryptAlg	M	RO

DOCS-IETF-BPI2-MIB [RFC 4131]		
Object	**CMTS**	**Access**
docsBpi2CmtsIpMulticastDataAuthentAlg	M	RO
docsBpi2CmtsIpMulticastSAMapRequests	M	RO
docsBpi2CmtsIpMulticastSAMapReplies	M	RO
docsBpi2CmtsIpMulticastSAMapRejects	M	RO
docsBpi2CmtsIpMulticastSAMapRejectErrorCode	M	RO
docsBpi2CmtsIpMulticastSAMapRejectErrorString	M	RO
docsBpi2CmtsIpMulticastMapControl	M	RO
docsBpi2CmtsIpMulticastMapStorageType	M	RO
docsBpi2CmtsMulticastAuthTable	D	N-Acc
docsBpi2CmtsMulticastAuthEntry	D	N-Acc
docsBpi2CmtsMulticastAuthSAId	D	N-Acc
docsBpi2CmtsMulticastAuthCmMacAddress	D	N-Acc
docsBpi2CmtsMulticastAuthControl	D	RC/RO
docsBpi2CmtsProvisionedCmCertTable	M	N-Acc
docsBpi2CmtsProvisionedCmCertEntry	M	N-Acc
docsBpi2CmtsProvisionedCmCertMacAddress	M	N-Acc
docsBpi2CmtsProvisionedCmCertTrust	M	RC
docsBpi2CmtsProvisionedCmCertSource	M	RO
docsBpi2CmtsProvisionedCmCertStatus	M	RC
docsBpi2CmtsProvisionedCmCert	M	RC
docsBpi2CmtsProvisionedCmCertDeviceType	M	RC
docsBpi2CmtsCACertTable	M	N-Acc
docsBpi2CmtsCACertEntry	M	N-Acc
docsBpi2CmtsCACertIndex	M	N-Acc
docsBpi2CmtsCACertSubject	M	RO
docsBpi2CmtsCACertIssuer	M	RO
docsBpi2CmtsCACertSerialNumber	M	RO
docsBpi2CmtsCACertTrust	M	RC
docsBpi2CmtsCACertSource	M	RO
docsBpi2CmtsCACertStatus	M	RC
docsBpi2CmtsCACert	M	RC
docsBpi2CmtsCACertThumbprint	M	RO
docsBpi2CodeDownloadGroup		
docsBpi2CodeDownloadStatusCode	O	RO
docsBpi2CodeDownloadStatusString	O	RO
docsBpi2CodeMfgOrgName	O	RO
docsBpi2CodeMfgCodeAccessStart	O	RO
docsBpi2CodeMfgCvcAccessStart	O	RO
docsBpi2CodeCoSignerOrgName	O	RO
docsBpi2CodeCoSignerCodeAccessStart	O	RO
docsBpi2CodeCoSignerCvcAccessStart	O	RO
docsBpi2CodeCvcUpdate	O	RW

DOCS-LOADBAL3-MIB [DOCS-LOADBAL3-MIB]		
Object	**CMTS**	**Access**
docsLoadbal3System		
docsLoadbal3SystemEnable	M	RW
docsLoadbal3SystemEnableError	M	RO
docsLoadbal3ChgOverGroup		
docsLoadbal3ChgOverGroupMacAddress	M	RW
docsLoadbal3ChgOverGroupInitTech	M	RW
docsLoadbal3ChgOverGroupForceUCC	M	RW
docsLoadbal3ChgOverGroupdownFrequency	M	RW
docsLoadbal3ChgOverGroupMdIfIndex	M	RW
docsLoadbal3ChgOverGroupRcpId	M	RW
docsLoadbal3ChgOverGroupRccId	M	RW
docsLoadbal3ChgOverGroupUsChSet	M	RW
docsLoadbal3ChgOverGroupServiceFlowInfo	M	RW
docsLoadbal3ChgOverGroupTransactionId	M	RW
docsLoadbal3ChgOverGroupCommit	M	RW
docsLoadbal3ChgOverGroupLastCommit	M	RO
docsLoadbal3ChgOverStatusTable	M	N-Acc
docsLoadbal3ChgOverStatusEntry	M	N-Acc
docsLoadbal3ChgOverStatusId	M	RO
docsLoadbal3ChgOverStatusMacAddr	M	RO
docsLoadbal3ChgOverStatusInitTech	M	RO
docsLoadbal3ChgOverStatusDownFrequency	M	RO
docsLoadbal3ChgOverStatusMdIfIndex	M	RO
docsLoadbal3ChgOverStatusRcpId	M	RO
docsLoadbal3ChgOverStatusRccId	M	RO
docsLoadbal3ChgOverStatusUsChSet	M	RO
docsLoadbal3ChgOverStatusServiceFlowInfo	M	RO
docsLoadbal3ChgOverStatusCmd	M	RO
docsLoadbal3ChgOverStatusTransactionId	M	RO
docsLoadbal3ChgOverStatusValue	M	RO
docsLoadbal3ChgOverStatusUpdate	M	RO
docsLoadbal3CmtsCmParamsTable	M	N-Acc
docsLoadbal3CmtsCmParamsEntry	M	N-Acc
docsLoadbal3CmtsCmParamsProvGrpId	M	RW/RO
docsLoadbal3CmtsCmParamsCurrentGrpId	M	RO
docsLoadbal3CmtsCmParamsProvServiceTypeID	M	RW/RO
docsLoadbal3CmtsCmParamsCurrentServiceTypeID	M	RO
docsLoadbal3CmtsCmParamsPolicyId	M	RW/RO
docsLoadbal3CmtsCmParamsPriority	M	RW/RO
docsLoadbal3GeneralGrpDefaults		
docsLoadbal3GeneralGrpDefaultsEnable	M	RW
docsLoadbal3GeneralGrpDefaultsPolicyId	M	RW
docsLoadbal3GeneralGrpDefaultsInitTech	M	RW
docsLoadbal3GeneralGrpCfgTable	M	N-Acc
docsLoadbal3GeneralGrpCfgEntry	M	N-Acc

DOCS-LOADBAL3-MIB [DOCS-LOADBAL3-MIB]		
Object	**CMTS**	**Access**
docsLoadbal3GeneralGrpCfgNodeName	M	N-Acc
docsLoadbal3GeneralGrpCfgEnable	M	RW
docsLoadbal3GeneralGrpCfgPolicyId	M	RW
docsLoadbal3GeneralGrpCfgInitTech	M	RW
docsLoadbal3ResGrpCfgTable	M	N-Acc
docsLoadbal3ResGrpCfgEntry	M	N-Acc
docsLoadbal3ResGrpCfgId	M	N-Acc
docsLoadbal3ResGrpCfgMdIfIndex	M	RC
docsLoadbal3ResGrpCfgDsChList	M	RC
docsLoadbal3ResGrpCfgUsChList	M	RC
docsLoadbal3ResGrpCfgEnable	M	RC
docsLoadbal3ResGrpCfgInitTech	M	RC
docsLoadbal3ResGrpCfgPolicyId	M	RC
docsLoadbal3ResGrpCfgServiceTypeId	M	RC
docsLoadbal3ResGrpCfgStatus	M	RC
docsLoadbal3GrpStatusTable	M	N-Acc
docsLoadbal3GrpStatusEntry	M	N-Acc
docsLoadbal3GrpStatusId	M	N-Acc
docsLoadbal3GrpStatusCfgIdOrZero	M	RO
docsLoadbal3GrpStatusMdIfIndex	M	RO
docsLoadbal3GrpStatusMdCmSgId	M	RO
docsLoadbal3GrpStatusDsChList	M	RO
docsLoadbal3GrpStatusUsChList	M	RO
docsLoadbal3GrpStatusEnable	M	RO
docsLoadbal3GrpStatusInitTech	M	RO
docsLoadbal3GrpStatusPolicyId	M	RO
docsLoadbal3GrpStatusChgOverSuccess	M	RO
docsLoadbal3GrpStatusChgOverFails	M	RO
docsLoadbal3RestrictCmCfgTable	M	N-Acc
docsLoadbal3RestrictCmCfgEntry	M	N-Acc
docsLoadbal3RestrictCmCfgId	M	N-Acc
docsLoadbal3RestrictCmCfgMacAddr	M	RC
docsLoadbal3RestrictCmCfgMacAddrMask	M	RC
docsLoadbal3RestrictCmCfgGrpId	M	RC
docsLoadbal3RestrictCmCfgServiceTypeId	M	RC
docsLoadbal3RestrictCmCfgStatus	M	RC
docsLoadbal3PolicyTable	M	N-Acc
docsLoadbal3PolicyEntry	M	N-Acc
docsLoadbal3PolicyId	M	N-Acc
docsLoadbal3PolicyRuleId	M	N-Acc
docsLoadbal3PolicyPtr	M	RC
docsLoadbal3PolicyRowStatus	M	RC
docsLoadbal3BasicRuleTable	M	N-Acc
docsLoadbal3BasicRuleEntry	M	N-Acc
docsLoadbal3BasicRuleId	M	N-Acc

DOCS-LOADBAL3-MIB [DOCS-LOADBAL3-MIB]		
Object	**CMTS**	**Access**
docsLoadbal3BasicRuleEnable	M	RC
docsLoadbal3BasicRuleDisStart	M	RC
docsLoadbal3BasicRuleDisPeriod	M	RC
docsLoadbal3BasicRuleRowStatus	M	RC

DOCS-IFEXT2-MIB [DOCS-IFEXT2-MIB]		
Object	**CMTS**	**Access**
docsIfExt2CmtsObjects		
docsIfExt2CmtsMscGlobalEnable	M	RW
docsIfExt2CmtsCmMscStatusTable	O	N-Acc
docsIfExt2CmtsCmMscStatusEntry	O	N-Acc
docsIfExt2CmtsCmMscStatusPowerShortfall	O	RO
docsIfExt2CmtsCmMscStatusCodeRatio	O	RO
docsIfExt2CmtsCmMscStatusMaximumScheduledCodes	O	RO
docsIfExt2CmtsCmMscStatusPowerHeadroom	O	RO
docsIfExt2CmtsCmMscStatusMeasuredSNR	O	RO
docsIfExt2CmtsCmMscStatusEffectiveSNR	O	RO
docsIfExt2CmtsUpChannelMscTable	O	N-Acc
docsIfExt2CmtsUpChannelMscEntry	O	N-Acc
docsIfExt2CmtsUpChannelMscState	O	RW
docsIfExt2CmtsUpChannelMSCTotalCMs	O	RO
docsIfExt2CmtsUpChannelMSCLimitIUC1	O	RO
docsIfExt2CmtsUpChannelMSCMinimumValue	O	RW
docsIfExt2CmtsUpChannelTable	O	N-Acc
docsIfExt2CmtsUpChannelEntry	O	N-Acc
docsIfExt2CmtsUpChannelTotalCMs	O	RO
docsIfExt2CmtsUpChannelTargetMapInterval	O	RO

HOST-RESOURCES-MIB [RFC 2790]		
Object	**CMTS**	**Access**
hrDeviceTable	O	N-Acc
hrDeviceEntry	O	N-Acc
hrDeviceIndex	O	RO
hrDeviceType	O	RO
hrDeviceDescr	O	RO
hrDeviceID	O	RO
hrDeviceStatus	O	RO
hrDeviceErrors	O	RO
hrSystem		
hrMemorySize	O	RO
hrStorageTable	O	N-Acc
hrStorageEntry	O	N-Acc
hrStorageIndex	O	RO
hrStorageType	O	RO
hrStorageDescr	O	RO

hrStorageAllocationUnits	O	RO
hrStorageSize	O	RO
hrStorageUsed	O	RO
hrStorageAllocationFailures	O	RO
hrSWRunTable	O	N-Acc
hrSWRunEntry	O	N-Acc
hrSWRunIndex	O	RO
hrSWRunName	O	RO
hrSWRunID	O	RO
hrSWRunPath	O	RO
hrSWRunParameters	O	RO
hrSWRunType	O	RO
hrSWRunStatus	O	RO
hrSWRunPerfTable	O	N-Acc
hrSWRunPerfEntry	O	N-Acc
hrSWRunPerfCPU	O	RO
hrSWRunPerfMem	O	RO
hrProcessorTable	O	N-Acc
hrProcessorEntry	O	N-Acc
hrProcessorFrwID	O	RO
hrProcessorLoad	O	RO

ENTITY-MIB [RFC 6933]		
Object	**CMTS**	**Access**
entPhysicalTable	O	N-Acc
entPhysicalEntry	O	N-Acc
entPhysicalIndex	O	N-Acc
entPhysicalDescr	O	RO
entPhysicalVendorType	O	RO
entPhysicalContainedIn	O	RO
entPhysicalClass	O	RO
entPhysicalParentRelPos	O	RO
entPhysicalName	O	RO
entPhysicalHardwareRev	O	RO
entPhysicalFirmwareRev	O	RO
entPhysicalSoftwareRev	O	RO
entPhysicalSerialNum	O	RO/RW
entPhysicalMfgName	O	RO
entPhysicalModelName	O	RO
entPhysicalAlias	O	RO/RW
entPhysicalAssetID	O	RO/RW
entPhysicalIsFRU	O	RO
entPhysicalMfgDate	O	RO
entPhysicalUris	O	RW
entPhysicalUUID	O	RO
entLogicalTable	O	N-Acc
entLogicalEntry	O	N-Acc

ENTITY-MIB [RFC 6933]		
Object	**CMTS**	**Access**
entLogicalIndex	O	N-Acc
entLogicalDescr	O	RO
entLogicalType	O	RO
entLogicalCommunity	D	RO
entLogicalTAddress	O	RO
entLogicalTDomain	O	RO
entLogicalContextEngineID	O	RO
entLogicalContextName	O	RO
entLPMappingTable	O	N-Acc
entLPMappingEntry	O	N-Acc
entLPPhysicalIndex	O	RO
entAliasMappingTable	O	N-Acc
entAliasMappingEntry	O	N-Acc
entAliasLogicalIndexOrZero	O	N-Acc
entAliasMappingIdentifier	O	RO
entPhysicalContainsTable	O	N-Acc
entPhysicalContainsEntry	O	N-Acc
entPhysicalChildIndex	O	RO
General Group		
entLastChangeTime	O	RO
Notification		
entConfigChange	O	Acc-FN

ENTITY-SENSOR-MIB [RFC 3433]		
Object	**CMTS**	**Access**
entPhySensorTable	O	N-Acc
entPhySensorEntry	O	N-Acc
entPhySensorType	O	RO
entPhySensorScale	O	RO
entPhySensorPrecision	O	RO
entPhySensorValue	O	RO
entPhySensorOperStatus	O	RO
entPhySensorUnitsDisplay	O	RO
entPhySensorValueTimeStamp	O	RO
entPhySensorValueUpdateRate	O	RO

SNMP-USM-DH-OBJECTS-MIB [RFC 2786]		
Object	**CMTS**	**Access**
usmDHParameters	O	RW
usmDHUserKeyTable	O	N-Acc
usmDHUserKeyEntry	O	N-Acc
usmDHUserAuthKeyChange	O	RC
usmDHUserOwnAuthKeyChange	O	RC
usmDHUserPrivKeyChange	O	RC
usmDHUserOwnPrivKeyChange	O	RC

SNMP-USM-DH-OBJECTS-MIB [RFC 2786]		
Object	**CMTS**	**Access**
usmDHKickstartTable	O	N-Acc
usmDHKickstartEntry	O	N-Acc
usmDHKickstartIndex	O	N-Acc
usmDHKickstartMyPublic	O	RO
usmDHKickstartMgrPublic	O	RO
usmDHKickstartSecurityName	O	RO

SNMP-VIEW-BASED-ACM-MIB [RFC 2575]		
Object	**CMTS**	**Access**
vacmContextTable	O	N-Acc
vacmContextEntry	O	N-Acc
vacmContextName	O	RO
vacmSecurityToGroupTable	O	N-Acc
vacmSecurityToGroupEntry	O	N-Acc
vacmSecurityModel	O	N-Acc
vacmSecurityName	O	N-Acc
vacmGroupName	O	RC
vacmSecurityToGroupStorageType	O	RC
vacmSecurityToGroupStatus	O	RC
vacmAccessTable	O	N-Acc
vacmAccessEntry	O	N-Acc
vacmAccessContextPrefix	O	N-Acc
vacmAccessSecurityModel	O	N-Acc
vacmAccessSecurityLevel	O	N-Acc
vacmAccessContextMatch	O	RC
vacmAccessReadViewName	O	RC
vacmAccessWriteViewName	O	RC
vacmAccessNotifyViewName	O	RC
vacmAccessStorageType	O	RC
vacmAccessStatus	O	RC
vacmViewSpinLock	O	RW
vacmViewTreeFamilyTable	O	N-Acc
vacmViewTreeFamilyEntry	O	N-Acc
vacmViewTreeFamilyViewName	O	N-Acc
vacmViewTreeFamilySubtree	O	N-Acc
vacmViewTreeFamilyMask	O	RC
vacmViewTreeFamilyType	O	RC
vacmViewTreeFamilyStorageType	O	RC
vacmViewTreeFamilyStatus	O	RC

SNMP-COMMUNITY-MIB [RFC 3584]		
Object	**CMTS**	**Access**
snmpCommunityTable	M	N-Acc
snmpCommunityEntry	M	N-Acc
snmpCommunityIndex	M	N-Acc

SNMP-COMMUNITY-MIB [RFC 3584]		
Object	**CMTS**	**Access**
snmpCommunityName	M	RC
snmpCommunitySecurityName	M	RC
snmpCommunityContextEngineID	M	RC
snmpCommunityContextName	M	RC
snmpCommunityTransportTag	M	RC
snmpCommunityStorageType	M	RC
snmpCommunityStatus	M	RC
snmpTargetAddrExtTable	M	N-Acc
snmpTargetAddrExtEntry	M	N-Acc
snmpTargetAddrTMask	M	RC
snmpTargetAddrMMS	M	RC
snmpTrapAddress	O	ACC-FN
snmpTrapCommunity	O	ACC-FN

SNMP-FRAMEWORK-MIB [RFC 3411]		
Object	**CMTS**	**Access**
snmpEngineGroup		
snmpEngineID	M	RO
snmpEngineBoots	M	RO
snmpEngineTime	M	RO
snmpEngineMaxMessageSize	M	RO

SNMP-MPD-MIB [RFC 3412]		
Object	**CMTS**	**Access**
snmpMPDStats		
snmpUnknownSecurityModels	M	RO
snmpInvalidMsgs	M	RO
snmpUnknownPDUHandlers	M	RO

SNMP Applications [RFC 2573]		
Object	**CMTS**	**Access**
snmpTargetSpinLock	M	RW
snmpTargetAddrTable	M	N-Acc
snmpTargetAddrEntry	M	N-Acc
snmpTargetAddrName	M	N-Acc
snmpTargetAddrTDomain	M	RC
snmpTargetAddrTAddress	M	RC
snmpTargetAddrTimeout	M	RC
snmpTargetAddrRetryCount	M	RC
snmpTargetAddrTagList	M	RC
snmpTargetAddrParams	M	RC
snmpTargetAddrStorageType	M	RC
snmpTargetAddrRowStatus	M	RC
snmpTargetParamsTable	M	N-Acc
snmpTargetParamsEntry	M	N-Acc

SNMP Applications [RFC 2573]		
Object	**CMTS**	**Access**
snmpTargetParamsName	M	N-Acc
snmpTargetParamsMPModel	M	RC
snmpTargetParamsSecurityModel	M	RC
snmpTargetParamsSecurityName	M	RC
snmpTargetParamsSecurityLevel	M	RC
snmpTargetParamsStorageType	M	RC
snmpTargetParamsRowStatus	M	RC
snmpUnavailableContexts	M	RO
snmpUnknownContexts	M	RO
snmpNotifyTable	M	N-Acc
snmpNotifyEntry	M	N-Acc
snmpNotifyName	M	N-Acc
snmpNotifyTag	M	RC
snmpNotifyType	M	RC
snmpNotifyStorageType	M	RC
snmpNotifyRowStatus	M	RC
snmpNotifyFilterProfileTable	M	N-Acc
snmpNotifyFilterProfileEntry	M	N-Acc
snmpNotifyFilterProfileName	M	RC
snmpNotifyFilterProfileStorType	M	RC
snmpNotifyFilterProfileRowStatus	M	RC
snmpNotifyFilterTable	M	N-Acc
snmpNotifyFilterEntry	M	N-Acc
snmpNotifyFilterSubtree	M	N-Acc
snmpNotifyFilterMask	M	RC
snmpNotifyFilterType	M	RC
snmpNotifyFilterStorageType	M	RC
snmpNotifyFilterRowStatus	M	RC

SNMP-USER-BASED-SM-MIB [RFC 3414]		
Object	**CMTS**	**Access**
usmStats		
usmStatsUnsupportedSecLevels	O	RO
usmStatsNotInTimeWindows	O	RO
usmStatsUnknownUserNames	O	RO
usmStatsUnknownEngineIDs	O	RO
usmStatsWrongDigests	O	RO
usmStatsDecryptionErrors	O	RO
usmUser		
usmUserSpinLock	O	RW
usmUserTable	O	N-Acc
usmUserEntry	O	N-Acc
usmUserEngineID	O	N-Acc
usmUserName	O	N-Acc
usmUserSecurityName	O	RO

SNMP-USER-BASED-SM-MIB [RFC 3414]		
Object	**CMTS**	**Access**
usmUserCloneFrom	O	RC
usmUserAuthProtocol	O	RC
usmUserAuthKeyChange	O	RC
usmUserOwnAuthKeyChange	O	RC
usmUserPrivProtocol	O	RC
usmUserPrivKeyChange	O	RC
usmUserOwnPrivKeyChange	O	RC
usmUserPublic	O	RC
usmUserStorageType	O	RC
usmUserStatus	O	RC

MGMD-STD-MIB [RFC 5519]		
Object	**CMTS**	**Access**
mgmdRouterInterfaceTable	M	N-Acc
mgmdRouterInterfaceEntry	M	N-Acc
mgmdRouterInterfaceIfIndex	M	N-Acc
mgmdRouterInterfaceQuerierType	M	N-Acc
mgmdRouterInterfaceQuerier	M	RO
mgmdRouterInterfaceQueryInterval	M	RC
mgmdRouterInterfaceStatus	M	RC
mgmdRouterInterfaceVersion	M	RC
mgmdRouterInterfaceQueryMaxResponseTime	M	RC
mgmdRouterInterfaceQuerierUpTime	M	RO
mgmdRouterInterfaceQuerierExpiryTime	M	RO
mgmdRouterInterfaceWrongVersionQueries	M	RO
mgmdRouterInterfaceJoins	M	RO
mgmdRouterInterfaceProxyIfIndex	M	RO/RC
mgmdRouterInterfaceGroups	M	RO
mgmdRouterInterfaceRobustness	M	RC
mgmdRouterInterfaceLastMemberQueryInterval	M	RC
mgmdRouterInterfaceLastMemberQueryCount	M	RO
mgmdRouterInterfaceStartupQueryCount	M	RO
mgmdRouterInterfaceStartupQueryInterval	M	RO
mgmdRouterCacheTable	M	N-Acc
mgmdRouterCacheEntry	M	N-Acc
mgmdRouterCacheAddressType	M	N-Acc
mgmdRouterCacheAddress	M	N-Acc
mgmdRouterCacheIfIndex	M	N-Acc
mgmdRouterCacheLastReporter	M	RO
mgmdRouterCacheUpTime	M	RO
mgmdRouterCacheExpiryTime	M	RO
mgmdRouterCacheExcludeModeExpiryTimer	M	RO
mgmdRouterCacheVersion1HostTimer	M	RO
mgmdRouterCacheVersion2HostTimer	M	RO
mgmdRouterCacheSourceFilterMode	M	RO

MGMD-STD-MIB [RFC 5519]		
Object	**CMTS**	**Access**
mgmdInverseRouterCacheTable	M	N-Acc
mgmdInverseRouterCacheEntry	M	N-Acc
mgmdInverseRouterCacheIfIndex	M	N-Acc
mgmdInverseRouterCacheAddressType	M	N-Acc
mgmdInverseRouterCacheAddress	M	RO
mgmdRouterSrcListTable	M	N-Acc
mgmdRouterSrcListEntry	M	N-Acc
mgmdRouterSrcListAddressType	M	N-Acc
mgmdRouterSrcListAddress	M	N-Acc
mgmdRouterSrcListIfIndex	M	N-Acc
mgmdRouterSrcListHostAddress	M	N-Acc
mgmdRouterSrcListExpire	M	RO

DOCS-DIAG-MIB [DOCS-DIAG-MIB]		
Object	**CMTS**	**Access**
docsDiagLogGlobal		
docsDiagLogMaxSize	M	RW
docsDiagLogCurrentSize	M	RO
docsDiagLogNotifyLogSizeHighThrshld	M	RW
docsDiagLogNotifyLogSizeLowThrshld	M	RW
docsDiagLogAging	M	RW
docsDiagLogResetAll	M	RW
docsDiagLogLastResetTime	M	RO
docsDiagLogClearAll	M	RW
docsDiagLogLastClearTime	M	RO
docsDiagLogNotifCtrl	M	RW
docsDiagLogTriggersCfg		
docsDiagLogIncludeTriggers	M	RW
docsDiagLogEnableAgingTriggers	M	RW
docsDiagLogRegTimeInterval	M	RW
docsDiagLogRegDetail	M	RW
docsDiagLogRangingRetryType	M	RW
docsDiagLogRangingRetryThrhld	M	RW
docsDiagLogRangingRetryStationMaintNum	M	RW
docsDiagLogTable	M	N-Acc
docsDiagLogEntry	M	N-Acc
docsDiagLogCmMacAddr	M	RO
docsDiagLogLastUpdateTime	M	RO
docsDiagLogCreateTime	M	RO
docsDiagLogLastRegTime	M	RO
docsDiagLogRegCount	M	RO
docsDiagLogRangingRetryCount	M	RO
docsDiagLogDetailTable	M	N-Acc
docsDiagLogDetailEntry	M	N-Acc
docsDiagLogDetailTypeValue	M	N-Acc

DOCS-DIAG-MIB [DOCS-DIAG-MIB]		
Object	**CMTS**	**Access**
docsDiagLogDetailCount	M	RO
docsDiagLogDetailLastUpdate	M	RO
docsDiagLogDetailLastErrorText	M	RO
Notifications		
docsDiagLogSizeHighThrshldReached	M	Notif
docsDiagLogSizeLowThrshldReached	M	Notif
docsDiagLogSizeFull	M	Notif

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosPktClassTable	M	N-Acc
docsQosPktClassEntry	M	N-Acc
docsQosPktClassId	M	N-Acc
docsQosPktClassDirection	M	RO
docsQosPktClassPriority	M	RO
docsQosPktClassIpTosLow	M	RO
docsQosPktClassIpTosHigh	M	RO
docsQosPktClassIpTosMask	M	RO
docsQosPktClassIpProtocol	M	RO
docsQosPktClassIpSourceAddr	M	RO
docsQosPktClassIpSourceMask	M	RO
docsQosPktClassIpDestAddr	M	RO
docsQosPktClassIpDestMask	M	RO
docsQosPktClassSourcePortStart	M	RO
docsQosPktClassSourcePortEnd	M	RO
docsQosPktClassDestPortStart	M	RO
docsQosPktClassDestPortEnd	M	RO
docsQosPktClassDestMacAddr	M	RO
docsQosPktClassDestMacMask	M	RO
docsQosPktClassSourceMacAddr	M	RO
docsQosPktClassEnetProtocolType	M	RO
docsQosPktClassEnetProtocol	M	RO
docsQosPktClassUserPriLow	M	RO
docsQosPktClassUserPriHigh	M	RO
docsQosPktClassVlanId	M	RO
docsQosPktClassState	M	RO
docsQosPktClassPkts	M	RO
docsQosPktClassBitMap	M	RO
docsQosPktClassIpAddrType	M	RO
docsQosPktClassFlowLabel	M	RO
docsQosPktClassIcmpTypeHigh	M	RO
docsQosPktClassIcmpTypeLow	M	RO
docsQosPktClassCmInterfaceMask	M	RO
docsQosParamSetTable	M	N-Acc
docsQosParamSetEntry	M	N-Acc

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosParamSetServiceClassName	M	RO
docsQosParamSetPriority	M	RO
docsQosParamSetMaxTrafficRate	M	RO
docsQosParamSetMaxTrafficBurst	M	RO
docsQosParamSetMinReservedRate	M	RO
docsQosParamSetMinReservedPkt	M	RO
docsQosParamSetActiveTimeout	M	RO
docsQosParamSetAdmittedTimeout	M	RO
docsQosParamSetMaxConcatBurst	M	RO
docsQosParamSetSchedulingType	M	RO
docsQosParamSetNomPollInterval	M	RO
docsQosParamSetTolPollJitter	M	RO
docsQosParamSetUnsolicitGrantSize	M	RO
docsQosParamSetNomGrantInterval	M	RO
docsQosParamSetTolGrantJitter	M	RO
docsQosParamSetGrantsPerInterval	M	RO
docsQosParamSetTosAndMask	M	RO
docsQosParamSetTosOrMask	M	RO
docsQosParamSetMaxLatency	M	RO
docsQosParamSetType	M	N-Acc
docsQosParamSetRequestPolicyOct	M	RO
docsQosParamSetBitMap	M	RO
docsQosParamSetServiceFlowId	M	N-Acc
docsQosParamSetRequiredAttrMask	M	RO
docsQosParamSetForbiddenAttrMask	M	RO
docsQosParamSetAttrAggrRuleMask	M	RO
docsQosParamSetAppId	M	RO
docsQosParamSetMultiplierContentionReqWindow	M	RO
docsQosParamSetMultiplierBytesReq	M	RO
docsQosParamSetMaxReqPerSidCluster	D	RO
docsQosParamSetMaxOutstandingBytesPerSidCluster	D	RO
docsQosParamSetMaxTotBytesReqPerSidCluster	D	RO
docsQosParamSetMaxTimeInSidCluster	D	RO
docsQosParamSetPeakTrafficRate	M	RO
docsQosParamSetDsResequencing	M	RO
docsQosParamSetMinimumBuffer	M	RO
docsQosParamSetTargetBuffer	M	RO
docsQosParamSetMaximumBuffer	M	RO
docsQosParamSetAqmDisabled	M	RO
docsQosParamSetAqmLatencyTarget	M	RO
docsQosParamSetHCMaxTrafficRate	D	RO
docsQosParamSetHCMinReservedRate	D	RO
docsQosParamSetHCPeakTrafficRate	D	RO
docsQosParamSetAqmAlgInUse	M	RO
docsQosParamSetGuaranteedGrantInterval	M	RO

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosParamSetGuaranteedGrantRate	M	RO
docsQosParamSetGuaranteedRequestInterval	M	RO
docsQosParamSetImmedAqmMaxThreshold	M	RO
docsQosParamSetImmedAqmRangeExponentRampFunc	M	RO
docsQosParamSetDataRateUnitSetting	M	RO
docsQosServiceFlowTable	M	N-Acc
docsQosServiceFlowEntry	M	N-Acc
docsQosServiceFlowId	M	N-Acc
docsQosServiceFlowSID	M	RO
docsQosServiceFlowDirection	M	RO
docsQosServiceFlowPrimary	M	RO
docsQosServiceFlowParamSetTypeStatus	M	RO
docsQosServiceFlowChSetId	M	RO
docsQosServiceFlowAttrAssignSuccess	M	RO
docsQosServiceFlowDsid	M	RO
docsQosServiceFlowMaxReqPerSidCluster	M	RO
docsQosServiceFlowMaxOutstandingBytesPerSidCluster	M	RO
docsQosServiceFlowMaxTotBytesReqPerSidCluster	M	RO
docsQosServiceFlowMaxTimeInSidCluster	M	RO
docsQosServiceFlowBufferSize	O	RO
docsQosServiceFlowIatcProfileName	M	RO
docsQosServiceFlowAggregateServiceFlowId	M	RO
docsQosServiceFlowType	M	RO
docsQosServiceFlowStatsTable	M	N-Acc
docsQosServiceFlowStatsEntry	M	N-Acc
docsQosServiceFlowPkts	M	RO
docsQosServiceFlowOctets	M	RO
docsQosServiceFlowTimeCreated	M	RO
docsQosServiceFlowTimeActive	M	RO
docsQosServiceFlowPHSUnknowns	D	RO
docsQosServiceFlowPolicedDropPkts	M	RO
docsQosServiceFlowPolicedDelayPkts	M	RO
docsQosServiceFlowAqmDroppedPkts	M	RO
docsQosUpstreamStatsTable	M	N-Acc
docsQosUpstreamStatsEntry	M	N-Acc
docsQosSID	M	N-Acc
docsQosUpstreamFragments	M	RO
docsQosUpstreamFragDiscards	M	RO
docsQosUpstreamConcatBursts	M	RO
docsQosDynamicServiceStatsTable	M	N-Acc
docsQosDynamicServiceStatsEntry	M	N-Acc
docsQosIfDirection	M	N-Acc
docsQosDSAReqs	M	RO
docsQosDSARsps	M	RO
docsQosDSAAcks	M	RO

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosDSCReqs	M	RO
docsQosDSCRsps	M	RO
docsQosDSCAcks	M	RO
docsQosDSDReqs	M	RO
docsQosDSDRsps	M	RO
docsQosDynamicAdds	M	RO
docsQosDynamicAddFails	M	RO
docsQosDynamicChanges	M	RO
docsQosDynamicChangeFails	M	RO
docsQosDynamicDeletes	M	RO
docsQosDynamicDeleteFails	M	RO
docsQosDCCReqs	M	RO
docsQosDCCRsps	M	RO
docsQosDCCAcks	M	RO
docsQosDCCs	M	RO
docsQosDCCFails	M	RO
docsQosDCCRspDeparts	M	RO
docsQosDCCRspArrives	M	RO
docsQosDbcReqs	M	RO
docsQosDbcRsps	M	RO
docsQosDbcAcks	M	RO
docsQosDbcSuccesses	M	RO
docsQosDbcFails	M	RO
docsQosDbcPartial	M	RO
docsQosServiceFlowLogTable	M	N-Acc
docsQosServiceFlowLogEntry	M	N-Acc
docsQosServiceFlowLogIndex	M	N-Acc
docsQosServiceFlowLogIfIndex	M	RO
docsQosServiceFlowLogSFID	M	RO
docsQosServiceFlowLogCmMac	M	RO
docsQosServiceFlowLogPkts	M	RO
docsQosServiceFlowLogOctets	M	RO
docsQosServiceFlowLogTimeDeleted	M	RO
docsQosServiceFlowLogTimeCreated	M	RO
docsQosServiceFlowLogTimeActive	M	RO
docsQosServiceFlowLogDirection	M	RO
docsQosServiceFlowLogPrimary	M	RO
docsQosServiceFlowLogServiceClassName	M	RO
docsQosServiceFlowLogPolicedDropPkts	M	RO
docsQosServiceFlowLogPolicedDelayPkts	M	RO
docsQosServiceFlowLogControl	M	RW
docsQosServiceClassTable	M	N-Acc
docsQosServiceClassEntry	M	N-Acc
docsQosServiceClassName	M	N-Acc
docsQosServiceClassStatus	M	RC

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosServiceClassPriority	M	RC
docsQosServiceClassMaxTrafficRate	M	RC
docsQosServiceClassMaxTrafficBurst	M	RC
docsQosServiceClassMinReservedRate	M	RC
docsQosServiceClassMinReservedPkt	M	RC
docsQosServiceClassMaxConcatBurst	M	RC
docsQosServiceClassNomPollInterval	M	RC
docsQosServiceClassTolPollJitter	M	RC
docsQosServiceClassUnsolicitGrantSize	M	RC
docsQosServiceClassNomGrantInterval	M	RC
docsQosServiceClassTolGrantJitter	M	RC
docsQosServiceClassGrantsPerInterval	M	RC
docsQosServiceClassMaxLatency	M	RC
docsQosServiceClassActiveTimeout	M	RC
docsQosServiceClassAdmittedTimeout	M	RC
docsQosServiceClassSchedulingType	M	RC
docsQosServiceClassRequestPolicy	M	RC
docsQosServiceClassTosAndMask	M	RC
docsQosServiceClassTosOrMask	M	RC
docsQosServiceClassDirection	M	RC
docsQosServiceClassStorageType	M	RC
docsQosServiceClassDSCPOverwrite	M	RC
docsQosServiceClassRequiredAttrMask	M	RC
docsQosServiceClassForbiddenAttrMask	M	RC
docsQosServiceClassAttrAggrRuleMask	M	RC
docsQosServiceClassAppId	M	RC
docsQosServiceClassMultiplierContentionReqWindow	M	RC
docsQosServiceClassMultiplierBytesReq	M	RC
docsQosServiceClassMaxReqPerSidCluster	D	RC
docsQosServiceClassMaxOutstandingBytesPerSidCluster	D	RC
docsQosServiceClassMaxTotBytesReqPerSidCluster	D	RC
docsQosServiceClassMaxTimeInSidCluster	D	RC
docsQosServiceClassPeakTrafficRate	M	RC
docsQosServiceClassDsResequencing	M	RC
docsQosServiceClassMinimumBuffer	M	RC
docsQosServiceClassTargetBuffer	M	RC
docsQosServiceClassMaximumBuffer	M	RC
docsQosServiceClassAqmDisabled	M	RC
docsQosServiceClassAqmLatencyTarget	M	RC
docsQosServiceClassHCMaxTrafficRate	Ob	RO
docsQosServiceClassHCMinReservedRate	Ob	RO
docsQosServiceClassHCPeakTrafficRate	Ob	RO
docsQosServiceClassGuaranteedGrantInterval	M	RC
docsQosServiceClassGuaranteedGrantRate	M	RC
docsQosServiceClassGuaranteedRequestInterval	M	RC

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosServiceClassAqmAlgorithm	M	RC
docsQosServiceClassImmedAqmMaxThreshold	M	RC
docsQosServiceClassImmedAqmRangeExponentRampFunc	M	RC
docsQosServiceClassLatencyHistBinEdges	M	RC
docsQosServiceClassDataRateUnitSetting	M	RC
docsQosPHSTable	D	N-Acc
docsQosPHSEntry	D	N-Acc
docsQosPHSField	D	RO
docsQosPHSMask	D	RO
docsQosPHSSize	D	RO
docsQosPHSVerify	D	RO
docsQosPHSIndex	D	RO
docsQosCmtsMacToSrvFlowTable	M	N-Acc
docsQosCmtsMacToSrvFlowEntry	M	N-Acc
docsQosCmtsCmMac	M	N-Acc
docsQosCmtsServiceFlowId	M	N-Acc
docsQosCmtsIfIndex	M	RO
docsQosServiceFlowSidClusterTable	M	N-Acc
docsQosServiceFlowSidClusterEntry	M	N-Acc
docsQosServiceFlowSidClusterId	M	N-Acc
docsQosServiceFlowSidClusterUcid	M	N-Acc
docsQosServiceFlowSidClusterSid	M	RO
docsQosAggregateServiceFlowTable	M	N-Acc
docsQosAggregateServiceFlowEntry	M	N-Acc
docsQosAggregateServiceFlowId	M	N-Acc
docsQosAggregateServiceFlowDirection	M	RO
docsQosAggregateServiceFlowPriority	M	RO
docsQosAggregateServiceFlowMaxAggregateTrafficRate	M	RO
docsQosAggregateServiceFlowMaxTrafficBurst	M	RO
docsQosAggregateServiceFlowMinReservedRate	M	RO
docsQosAggregateServiceFlowMinReservedPkt	M	RO
docsQosAggregateServiceFlowPeakTrafficRate	M	RO
docsQosAggregateServiceFlowDataRateUnitSetting	M	RO
docsQosAggregateServiceFlowLowLatencyAsf	M	RO
docsQosAggregateServiceFlowLowLatencySfId	M	RO
docsQosAggregateServiceFlowClassicSfScn	M	RO
docsQosAggregateServiceFlowLowLatencySfScn	M	RO
docsQosAggregateServiceFlowAqmCouplingFactor	M	RO
docsQosAggregateServiceFlowSchedulingWeight	M	RO
docsQosAggregateServiceFlowQpEnable	M	RO
docsQosAggregateServiceFlowQpLatencyThreshold	M	RO
docsQosAggregateServiceFlowQpQueuingScoreThreshold	M	RO
docsQosAggregateServiceFlowQpDrainRateExponent	M	RO
docsQosAggregateServiceFlowHCMaxAggregateTrafficRate	D	RO
docsQosAggregateServiceFlowHCMinReservedRate	D	RO

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosAggregateServiceFlowHCPeakTrafficRate	D	RO
docsQosAggregateServiceFlowAsfQosProfileName	**M**	**RO**
docsQosAqpTable	M	N-Acc
docsQosAqpEntry	M	N-Acc
docsQosAqpName	M	N-Acc
docsQosAqpStatus	M	RC
docsQosAqpDirection	M	RC
docsQosAqpPriority	M	RC
docsQosAqpMaxAggregateTrafficRate	M	RC
docsQosAqpMaxTrafficBurst	M	RC
docsQosAqpPeakTrafficRate	M	RC
docsQosAqpMinReservedRate	M	RC
docsQosAqpMinReservedPkt	M	RC
docsQosAqpDataRateUnitSetting	M	RC
docsQosAqpLowLatencyAsf	M	RC
docsQosAqpClassicSfScn	M	RC
docsQosAqpLatencySfScn	M	RC
docsQosAqpAqmCouplingFactor	M	RC
docsQosAqpSchedulingWeight	M	RC
docsQosAqpQpEnable	M	RC
docsQosAqpQpLatencyThreshold	M	RC
docsQosAqpQpQueuingScoreThreshold	M	RC
docsQosAqpQpDrainRateExponent	M	RC
docsQosAqpLowLatencyClassifierList	M	RC
docsQosAggregateServiceFlowStatsTable	M	N-Acc
docsQosAggregateServiceFlowStatsEntry	M	N-Acc
docsQosAggregateServiceFlowStatsPkts	M	RO
docsQosAggregateServiceFlowStatsOctets	M	RO
docsQosAggregateServiceFlowStatsTimeCreated	M	RO
docsQosAggregateServiceFlowStatsTimeActive	M	RO
docsQosSfLatencyHistCfgTable	M	N-Acc
docsQosSfLatencyHistCfgEntry	M	N-Acc
docsQosSfLatencyHistCfgStatus	M	RC
docsQosSfLatencySfLabel	M	RC
docsQosSfLatencyBin1UpperEdge	M	RC
docsQosSfLatencyBin2UpperEdge	M	RC
docsQosSfLatencyBin3UpperEdge	M	RC
docsQosSfLatencyBin4UpperEdge	M	RC
docsQosSfLatencyBin5UpperEdge	M	RC
docsQosSfLatencyBin6UpperEdge	M	RC
docsQosSfLatencyBin7UpperEdge	M	RC
docsQosSfLatencyBin8UpperEdge	M	RC
docsQosSfLatencyBin9UpperEdge	M	RC
docsQosSfLatencyBin10UpperEdge	M	RC
docsQosSfLatencyBin11UpperEdge	M	RC

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosSfLatencyBin12UpperEdge	M	RC
docsQosSfLatencyBin13UpperEdge	M	RC
docsQosSfLatencyBin14UpperEdge	M	RC
docsQosSfLatencyBin15UpperEdge	M	RC
docsQosSfLatencyBinEdgeNum	M	RC
docsQosSfLatencyStatsTable	M	N-Acc
docsQosSfLatencyStatsEntry	M	N-Acc
docsQosSfLatencyMaxLatency	M	RO
docsQosSfLatencyNumHistUpdates	M	RO
docsQosSfLatencyBin1Pkts	M	RO
docsQosSfLatencyBin2Pkts	M	RO
docsQosSfLatencyBin3Pkts	M	RO
docsQosSfLatencyBin4Pkts	M	RO
docsQosSfLatencyBin5Pkts	M	RO
docsQosSfLatencyBin6Pkts	M	RO
docsQosSfLatencyBin7Pkts	M	RO
docsQosSfLatencyBin8Pkts	M	RO
docsQosSfLatencyBin9Pkts	M	RO
docsQosSfLatencyBin10Pkts	M	RO
docsQosSfLatencyBin11Pkts	M	RO
docsQosSfLatencyBin12Pkts	M	RO
docsQosSfLatencyBin13Pkts	M	RO
docsQosSfLatencyBin14Pkts	M	RO
docsQosSfLatencyBin15Pkts	M	RO
docsQosSfLatencyBin16Pkts	M	RO
docsQosSfLatencySantionedPkts	M	RO
docsQosSfLatencyDroppedPkts	M	RO
docsQosSfLatencyTotalEct0Pkts	M	RO
docsQosSfLatencyCeMarkedEct0Pkts	M	RO
docsQosSfLatencyTotalEct1Pkts	M	RO
docsQosSfLatencyCeMarkedEct1Pkts	M	RO
docsQosGrpServiceFlowTable	M	N-Acc
docsQosGrpServiceFlowEntry	M	N-Acc
docsQosGrpServiceFlowIsDef	M	RO
docsQosGrpServiceFlowQosConfigId	M	RO
docsQosGrpServiceFlowNumSess	M	RO
docsQosGrpServiceFlowSrcAddr	M	RO
docsQosGrpServiceFlowGrpAddr	M	RO
docsQosGrpServiceFlowAddrType	D	RO
docsQosGrpServiceFlowSrcAddrType	M	RO
docsQosGrpServiceFlowGrpAddrType	M	RO
docsQosGrpPktClassTable	M	N-Acc
docsQosGrpPktClassEntry	M	N-Acc
docsQosGrpPktClassGrpConfigId	M	RO
docsQosUpChCounterExtTable	M	N-Acc

DOCS-QOS3-MIB [DOCS-QOS3-MIB]		
Object	**CMTS**	**Access**
docsQosUpChCounterExtEntry	M	N-Acc
docsQosUpChCounterExtSgmtValids	M	RO
docsQosUpChCounterExtSgmtDiscards	M	RO
docsQosServiceFlowCcfStatsTable	M	N-Acc
docsQosServiceFlowCcfStatsEntry	M	N-Acc
docsQosServiceFlowCcfStatsSgmtValids	M	RO
docsQosServiceFlowCcfStatsSgmtLost	M	RO
docsQosCmtsDsidTable	M	N-Acc
docsQosCmtsDsidEntry	M	N-Acc
docsQosCmtsDsidDsid	M	N-Acc
docsQosCmtsDsidUsage	M	RO
docsQosCmtsDsidDsChSet	M	RO
docsQosCmtsDsidReseqWaitTime	M	RO
docsQosCmtsDsidReseqWarnThrshld	M	RO
docsQosCmtsDsidStatusHoldOffTimerSeqOutOfRng	M	RO
docsQosCmtsDsidCurrentSeqNum	M	RO
docsQosCmtsDebugDsidTable	M	N-Acc
docsQosCmtsDebugDsidEntry	M	N-Acc
docsQosCmtsDebugDsidDsid	M	N-Acc
docsQosCmtsDebugDsidRowStatus	M	RC
docsQosCmtsDebugDsidStatsTable	M	N-Acc
docsQosCmtsDebugDsidStatsEntry	M	N-Acc
docsQosCmtsDebugDsidStatsDsIfIndex	M	N-Acc
docsQosCmtsDebugDsidStatsDsidPackets	M	RO
docsQosCmtsDebugDsidStatsDsidOctets	M	RO
docsQosCmtsIatcProfileStatsTable	M	N-Acc
docsQosCmtsIatcProfileStatsEntry	M	N-Acc
docsQosCmtsIatcProfileStatsName	M	N-Acc
docsQosCmtsIatcProfileStatsIfIndex	M	RO
docsQosCmtsIatcProfileStatsDirection	M	RO
docsQosCmtsIatcProfileStatsPkts	M	RO
docsQosCmtsIatcProfileStatsOctets	M	RO
docsQosCmtsIatcProfileStatsPolicedDropPkts	M	RO
docsQosCmtsIatcProfileStatsPolicedDelayPkts	M	RO
docsQosSfCongestionStatsTable	M	N-Acc
docsQosSfCongestionStatsEntry	M	N-Acc
docsQosSfCongestionSanctionedPkts	M	RO
docsQosSfCongestionTotalEct0Pkts	M	RO
docsQosSfCongestionTotalEct1Pkts	M	RO
docsQosSfCongestionCeMarkedEct1Pkts	M	RO
docsQosSfCongestionArrivedCePkts	M	RO
docsQosCfgAqmGlobalEnable	M	RO
docsQosCfgAqmGlobalDefaultLatencyTarget	M	RO

DOCS-IF3-MIB [DOCS-IF3-MIB]		
Object	**CMTS**	**Access**
docsIf3MdNodeStatusTable	M	N-Acc
docsIf3MdNodeStatusEntry	M	N-Acc
docsIf3MdNodeStatusNodeName	M	N-Acc
docsIf3MdNodeStatusMdCmSgId	M	N-Acc
docsIf3MdNodeStatusMdDsSgId	M	RO
docsIf3MdNodeStatusMdUsSgId	M	RO
docsIf3MdDsSgStatusTable	M	N-Acc
docsIf3MdDsSgStatusEntry	M	N-Acc
docsIf3MdDsSgStatusMdDsSgId	M	N-Acc
docsIf3MdDsSgStatusChSetId	M	RO
docsIf3MdUsSgStatusTable	M	N-Acc
docsIf3MdUsSgStatusEntry	M	N-Acc
docsIf3MdUsSgStatusMdUsSgId	M	N-Acc
docsIf3MdUsSgStatusChSetId	M	RO
docsIf3CmtsCmRegStatusTable	M	N-Acc
docsIf3CmtsCmRegStatusEntry	M	N-Acc
docsIf3CmtsCmRegStatusId	M	N-Acc
docsIf3CmtsCmRegStatusMacAddr	M	RO
docsIf3CmtsCmRegStatusIPv6Addr	M	RO
docsIf3CmtsCmRegStatusIPv6LinkLocal	M	RO
docsIf3CmtsCmRegStatusIPv4Addr	M	RO
docsIf3CmtsCmRegStatusValue	M	RO
docsIf3CmtsCmRegStatusMdIfIndex	M	RO
docsIf3CmtsCmRegStatusMdCmSgId	M	RO
docsIf3CmtsCmRegStatusRcpId	M	RO
docsIf3CmtsCmRegStatusRccStatusId	M	RO
docsIf3CmtsCmRegStatusRcsId	M	RO
docsIf3CmtsCmRegStatusTcsId	M	RO
docsIf3CmtsCmRegStatusQosVersion	M	RO
docsIf3CmtsCmRegStatusLastRegTime	M	RO
docsIf3CmtsCmRegStatusAddrResolutionReqs	M	RO
docsIf3CmtsCmRegStatusEnergyMgtEnabled	M	RO
docsIf3CmtsCmRegStatusEnergyMgtOperStatus	M	RO
docsIf3CmtsCmUsStatusTable	M	N-Acc
docsIf3CmtsCmUsStatusEntry	M	N-Acc
docsIf3CmtsCmUsStatusChIfIndex	M	N-Acc
docsIf3CmtsCmUsStatusModulationType	M	RO
docsIf3CmtsCmUsStatusRxPower	M	RO
docsIf3CmtsCmUsStatusSignalNoise	M	RO
docsIf3CmtsCmUsStatusMicroreflections	M	RO
docsIf3CmtsCmUsStatusEqData	M	RO
docsIf3CmtsCmUsStatusUnerroreds	M	RO
docsIf3CmtsCmUsStatusCorrecteds	M	RO
docsIf3CmtsCmUsStatusUncorrectables	M	RO
docsIf3CmtsCmUsStatusHighResolutionTimingOffset	M	RO

DOCS-IF3-MIB [DOCS-IF3-MIB]		
Object	**CMTS**	**Access**
docsIf3CmtsCmUsStatusIsMuted	M	RO
docsIf3CmtsCmUsStatusRangingStatus	M	RO
docsIf3MdCfgTable	M	N-Acc
docsIf3MdCfgEntry	M	N-Acc
docsIf3MdCfgMddInterval	M	RW
docsIf3MdCfgIpProvMode	M	RW
docsIf3MdCfgCmStatusEvCtlEnabled	M	RW
docsIf3MdCfgUsFreqRange	M	RW
docsIf3MdCfgMcastDsidFwdEnabled	O	RW
docsIf3MdCfgMultRxChModeEnabled	M	RW
docsIf3MdCfgMultTxChModeEnabled	M	RW
docsIf3MdCfgEarlyAuthEncrCtrl	M	RW
docsIf3MdCfgTftpProxyEnabled	M	RW
docsIf3MdCfgSrcAddrVerifEnabled	M	RW
docsIf3MdCfgDownChannelAnnex	M	RW
docsIf3MdCfgCmUdcEnabled	M	RW
docsIf3MdCfgSendUdcRulesEnabled	O	RW
docsIf3MdCfgServiceTypeIdList	M	RW
docsIf3MdCfgBpi2EnforceCtrl	M	RW
docsIf3MdCfgEnergyMgt1x1Enabled	M	RW
docsIf3MdChCfgTable	M	N-Acc
docsIf3MdChCfgEntry	M	N-Acc
docsIf3MdChCfgChIfIndex	M	N-Acc
docsIf3MdChCfgIsPriCapableDs	M	RC
docsIf3MdChCfgChId	M	RC
docsIf3MdChCfgSfProvAttrMask	M	RC
docsIf3MdChCfgRowStatus	M	RC
docsIf3MdUsToDsChMappingTable	M	N-Acc
docsIf3MdUsToDsChMappingEntry	M	N-Acc
docsIf3MdUsToDsChMappingUsIfIndex	M	N-Acc
docsIf3MdUsToDsChMappingDsIfIndex	M	N-Acc
docsIf3MdUsToDsChMappingMdIfIndex	M	RO
docsIf3DsChSetTable	M	N-Acc
docsIf3DsChSetEntry	M	N-Acc
docsIf3DsChSetId	M	N-Acc
docsIf3DsChSetChList	M	RO
docsIf3UsChSetTable	M	N-Acc
docsIf3UsChSetEntry	M	N-Acc
docsIf3UsChSetId	M	N-Acc
docsIf3UsChSetChList	M	RO
docsIf3BondingGrpCfgTable	M	N-Acc
docsIf3BondingGrpCfgEntry	M	N-Acc
docsIf3BondingGrpCfgDir	M	N-Acc
docsIf3BondingGrpCfgCfgId	M	N-Acc
docsIf3BondingGrpCfgChList	M	RC

DOCS-IF3-MIB [DOCS-IF3-MIB]		
Object	**CMTS**	**Access**
docsIf3BondingGrpCfgSfProvAttrMask	M	RC
docsIf3BondingGrpCfgDsidReseqWaitTime	M	RC
docsIf3BondingGrpCfgDsidReseqWarnThrshld	M	RC
docsIf3BondingGrpCfgRowStatus	M	RC
docsIf3DsBondingGrpStatusTable	M	N-Acc
docsIf3DsBondingGrpStatusEntry	M	N-Acc
docsIf3DsBondingGrpStatusChSetId	M	N-Acc
docsIf3DsBondingGrpStatusMdDsSgId	M	RO
docsIf3DsBondingGrpStatusCfgId	M	RO
docsIf3UsBondingGrpStatusTable	M	N-Acc
docsIf3UsBondingGrpStatusEntry	M	N-Acc
docsIf3UsBondingGrpStatusChSetId	M	N-Acc
docsIf3UsBondingGrpStatusMdUsSgId	M	RO
docsIf3UsBondingGrpStatusCfgId	M	RO
docsIf3RccCfgTable	D	N-Acc
docsIf3RccCfgEntry	D	N-Acc
docsIf3RccCfgRcpId	D	N-Acc
docsIf3RccCfgRccCfgId	D	N-Acc
docsIf3RccCfgVendorSpecific	D	RC
docsIf3RccCfgDescription	D	RC
docsIf3RccCfgRowStatus	D	RC
docsIf3RxChCfgTable	D	N-Acc
docsIf3RxChCfgEntry	D	N-Acc
docsIf3RxChCfgRcId	D	N-Acc
docsIf3RxChCfgChIfIndex	D	RO
docsIf3RxChCfgPrimaryDsIndicator	D	RC
docsIf3RxChCfgRcRmConnectivityId	D	RC
docsIf3RxChCfgRowStatus	D	RC
docsIf3RxModuleCfgTable	D	N-Acc
docsIf3RxModuleCfgEntry	D	N-Acc
docsIf3RxModuleCfgRmId	D	N-Acc
docsIf3RxModuleCfgRmRmConnectivityId	D	RC
docsIf3RxModuleCfgFirstCenterFrequency	D	RC
docsIf3RxModuleCfgRowStatus	D	RC
docsIf3RccStatusTable	M	N-Acc
docsIf3RccStatusEntry	M	N-Acc
docsIf3RccStatusRcpId	M	N-Acc
docsIf3RccStatusRccStatusId	M	N-Acc
docsIf3RccStatusRccCfgId	M	RO
docsIf3RccStatusValidityCode	M	RO
docsIf3RccStatusValidityCodeText	M	RO
docsIf3RxChStatusTable	M	N-Acc
docsIf3RxChStatusEntry	M	N-Acc
docsIf3RxChStatusRcId	M	N-Acc
docsIf3RxChStatusChIfIndex	M	RO

DOCS-IF3-MIB [DOCS-IF3-MIB]		
Object	**CMTS**	**Access**
docsIf3RxChStatusPrimaryDsIndicator	M	RO
docsIf3RxChStatusRcRmConnectivityId	M	RO
docsIf3RxModuleStatusTable	M	N-Acc
docsIf3RxModuleStatusEntry	M	N-Acc
docsIf3RxModuleStatusRmId	M	N-Acc
docsIf3RxModuleStatusRmRmConnectivityId	M	RO
docsIf3RxModuleStatusFirstCenterFrequency	M	RO
docsIf3SignalQualityExtTable	M	N-Acc
docsIf3SignalQualityExtEntry	M	N-Acc
docsIf3SignalQualityExtRxMER	M	RO
docsIf3SignalQualityExtRxMerSamples	M	RO
docsIf3CmtsSignalQualityExtTable	M	N-Acc
docsIf3CmtsSignalQualityExtEntry	M	N-Acc
docsIf3CmtsSignalQualityExtCNIR	M	RO
docsIf3CmtsSignalQualityExtExpectedRxSignalPower	M	RW
docsIf3CmtsSpectrumAnalysisMeasTable	D	N-Acc
docsIf3CmtsSpectrumAnalysisMeasEntry	D	N-Acc
docsIf3CmtsSpectrumAnalysisMeasAmplitudeData	D	RO
docsIf3CmtsSpectrumAnalysisMeasTimeInterval	D	RO
docsIf3CmtsSpectrumAnalysisMeasRowStatus	D	RC
docsIf3UsChExtTable	D	N-Acc
docsIf3UsChExtEntry	D	N-Acc
docsIf3UsChExtSacCodeHoppingSelectionMode	D	RO
docsIf3UsChExtScdmaSelectionStringActiveCodes	D	RO
docsIf3CmtsCmCtrlCmd		
docsIf3CmtsCmCtrlCmdMacAddr	M	RW
docsIf3CmtsCmCtrlCmdMuteUsChId	M	RW
docsIf3CmtsCmCtrlCmdMuteInterval	M	RW
docsIf3CmtsCmCtrlCmdDisableForwarding	M	RW
docsIf3CmtsCmCtrlCmdCommit	M	RW
docsIf3CmtsEventCtrlTable	M	N-Acc
docsIf3CmtsEventCtrlEntry	M	N-Acc
docsIf3CmtsEventCtrlEventId	M	N-Acc
docsIf3CmtsEventCtrlStatus	M	RC
docsIf3CmtsCmEmStatsTable	M	N-Acc
docsIf3CmtsCmEmStatsEntry	M	N-Acc
docsIf3CmtsCmEmStatsEm1x1ModeTotalDuration	M	RO
Notifications		
docsIf3CmtsEventNotif	M	Notif

DOCS-SUBMGT3-MIB [DOCS-SUBMGT3-MIB]		
Object	**CMTS**	**Access**
docsSubmgt3Base		
docsSubmgt3BaseCpeMaxIpv4Def	M	RW
docsSubmgt3BaseCpeMaxIpv6AddressesDef	D	RW

DOCS-SUBMGT3-MIB [DOCS-SUBMGT3-MIB]		
Object	**CMTS**	**Access**
docsSubmgt3BaseCpeMaxIpv6PrefixesDef	M	RW
docsSubmgt3BaseCpeActiveDef	M	RW
docsSubmgt3BaseCpeLearnableDef	M	RW
docsSubmgt3BaseSubFilterDownDef	M	RW
docsSubmgt3BaseSubFilterUpDef	M	RW
docsSubmgt3BaseCmFilterDownDef	M	RW
docsSubmgt3BaseCmFilterUpDef	M	RW
docsSubmgt3BasePsFilterDownDef	M	RW
docsSubmgt3BasePsFilterUpDef	M	RW
docsSubmgt3BaseMtaFilterDownDef	M	RW
docsSubmgt3BaseMtaFilterUpDef	M	RW
docsSubmgt3BaseStbFilterDownDef	M	RW
docsSubmgt3BaseStbFilterUpDef	M	RW
docsSubmgt3CpeCtrlTable	M	N-Acc
docsSubmgt3CpeCtrlEntry	M	N-Acc
docsSubmgt3CpeCtrlMaxCpeIpv4	M	RW
docsSubmgt3CpeCtrlMaxCpeIpv6Addresses	D	RW
docsSubmgt3CpeCtrlMaxCpeIpv6Prefixes	M	RW
docsSubmgt3CpeCtrlActive	M	RW
docsSubmgt3CpeCtrlLearnable	M	RW
docsSubmgt3CpeCtrlReset	M	RW
docsSubmgt3CpeCtrlLastReset	M	RW
docsSubmgt3CpeIpTable	M	N-Acc
docsSubmgt3CpeIpEntry	M	N-Acc
docsSubmgt3CpeIpId	M	N-Acc
docsSubmgt3CpeIpAddrType	M	RO
docsSubmgt3CpeIpAddr	M	RO
docsSubmgt3CpeIpAddrPrefixLen	M	RO
docsSubmgt3CpeIpLearned	M	RO
docsSubmgt3CpeIpType	M	RO
docsSubmgt3GrpTable	M	N-Acc
docsSubmgt3GrpEntry	M	N-Acc
docsSubMgt3GrpUdcGroupIds	M	RW
docsSubMgt3GrpUdcSentInRegRsp	M	RW
docsSubmgt3GrpSubFilterDs	M	RW
docsSubmgt3GrpSubFilterUs	M	RW
docsSubmgt3GrpCmFilterDs	M	RW
docsSubmgt3GrpCmFilterUs	M	RW
docsSubmgt3GrpPsFilterDs	M	RW
docsSubmgt3GrpPsFilterUs	M	RW
docsSubmgt3GrpMtaFilterDs	M	RW
docsSubmgt3GrpMtaFilterUs	M	RW
docsSubmgt3GrpStbFilterDs	M	RW
docsSubmgt3GrpStbFilterUs	M	RW
docsSubmgt3FilterGrpTable	M	N-Acc

DOCS-SUBMGT3-MIB [DOCS-SUBMGT3-MIB]		
Object	**CMTS**	**Access**
docsSubmgt3FilterGrpEntry	M	N-Acc
docsSubmgt3FilterGrpGrpId	M	N-Acc
docsSubmgt3FilterGrpRuleId	M	N-Acc
docsSubmgt3FilterGrpAction	M	RC
docsSubmgt3FilterGrpPriority	M	RC
docsSubmgt3FilterGrpIpTosLow	M	RC
docsSubmgt3FilterGrpIpTosHigh	M	RC
docsSubmgt3FilterGrpIpTosMask	M	RC
docsSubmgt3FilterGrpIpProtocol	M	RC
docsSubmgt3FilterGrpInetAddrType	M	RC
docsSubmgt3FilterGrpInetSrcAddr	M	RC
docsSubmgt3FilterGrpInetSrcMask	M	RC
docsSubmgt3FilterGrpInetDestAddr	M	RC
docsSubmgt3FilterGrpInetDestMask	M	RC
docsSubmgt3FilterGrpSrcPortStart	M	RC
docsSubmgt3FilterGrpSrcPortEnd	M	RC
docsSubmgt3FilterGrpDestPortStart	M	RC
docsSubmgt3FilterGrpDestPortEnd	M	RC
docsSubmgt3FilterGrpDestMacAddr	M	RC
docsSubmgt3FilterGrpDestMacMask	M	RC
docsSubmgt3FilterGrpSrcMacAddr	M	RC
docsSubmgt3FilterGrpEnetProtocolType	M	RC
docsSubmgt3FilterGrpEnetProtocol	M	RC
docsSubmgt3FilterGrpUserPriLow	M	RC
docsSubmgt3FilterGrpUserPriHigh	M	RC
docsSubmgt3FilterGrpVlanId	M	RC
docsSubmgt3FilterGrpClassPkts	M	RO
docsSubmgt3FilterGrpFlowLabel	M	RC
docsSubmgt3FilterGrpCmInterfaceMask	M	RC
docsSubmgt3FilterGrpRowStatus	M	RC

CLAB-TOPO-MIB [CLAB-TOPO-MIB]		
Object	**CMTS**	**Access**
clabTopoFiberNodeCfgTable	M	N-Acc
clabTopoFiberNodeCfgEntry	M	N-Acc
clabTopoFiberNodeCfgNodeName	M	N-Acc
clabTopoFiberNodeCfgNodeDescr	M	RC
clabTopoFiberNodeCfgRowStatus	M	RC
clabTopoChFnCfgTable	M	N-Acc
clabTopoChFnCfgEntry	M	N-Acc
clabTopoChFnCfgNodeName	M	N-Acc
clabTopoChFnCfgChIfIndex	M	N-Acc
clabTopoChFnCfgRowStatus	M	RC

DOCS-MCAST-AUTH-MIB [DOCS-MCAST-AUTH-MIB]		
Object	**CMTS**	**Access**
docsMcastAuthCtrl		
docsMcastAuthCtrlEnable	M	RW
docsMcastAuthCtrlDefProfileNameList	M	RW
docsMcastAuthCtrlDefAction	M	RW
docsMcastAuthCtrlDefMaxNumSess	M	RW
docsMcastAuthCmtsCmStatusTable	M	N-Acc
docsMcastAuthCmtsCmStatusEntry	M	N-Acc
docsMcastAuthCmtsCmStatusCfgProfileNameList	M	RO
docsMcastAuthCmtsCmStatusCfgListId	M	RO
docsMcastAuthCmtsCmStatusMaxNumSess	M	RO
docsMcastAuthCmtsCmStatusCfgParamFlag	M	RO
docsMcastAuthProfileSessRuleTable	M	N-Acc
docsMcastAuthProfileSessRuleEntry	M	N-Acc
docsMcastAuthProfileSessRuleId	M	N-Acc
docsMcastAuthProfileSessRulePriority	M	RC
docsMcastAuthProfileSessRulePrefixAddrType	M	RC
docsMcastAuthProfileSessRuleSrcPrefixAddr	M	RC
docsMcastAuthProfileSessRuleSrcPrefixLen	M	RC
docsMcastAuthProfileSessRuleGrpPrefixAddr	M	RC
docsMcastAuthProfileSessRuleGrpPrefixLen	M	RC
docsMcastAuthProfileSessRuleAction	M	RC
docsMcastAuthProfileSessRuleRowStatus	M	RC
docsMcastAuthStaticSessRuleTable	O	N-Acc
docsMcastAuthStaticSessRuleEntry	O	N-Acc
docsMcastAuthStaticSessRuleCfgListId	O	N-Acc
docsMcastAuthStaticSessRuleId	O	N-Acc
docsMcastAuthStaticSessRulePriority	O	RO
docsMcastAuthStaticSessRulePrefixAddrType	M	RO
docsMcastAuthStaticSessRuleSrcPrefixAddr	O	RO
docsMcastAuthStaticSessRuleSrcPrefixLen	O	RO
docsMcastAuthStaticSessRuleGrpPrefixAddr	O	RO
docsMcastAuthStaticSessRuleGrpPrefixLen	O	RO
docsMcastAuthStaticSessRuleAction	O	RO
docsMcastAuthStaticSessRuleSrcPrefixAddrType	O	RO
docsMcastAuthStaticSessRuleGrpPrefixAddrType	O	RO
docsMcastAuthProfilesTable	M	N-Acc
docsMcastAuthProfilesEntry	M	N-Acc
docsMcastAuthProfilesName	M	N-Acc
docsMcastAuthProfilesDescription	M	RC
docsMcastAuthProfilesRowStatus	M	RC

DOCS-MCAST-MIB [DOCS-MCAST-MIB]		
Object	**CMTS**	**Access**
docsMcastCmtsGrpCfgTable	M	N-Acc
docsMcastCmtsGrpCfgEntry	M	N-Acc

DOCS-MCAST-MIB [DOCS-MCAST-MIB]		
Object	**CMTS**	**Access**
docsMcastCmtsGrpCfgId	M	N-Acc
docsMcastCmtsGrpCfgRulePriority	M	RC
docsMcastCmtsGrpCfgPrefixAddrType	M	RC
docsMcastCmtsGrpCfgSrcPrefixAddr	M	RC
docsMcastCmtsGrpCfgSrcPrefixLen	M	RC
docsMcastCmtsGrpCfgGrpPrefixAddr	M	RC
docsMcastCmtsGrpCfgGrpPrefixLen	M	RC
docsMcastCmtsGrpCfgTosLow	M	RC
docsMcastCmtsGrpCfgTosHigh	M	RC
docsMcastCmtsGrpCfgTosMask	M	RC
docsMcastCmtsGrpCfgQosConfigId	M	RC
docsMcastCmtsGrpCfgEncryptConfigId	M	RC
docsMcastCmtsGrpCfgPhsConfigId	D	RC
docsMcastCmtsGrpCfgRowStatus	M	RC
docsMcastCmtsGrpEncryptCfgTable	M	N-Acc
docsMcastCmtsGrpEncryptCfgEntry	M	N-Acc
docsMcastCmtsGrpEncryptCfgId	M	N-Acc
docsMcastCmtsGrpEncryptCfgCtrl	M	RC
docsMcastCmtsGrpEncryptCfgAlg	M	RC
docsMcastCmtsGrpEncryptCfgRowStatus	M	RC
docsMcastCmtsGrpPhsCfgTable	D	N-Acc
docsMcastCmtsGrpPhsCfgEntry	D	N-Acc
docsMcastCmtsGrpPhsCfgId	D	N-Acc
docsMcastCmtsGrpPhsCfgPhsField	D	RC
docsMcastCmtsGrpPhsCfgPhsMask	D	RC
docsMcastCmtsGrpPhsCfgPhsSize	D	RC
docsMcastCmtsGrpPhsCfgPhsVerify	D	RC
docsMcastCmtsGrpPhsCfgRowStatus	D	RC
docsMcastCmtsGrpQosCfgTable	M	N-Acc
docsMcastCmtsGrpQosCfgEntry	M	N-Acc
docsMcastCmtsGrpQosCfgId	M	N-Acc
docsMcastCmtsGrpQosCfgServiceClassName	M	RC
docsMcastCmtsGrpQosCfgQosCtrl	M	RC
docsMcastCmtsGrpQosCfgAggSessLimit	M	RC
docsMcastCmtsGrpQosCfgAppId	M	RC
docsMcastCmtsGrpQosCfgRowStatus	M	RC
docsMcastCmtsReplSessTable	M	N-Acc
docsMcastCmtsReplSessEntry	M	N-Acc
docsMcastCmtsReplSessPrefixAddrType	M	N-Acc
docsMcastCmtsReplSessGrpPrefix	M	N-Acc
docsMcastCmtsReplSessSrcPrefix	M	N-Acc
docsMcastCmtsReplSessMdlfIndex	M	N-Acc
docsMcastCmtsReplSessDcsId	M	N-Acc
docsMcastCmtsReplSessServiceFlowId	M	N-Acc
docsMcastCmtsReplSessDsid	M	RO

DOCS-MCAST-MIB [DOCS-MCAST-MIB]		
Object	**CMTS**	**Access**
docsMcastCmtsReplSessSaid	M	RO
docsMcastDefGrpSvcClass		
docsMcastDefGrpSvcClassDef	M	RW
docsMcastDsidPhsTable	D	N-Acc
docsMcastDsidPhsEntry	D	N-Acc
docsMcastDsidPhsDsid	D	N-Acc
docsMcastDsidPhsPhsField	D	RO
docsMcastDsidPhsPhsMask	D	RO
docsMcastDsidPhsPhsSize	D	RO
docsMcastDsidPhsPhsVerify	D	RO
docsMcastStatsTable	M	N-Acc
docsMcastStatsEntry	M	N-Acc
docsMcastStatsGrpAddrType	M	N-Acc
docsMcastStatsGrpAddr	M	N-Acc
docsMcastStatsGrpPrefixLen	D	N-Acc
docsMcastStatsSrcAddrType	M	N-Acc
docsMcastStatsSrcAddr	M	N-Acc
docsMcastStatsSrcPrefixLen	D	N-Acc
docsMcastStatsDroppedPkts	M	RO
docsMcastStatsDroppedOctets	M	RO
docsMcastCpeListTable	M	N-Acc
docsMcastCpeListEntry	M	N-Acc
docsMcastCpeListGrpAddrType	M	N-Acc
docsMcastCpeListGrpAddr	M	N-Acc
docsMcastCpeListGrpPrefixLen	D	N-Acc
docsMcastCpeListSrcAddrType	M	N-Acc
docsMcastCpeListSrcAddr	M	N-Acc
docsMcastCpeListSrcPrefixLen	D	N-Acc
docsMcastCpeListCmMacAddr	M	N-Acc
docsMcastCpeListDsid	M	RO
docsMcastCpeListCpeMacAddr	M	RO
docsMcastCpeListCpeIpAddrType	M	RO
docsMcastCpeListCpeIpAddr	M	RO
docsMcastBandwidthTable	M	N-Acc
docsMcastBandwidthEntry	M	N-Acc
docsMcastBandwidthAdmittedAggrBW	M	RO
docsMcastBandwidthAdmittedAggrLowWater	M	RO
docsMcastBandwidthAdmittedAggrHighWater	M	RO

DOCS-SEC-MIB [DOCS-SEC-MIB]		
Object	**CMTS**	**Access**
docsSecCmtsCertRevocationList		
docsSecCmtsCertRevocationListUrl	M	RW
docsSecCmtsCertRevocationListRefreshInterval	M	RW
docsSecCmtsCertRevocationListLastUpdate	M	RO

DOCS-SEC-MIB [DOCS-SEC-MIB]		
Object	**CMTS**	**Access**
docsSecCmtsOnlineCertStatusProtocol		
docsSecCmtsOnlineCertStatusProtocolUrl	M	RW
docsSecCmtsOnlineCertStatusProtocolSignatureBypass	M	RW
docsSecCmtsServerCfg		
docsSecCmtsServerCfgTftpOptions	M	RW
docsSecCmtsServerCfgConfigFileLearningEnable	M	RW
docsSecCmtsEncrypt		
docsSecCmtsEncryptEncryptAlgPriority	M	RW
docsSecCmtsSavControl		
docsSecCmtsSavControlCmAuthEnable	M	RW
docsSecCmtsCmEaeExclusionTable	M	N-Acc
docsSecCmtsCmEaeExclusionEntry	M	N-Acc
docsSecCmtsCmEaeExclusionId	M	N-Acc
docsSecCmtsCmEaeExclusionMacAddr	M	RC
docsSecCmtsCmEaeExclusionMacAddrMask	M	RC
docsSecCmtsCmEaeExclusionRowStatus	M	RC
docsSecSavCmAuthTable	M	N-Acc
docsSecSavCmAuthEntry	M	N-Acc
docsSecSavCmAuthGrpName	M	RO
docsSecSavCmAuthStaticPrefixListId	M	RO
docsSecSavCfgListTable	M	N-Acc
docsSecSavCfgListEntry	M	N-Acc
docsSecSavCfgListName	M	N-Acc
docsSecSavCfgListRuleId	M	N-Acc
docsSecSavCfgListPrefixAddrType	M	RC
docsSecSavCfgListPrefixAddr	M	RC
docsSecSavCfgListPrefixLen	M	RC
docsSecSavCfgListRowStatus	M	RC
docsSecSavStaticListTable	M	N-Acc
docsSecSavStaticListEntry	M	N-Acc
docsSecSavStaticListId	M	N-Acc
docsSecSavStaticListRuleId	M	N-Acc
docsSecSavStaticListPrefixAddrType	M	RO
docsSecSavStaticListPrefixAddr	M	RO
docsSecSavStaticListPrefixLen	M	RO
docsSecCmtsCmSavStatsTable	M	N-Acc
docsSecCmtsCmSavStatsEntry	M	N-Acc
docsSecCmtsCmSavStatsSavDiscards	M	RO
docsSecCmtsCertificate		
docsSecCmtsCertificateCertRevocationMethod	M	RW
docsSecCmtsCmBpi2EnforceExclusionTable	M	N-Acc
docsSecCmtsCmBpi2EnforceExclusionEntry	M	N-Acc
docsSecCmtsCmBpi2EnforceExclusionId	M	N-Acc
docsSecCmtsCmBpi2EnforceExclusionMacAddr	M	N-Acc
docsSecCmtsCmBpi2EnforceExclusionMacAddrMask	M	RC

DOCS-SEC-MIB [DOCS-SEC-MIB]		
Object	**CMTS**	**Access**
docsSecCmtsCmBpi2EnforceExclusionRowStatus	M	RC

IPMCAST-MIB [RFC 5132]		
Object	**CMTS**	**Access**
ipMcast Group		
ipMcastEnabled	M	RO
ipMcastRouteEntryCount	M	RO
ipMcastRouteTable	M	N-Acc
ipMcastRouteEntry	M	N-Acc
ipMcastRouteGroupAddressType	M	N-Acc
ipMcastRouteGroup	M	N-Acc
ipMcastRouteGroupPrefixLength	M	N-Acc
ipMcastRouteSourceAddressType	M	N-Acc
ipMcastRouteSource	M	N-Acc
ipMcastRouteSourcePrefixLength	M	N-Acc
ipMcastRouteUpstreamNeighborType	M	RO
ipMcastRouteUpstreamNeighbor	M	RO
ipMcastRouteInIfIndex	M	RO
ipMcastRouteTimeStamp	M	RO
ipMcastRouteExpiryTime	M	RO
ipMcastRouteProtocol	M	RO
ipMcastRouteRtProtocol	M	RO
ipMcastRouteRtAddressType	M	RO
ipMcastRouteRtPrefixLength	M	RO
ipMcastRouteRtType	M	RO
ipMcastRouteOctets	M	RO
ipMcastRoutePkts	M	RO
ipMcastRouteTtlDropOctets	M	RO
ipMcastRouteTtlDropPackets	M	RO
ipMcastRouteDifferentInIfOctets	M	RO
ipMcastRouteDifferentInIfPackets	M	RO
ipMcastRouteBps	M	RO

DOCS-LEAK-DETECT-MIB [DOCS-LEAK-DETECT-MIB]		
Object	**CMTS**	**Access**
docsLeakDetTestGroup		
docsLeakDetTestSupportsNumBurstsNotReceived	M	RO
docsLeakDetTestSessionStatusTable	M	N-Acc
docsLeakDetTestSessionStatusEntry	M	N-Acc
docsLeakDetTestSessionStatusSessionId	M	N-Acc
docsLeakDetTestSessionStatusSessionType	M	RO
docsLeakDetTestSessionStatusStatus	M	RO
docsLeakDetTestSessionStatusStartTime	M	RO
docsLeakDetTestSessionStatusStopTime	M	RO
docsLeakDetTestSessionStatsTable	M	N-Acc

DOCS-LEAK-DETECT-MIB [DOCS-LEAK-DETECT-MIB]		
Object	**CMTS**	**Access**
docsLeakDetTestSessionStatsEntry	M	N-Acc
docsLeakDetTestSessionStatsCmMacAddress	M	N-Acc
docsLeakDetTestSessionStatsNumBurstsGranted	M	RO
docsLeakDetTestSessionStatsNumBurstsNotReceived	M	RO
docsLeakDetTestSessionStatsNumTestBytesReceived	M	RO
docsLeakDetTestChannelStatusTable	M	N-Acc
docsLeakDetTestChannelStatusEntry	M	N-Acc
docsLeakDetTestChannelStatusInterfaceName	M	N-Acc
docsLeakDetTestChannelStatusTestStartFreq	M	RO
docsLeakDetTestChannelStatusTestEndFreq	M	RO

A.2 CCAP-MIB Object Details

The table below lists the CCAP compliance requirements summary.

Table 620 - CCAP-MIB Object Details

CCAP-MIB [CCAP-MIB]		
ccapInterfaceIndexMapTable		
Objects	**Requirement**	**Access**
ccapInterfaceIndexMapEntry	M	N-Acc
ccapInterfaceIndexMapPath	M	RO
ccapInterfaceIndexMapEntPhysicalIndex	M	RO
ccapMpegInputProgTable		
Objects	**Requirement**	**Access**
ccapMpegInputProgEntry	M	N-Acc
ccapMpegInputProgBitRate	M	RO
ccapMpegInputProgRequestedBandwidth	M	RO
ccapMpegOutputProgTable		
Objects	**Requirement**	**Access**
ccapMpegOutputProgEntry	M	N-Acc
ccapMpegOutputProgBitRate	M	RO
ccapMpegInputProgVideoSessionTable		
Objects	**Requirement**	**Access**
ccapMpegInputProgVideoSessionEntry	M	N-Acc
ccapMpegInputProgVideoSessionStatus	M	RO
ccapMpegOutputProgVideoSessionTable		
Objects	**Requirement**	**Access**
ccapMpegOutputProgVideoSessionEntry	M	N-Acc
ccapMpegOutputProgVideoSessionStatus	M	RO
ccapEcmgStatusTable		
Objects	**Requirement**	**Access**
ccapEcmgStatusEntry	M	N-Acc
ccapEcmgIndex	M	N-Acc
ccapEcmgNumActiveSessions	M	RO
ccapEcmgCwMessageCount	M	RO
ccapEcmdStatusTable		
Objects	**Requirement**	**Access**
ccapEcmdStatusEntry	M	N-Acc
ccapEcmdIndex	M	N-Acc
ccapEcmdNumActiveSessions	M	RO
ccapEcmdCwMessageCount	M	RO
ccapMpegDecryptSessionTable		
Objects	**Requirement**	**Access**
ccapMpegDecryptSessionEntry	M	N-Acc
ccapMpegDecryptSessionDecrypted=	M	RO

A.3 HMS-MIB Object Details

The table below lists the CCAP compliance requirements summary.

Table 621 - HMS-MIB Object Details

SCTE-HMS-QAM-MIB [SCTE 154-2]		
qamChannelTable		
Objects	**Requirement**	**Access**
qamChannelFrequency	M	RO
qamChannelModulationFormat	M	RO
qamChannelInterleaverLevel	M	RO
qamChannelInterleaverMode	M	RO
qamChannelPower	M	RO
qamChannelSquelch	M	RO
qamChannelContWaveMode	M	RO
qamChannelAnnexMode	M	RO
qamChannelCommonTable		
Objects	**Requirement**	**Access**
qamChannelCommonOutputBw	M	RO
qamChannelCommonUtilization	M	RO
qamConfigTable		
Objects	**Requirement**	**Access**
qamConfigIndex	M	N-Acc
qamConfigQamChannelIdMin	M	RO
qamConfigQamChannelIdMax	M	RO
qamConfigIPAddrType	M	RO
qamConfigIPAddr	M	RO
qamConfigUdpPortRangeMin	M	RO
qamConfigUdpPortRangeMax	M	RO
qamConfigOutputProgNoMin	M	RO
qamConfigOutputProgNoMax	M	RO
SCTE-HMS-MPEG-MIB [SCTE 154-4]		
mpegDigitalInputs		
Object	**Requirement**	**Access**
mpegLossOfSignalTimeout	M	RO
mpegInputTSTable		
Objects	**Requirement**	**Access**
mpegInputTSIndex	M	N-Acc
mpegInputTSType	M	RO
mpegInputTSConnectionType	M	RO
mpegInputTSConnection	M	RO
mpegInputTSActiveConnection	M	RO
mpegInputTSPsiDetected	M	RO
mpegInputTSStartTime	M	RO
mpegInputTSResourceAllocated	M	RO
mpegInputTSNumPrograms	M	RO
mpegInputTSRate	M	RO

SCTE-HMS-QAM-MIB [SCTE 154-2]		
mpegInputTSMaxRate	M	RO
mpegInputTSPatVersion	M	RO
mpegInputTSCatVersion	M	RO
mpegInputTSNitPid	M	RO
mpegInputTSNumEmms	M	RO
mpegInputTSTSID	M	RO
mpegInputTSLock	O	RO
mpegInputProgTable		
Objects	**Requirement**	**Access**
mpegInputProgIndex	M	N-Acc
mpegInputProgNo	M	RO
mpegInputProgPmtVersion	M	RO
mpegInputProgPmtPid	M	RO
mpegInputProgPcrPid	M	RO
mpegInputProgEcmPid	M	RO
mpegInputProgNumElems	M	RO
mpegInputProgNumEcms	M	RO
mpegInputProgCaDescr	M	RO
mpegInputProgScte35Descr	O	RO
mpegInputProgScte18Descr	O	RO
mpegProgESTable		
Objects	**Requirement**	**Access**
mpegProgESIndex	M	N-Acc
mpegProgESPID	M	RO
mpegProgESType	M	RO
mpegProgESCaDescr	M	RO
mpegProgESScte35Descr	O	RO
mpegProgESScte18Descr	O	RO
mpegInputStatsTable		
Objects	**Requirement**	**Access**
mpegInputStatsPcrJitter	M	RO
mpegInputStatsMaxPacketJitter	M	RO
mpegInputStatsPcrPackets	M	RO
mpegInputStatsNonPcrPackets	M	RO
mpegInputStatsUnexpectedPackets	M	RO
mpegInputStatsContinuityErrors	M	RO
mpegInputStatsSyncLossPackets	M	RO
mpegInputStatsPcrIntervalExceeds	M	RO
mpegInputUdpOriginationTable		
Objects	**Requirement**	**Access**
mpegInputUdpOriginationIndex	M	N-Acc
mpegInputUdpOriginationId	M	N-Acc
mpegInputUdpOriginationIfIndex	M	RO
mpegInputUdpOriginationInetAddrType	M	RO
mpegInputUdpOriginationSrcInetAddr	M	RO
mpegInputUdpOriginationDestInetAddr	M	RO

SCTE-HMS-QAM-MIB [SCTE 154-2]		
mpegInputUdpOriginationDestPort	M	RO
mpegInputUdpOriginationActive	M	RO
mpegInputUdpOriginationPacketsDetected	M	RO
mpegInputUdpOriginationRank	M	RO
mpegInputUdpOriginationInputTSIndex	M	RO
mpegInsertPacketTable		
Objects	**Requirement**	**Access**
mpegInsertPacketIndex	M	N-Acc
mpegInsertPacketListId	M	RO
mpegInsertPacketImmediateExecution	M	RO
mpegInsertPacketStartTime	M	RO
mpegInsertPacketRepeat	M	RO
mpegInsertPacketContinuousFlag	M	RO
mpegInsertPacketRate	M	RO
mpegInsertPacketDeviceIndex	M	RO
mpegOutputStatsTable		
Objects	**Requirement**	**Access**
mpegOutputStatsDroppedPackets	M	RO
mpegOutputStatsFifoOverflow	M	RO
mpegOutputStatsFifoUnderflow	M	RO
mpegOutputStatsDataRate	M	RO
mpegOutputStatsAvailableBandwidth	M	RO
mpegOutputStatsChannelUtilization	M	RO
mpegOutputStatsTotalPackets	M	RO
mpegOutputTSTable		
Objects	**Requirement**	**Access**
mpegOutputTSIndex	M	N-Acc
mpegOutputTSType	M	RO
mpegOutputTSConnectionType	M	RO
mpegOutputTSConnection	M	RO
mpegOutputTSNumPrograms	M	RO
mpegOutputTSTSID	M	RO
mpegOutputTSNitPid	M	RO
mpegOutputTSCaPid	M	RO
mpegOutputTSCatInsertRate	M	RO
mpegOutputTSPatInsertRate	M	RO
mpegOutputTSPmtInsertRate	M	RO
mpegOutputTSStartTime	M	RO
mpegOutputProgTable		
Objects	**Requirement**	**Access**
mpegOutputProgIndex	M	N-Acc
mpegOutputProgNo	M	RO
mpegOutputProgPmtVersion	M	RO
mpegOutputProgPmtPid	M	RO
mpegOutputProgPcrPid	M	RO
mpegOutputProgEcmPid	M	RO

SCTE-HMS-QAM-MIB [SCTE 154-2]		
mpegOutputProgNumElems	M	RO
mpegOutputProgNumEcms	M	RO
mpegOutputProgCaDescr	M	RO
mpegOutputProgScte35Descr	O	RO
mpegOutputProgScte18Descr	O	RO
mpegOutputProgElemStatsTable		
Objects	**Requirement**	**Access**
mpegOutputProgElemStatsIndex	M	N-Acc
mpegOutputProgElemStatsPid	M	RO
mpegOutputProgElemStatsElemType	M	RO
mpegOutputProgElemStatsDataRate	O	RO
mpegOutputUdpDestinationTable		
Objects	**Requirement**	**Access**
mpegOutputUdpDestinationIndex	NA	
mpegOutputUdpDestinationId	NA	
mpegOutputUdpDestinationIfIndex	NA	
mpegOutputUdpDestinationInetAddrType	NA	
mpegOutputUdpDestinationSrcInetAddr	NA	
mpegOutputUdpDestinationDestInetAddr	NA	
mpegOutputUdpDestinationDestPort	NA	
mpegOutputUdpDestinationOutputTSIndex	NA	
mpegProgramMappingTable		
Objects	**Requirement**	**Access**
mpegProgramMappingIndex	M	N-Acc
mpegProgramMappingOutputProgIndex	M	RO
mpegProgramMappingOutputTSIndex	M	RO
mpegProgramMappingInputProgIndex	M	RO
mpegProgramMappingInputTSIndex	M	RO
mpegVideoSessionTable		
Objects	**Requirement**	**Access**
mpegVideoSessionIndex	M	N-Acc
mpegVideoSessionPhyMappingIndex	M	RO
mpegVideoSessionPIDRemap	M	RO
mpegVideoSessionMode	M	RO
mpegVideoSessionState	M	RO
mpegVideoSessionProvMethod	M	RO
mpegVideoSessionEncryptionType	M	RO
mpegVideoSessionEncryptionInfo	M	RO
mpegVideoSessionBitRate	M	RO
mpegVideoSessionID	M	RO
mpegVideoSessionSelectedInput	M	RO
mpegVideoSessionSelectedOutput	M	RO
mpegVideoSessionPtrTable		
Objects	**Requirement**	**Access**
mpegVideoSessionPtrInputProgIndex	M	N-Acc
mpegVideoSessionPtrInputTSIndex	M	RO

SCTE-HMS-QAM-MIB [SCTE 154-2]		
mpegVideoSessionPtrInputTSConnType	M	RO
mpegVideoSessionPtrInputTSConnection	M	RO
mpegVideoSessionPtrOutputProgIndex	M	RO
mpegVideoSessionPtrOutputTSIndex	M	RO
mpegVideoSessionPtrOutputTSConnType	M	RO
mpegVideoSessionPtrOutputTSConnection	M	RO
mpegVideoSessionPtrStatus	M	RO
mpegInputTSOutputSessionTable		
Objects	**Requirement**	**Access**
mpegInputTSOutputSessionCreateTime	M	RO

A.4 PNM MIB Object Details

The table below lists the CCAP compliance requirements summary.

Table 622 - PNM MIB Object Details

DOCS-PNM-MIB [DOCS-PNM-MIB]		
Object	**CMTS**	**Access**
docsPnmCcapBulkDataControlTable	M	N-Acc
docsPnmCcapBulkDataControlEntry	M	N-Acc
docsPnmCcapBulkDataControlServerIndex	M	N-Acc
docsPnmCcapBulkDataControlDestIpAddrType	M	RW
docsPnmCcapBulkDataControlDestIpAddr	M	RW
docsPnmCcapBulkDataControlDestPath	M	RW
docsPnmCcapBulkDataControlUploadControl	M	RW
docsPnmCcapBulkDataControlPnmTestSelector	M	RW
docsPnmBulkFileTable	D	N-Acc
docsPnmBulkFileEntry	D	N-Acc
docsPnmBulkFileIndex	D	N-Acc
docsPnmBulkFileName	D	RO
docsPnmBulkFileControl	D	RW
docsPnmBulkFileUploadStatus	D	RO
docsPnmCmtsDsOfdmSymCapTable	M	N-Acc
docsPnmCmtsDsOfdmSymCapEntry	M	N-Acc
docsPnmCmtsDsOfdmSymTrigEnable	M	RW
docsPnmCmtsDsOfdmSymTrigGroupId	M	RW
docsPnmCmtsDsOfdmSymCaptFileName	M	RW
docsPnmCmtsDsOfdmSymMeasStatus	M	RO
docsPnmCmtsDsOfdmSymFirstActSubCarIdx	M	RO
docsPnmCmtsDsOfdmSymLastActSubCarIdx	M	RO
docsPnmCmtsDsOfdmSymRxWindowing	M	RO
docsPnmCmtsDsOfdmSymTransactionId	M	RO
docsPnmCmtsDsOfdmSymSampleRate	M	RO
docsPnmCmtsDsOfdmSymFftLength	M	RO
docsPnmCmtsDsOfdmSymDestinationIndex	M	RW
docsPnmCmtsDsOfdmNoisePwrRatioTable	M	N-Acc

DOCS-PNM-MIB [DOCS-PNM-MIB]		
Object	**CMTS**	**Access**
docsPnmCmtsDsOfdmNoisePwrRatioEntry	M	N-Acc
docsPnmCmtsDsOfdmNprStartSubcar	M	RW
docsPnmCmtsDsOfdmNprStopSubcar	M	RW
docsPnmCmtsDsOfdmNprEnable	M	RW
docsPnmCmtsDsOfdmNprDuration	M	RW
docsPnmCmtsUsOfdmaAQProbeTable	M	N-Acc
docsPnmCmtsUsOfdmaAQProbeEntry	M	N-Acc
docsPnmCmtsUsOfdmaAQProbeCmMacAddr	M	RW
docsPnmCmtsUsOfdmaAQProbeUseIdleSid	M	RW
docsPnmCmtsUsOfdmaAQProbePreEqOn	M	RW
docsPnmCmtsUsOfdmaAQProbeEnable	M	RW
docsPnmCmtsUsOfdmaAQProbeTimeout	M	RW
docsPnmCmtsUsOfdmaAQProbeNumSymToCapt	M	RW
docsPnmCmtsUsOfdmaAQProbeMaxCaptSymbols	M	RO
docsPnmCmtsUsOfdmaAQProbeNumSamples	M	RO
docsPnmCmtsUsOfdmaAQProbeTimeStamp	M	RO
docsPnmCmtsUsOfdmaAQProbeMeasStatus	M	RO
docsPnmCmtsUsOfdmaAQProbeFreqDomainSamples	M	RW
docsPnmCmtsUsOfdmaAQProbeDestinationIndex	M	RW
docsPnmCmtsUsOfdmaAQProbeFileName	M	RW
docsPnmCmtsUsImpNoiseTable	M	N-Acc
docsPnmCmtsUsImpNoiseEntry	M	N-Acc
docsPnmCmtsUsImpNoiseEnable	M	RW
docsPnmCmtsUsImpNoiseFreeRunDuration	M	RW
docsPnmCmtsUsImpNoiseStTrigLvl	M	RW
docsPnmCmtsUsImpNoiseEndTrigLvl	M	RW
docsPnmCmtsUsImpNoiseCenterFrq	M	RW
docsPnmCmtsUsImpNoiseMeasBw	M	RW
docsPnmCmtsUsImpNoiseNumEvtsCnted	M	RO
docsPnmCmtsUsImpNoiseLastEvtTimeStamp	M	RO
docsPnmCmtsUsImpNoiseLastEvtDuration	M	RO
docsPnmCmtsUsImpNoiseLastEvtAvgPwr	M	RO
docsPnmCmtsUsImpNoiseMeasStatus	M	RO
docsPnmCmtsUsImpNoiseFileName	M	RW
docsPnmCmtsUsImpNoiseDestinationIndex	M	RW
docsPnmCmtsUsHistTable	M	N-Acc
docsPnmCmtsUsHistEntry	M	N-Acc
docsPnmCmtsUsHistEnable	M	RW
docsPnmCmtsUsHistTimeOut	M	RW
docsPnmCmtsUsHistMeasStatus	M	RO
docsPnmCmtsUsHistFileName	M	RW
docsPnmCmtsUsHistDestinationIndex	M	RW
docsPnmCmtsUsOfdmaRxPwrTable	M	N-Acc
docsPnmCmtsUsOfdmaRxPwrEntry	M	N-Acc
docsPnmCmtsUsOfdmaRxPwrEnable	M	RW

DOCS-PNM-MIB [DOCS-PNM-MIB]		
Object	**CMTS**	**Access**
docsPnmCmtsUsOfdmaRxPwrCmMac	M	N-Acc
docsPnmCmtsUsOfdmaRxPwrPreEq	M	RW
docsPnmCmtsUsOfdmaRxPwrNumAvgs	M	RW
docsPnmCmtsUsOfdmaRxPwrOnePtSixPsd	M	RO
docsPnmCmtsUsOfdmaRxPwrMeasStatus	M	RO
docsPnmCmtsUsOfdmaRxMerTable	M	N-Acc
docsPnmCmtsUsOfdmaRxMerEntry	M	N-Acc
docsPnmCmtsUsOfdmaRxMerEnable	M	RW
docsPnmCmtsUsOfdmaRxMerCmMac	M	RW
docsPnmCmtsUsOfdmaRxMerPreEq	M	RW
docsPnmCmtsUsOfdmaRxMerNumAvgs	M	RW
docsPnmCmtsUsOfdmaRxMerMeasStatus	M	RO
docsPnmCmtsUsOfdmaRxMerFileName	M	RW
docsPnmCmtsUsOfdmaRxMerDestinationIndex	M	RW
docsPnmCmtsUsSpecAnTable	D	N-Acc
docsPnmCmtsUsSpecAnEntry	D	N-Acc
docsPnmCmtsUsSpecAnEnable	D	RW
docsPnmCmtsUsSpecAnTrigMode	D	RW
docsPnmCmtsUsSpecAnMiniSlotCnt	D	RW
docsPnmCmtsUsSpecAnSid	D	RW
docsPnmCmtsUsSpecAnMiniSlotNum	D	RW
docsPnmCmtsUsSpecAnCmMac	D	RW
docsPnmCmtsUsSpecAnCenterFreq	D	RW
docsPnmCmtsUsSpecAnSpan	D	RW
docsPnmCmtsUsSpecAnNumberOfBins	D	RW
docsPnmCmtsUsSpecAnMeasStatus	D	RO
docsPnmCmtsUsSpecAnFileName	D	RW
docsPnmCmtsOptReqTable	M	N-Acc
docsPnmCmtsOptReqEntry	M	N-Acc
docsPnmCmtsOptReqCmMacAddr	M	N-Acc
docsPnmCmtsOptReqDsOfdmChanCfgIndex	M	N-Acc
docsPnmCmtsOptReqDsOfdmProfCfgId	M	N-Acc
docsPnmCmtsOptReqOpCode	M	RC
docsPnmCmtsOptReqProfileTest	M	RC
docsPnmCmtsOptReqMaxDuration	M	RC
docsPnmCmtsOptReqMaxCodewords	M	RC
docsPnmCmtsOptReqMaxUncorrectableCws	M	RC
docsPnmCmtsOptReqCwTaggingEnabled	M	RC
docsPnmCmtsOptReqNcpFields	M	RC
docsPnmCmtsOptReqMaxNcpCrcFails	M	RC
docsPnmCmtsOptReqStatus	M	RC
docsPnmCmtsOptMerThreshCfgTable	M	N-Acc
DocsPnmCmtsOptMerThreshCfgEntry	M	N-Acc
docsPnmCmtsOptMerThreshCfgModOrder	M	N-Acc
docsPnmCmtsOptMerThreshCfgRxMerVsBitloadingTarget	M	RC

DOCS-PNM-MIB [DOCS-PNM-MIB]		
Object	**CMTS**	**Access**
docsPnmCmtsOptMerThreshCfgRxMerMargin	M	RC
docsPnmCmtsOptMerThreshCfgStatus	M	RC
docsPnmCmtsOptProfChgCfgTable	O	N-Acc
docsPnmCmtsOptProfChgCfgEntry	O	N-Acc
docsPnmCmtsOptProfChgCfgIfIndex	O	N-Acc
docsPnmCmtsOptProfChgCfgDsProfList	O	RC
docsPnmCmtsOptProfChgCfgStatus	O	RC
docsPnmCmtsOptRespTable	M	N-Acc
docsPnmCmtsOptRespEntry	M	N-Acc
docsPnmCmtsOptRespStatus	M	RO
docsPnmCmtsOptRespFirstActiveSubcarrierNum	M	RO
docsPnmCmtsOptRespMerData	M	RO
docsPnmCmtsOptRespMerPassFailData	M	RO
docsPnmCmtsOptRespNumSubcarriersBelowThresh	M	RO
docsPnmCmtsOptRespSnrMarginData	M	RO
docsPnmCmtsOptRespCodewordCt	M	RO
docsPnmCmtsOptRespCorrectedCodewordCt	M	RO
docsPnmCmtsOptRespUncorrectableCodewordCt	M	RO
docsPnmCmtsOptRespNcpFieldCt	M	RO
docsPnmCmtsOptRespNcpCrcFailCt	M	RO
docsPnmCmtsUtscCapabTable	M	N-Acc
docsPnmCmtsUtscCapabEntry	M	N-Acc
docsPnmCmtsUtscCapabTriggerMode	M	RO
docsPnmCmtsUtscCapabOutputFormat	M	RO
docsPnmCmtsUtscCapabWindow	M	RO
docsPnmCmtsUtscCapabDescription	M	RO
docsPnmCmtsUtscCfgTable	M	N-Acc
docsPnmCmtsUtscCfgEntry	M	N-Acc
docsPnmCmtsUtscCfgIndex	M	N-Acc
docsPnmCmtsUtscCfgLogicalChIfIndex	M	RC
docsPnmCmtsUtscCfgTriggerMode	M	RC
docsPnmCmtsUtscCfgMinislotCount	M	RC
docsPnmCmtsUtscCfgSid	M	RC
docsPnmCmtsUtscCfgCmMacAddr	M	RC
docsPnmCmtsUtscCfgTimestamp	M	RC
docsPnmCmtsUtscCfgCenterFreq	M	RC
docsPnmCmtsUtscCfgSpan	M	RC
docsPnmCmtsUtscCfgNumBins	M	RC
docsPnmCmtsUtscCfgAveraging	M	RC
docsPnmCmtsUtscCfgFilename	M	RC
docsPnmCmtsUtscCfgQualifyCenterFreq	M	RC
docsPnmCmtsUtscCfgQualifyBw	M	RC
docsPnmCmtsUtscCfgQualifyThrshld	M	RC
docsPnmCmtsUtscCfgWindow	M	RC
docsPnmCmtsUtscCfgOutputFormat	M	RC

DOCS-PNM-MIB [DOCS-PNM-MIB]		
Object	**CMTS**	**Access**
docsPnmCmtsUtscCfgRepeatPeriod	M	RC
docsPnmCmtsUtscCfgFreeRunDuration	M	RC
docsPnmCmtsUtscCfgTriggerCount	M	RW
docsPnmCmtsUtscCfgStatus	M	RC
docsPnmCmtsUtscCfgBurstIuc	M	RC
docsPnmCmtsUtscCfgMaxResultsPerFile	M	RC
docsPnmCmtsUtscCtrlTable	M	N-Acc
docsPnmCmtsUtscCtrlEntry	M	N-Acc
docsPnmCmtsUtscCtrlInitiateTest	M	RW
docsPnmCmtsUtscStatusTable	M	N-Acc
docsPnmCmtsUtscStatusEntry	M	N-Acc
docsPnmCmtsUtscStatusMeasStatus	M	RO
docsPnmCmtsUtscStatusCalibrationConstantK	M	RO
docsPnmCmtsUtscResultTable	M	N-Acc
docsPnmCmtsUtscResultEntry	M	N-Acc
docsPnmCmtsUtscResultSampleRate	M	RO
docsPnmCmtsUtscResultUsSampleSize	M	RO
docsPnmCmtsUtscResultSampleTimestamp	M	RO
docsPnmCmtsUtscResultResolutionBw	M	RO
docsPnmCmtsUtscResultOutput	M	RO
docsPnmCmtsUtscResultCalibrationConstantK	M	RO
docsPnmBulkDataTransferCfgTable	M	N-Acc
docsPnmBulkDataTransferCfgEntry	M	N-Acc
docsPnmBulkDataTransferCfgDestIndex	M	N-Acc
docsPnmBulkDataTransferCfgDestHostname	M	RC
docsPnmBulkDataTransferCfgDestHostIpAddrType	M	RC
docsPnmBulkDataTransferCfgDestHostIpAddress	M	RC
docsPnmBulkDataTransferCfgDestPort	M	RC
docsPnmBulkDataTransferCfgDestBaseUri	M	RC
docsPnmBulkDataTransferCfgProtocol	M	RC
docsPnmBulkDataTransferCfgLocalStore	M	RC
docsPnmBulkDataTransferCfgRowStatus	M	RC
docsPnmBulkFileStatusTable	M	N-Acc
docsPnmBulkFileStatusEntry	M	N-Acc
docsPnmBulkFileStatusIndex	M	N-Acc
docsPnmBulkFileStatusLocalFilename	M	RO
docsPnmBulkFileStatusFileStatus	M	RO
docsPnmBulkFileStatusDateCreated	M	RO
docsPnmBulkFileMgmtTable	M	N-Acc
docsPnmBulkFileMgmtEntry	M	N-Acc
docsPnmBulkFileMgmtControl	M	RC
docsPnmBulkFileMgmtDestIndex	M	RW
docsPnmBulkFileMgmtDeleteFile	M	RW
docsCmtsLatencyRptCfgTable	M	N-Acc
docsCmtsLatencyRptCfgEntry	M	N-Acc

DOCS-PNM-MIB [DOCS-PNM-MIB]		
Object	**CMTS**	**Access**
docsCmtsLatencyRptCfgCmMac	M	N-Acc
docsCmtsLatencyRptCfgSnapshotDuration	M	RC
docsCmtsLatencyRptCfgNumSnapshots	M	RC
docsCmtsLatencyRptCfgNumFiles	M	RC
docsCmtsLatencyRptCfgMeasStatus	M	RO
docsCmtsLatencyRptCfgFileName	M	RC
docsCmtsLatencyRptCfgDestinationIndex	M	RC
docsCmtsLatencyRptRowStatus	M	RC
docsDsSfLatencyCfgMetaDataTable	M	N-Acc
docsDsSfLatencyCfgMetaDataEntry	M	N-Acc
docsDsSfLatencyCfgMetaDataSfId	M	N-Acc
docsDsSfLatencyCfgMetaDataSfLabel	M	RO
docsDsSfLatencyCfgMetaDataNumBinEdges	M	RO
docsDsSfLatencyCfgMetaDataBinEdgeDefinitionsArray	M	RO
docsDsSfLatencyCfgMetaDataFirstSnapshotStartTimestamp	M	RO
docsDsSfSnapshotDataTable	M	RO
docsDsSfSnapshotDataEntry	M	RO
docsDsSfSnapshotDataSnapshotEndTimestamp	M	RO
docsDsSfSnapshotDataBinCountsArray	M	RO
docsDsSfSnapshotDataMaxLatency	M	RO
docsDsSfSnapshotDataNumHistogramUpdates	M	RO
docsDsSfSnapshotDataSanctionedPkts	M	RO
docsDsSfSnapshotDataDroppedPkts	M	RO
docsDsSfSnapshotDataTotalEct0Pkts	M	RO
docsDsSfSnapshotDataTotalEct1Pkts	M	RO
docsDsSfSnapshotDataCeMarkedEct1Pkts	M	RO
docsDsSfSnapshotDataSnapshotInterval	M	RO

Annex B IPDR for DOCSIS Cable Data Systems Subscriber Usage Billing Records (Normative)

B.1 Service Definition

Cable Data Systems consist of Cable Modem Termination Systems (CMTSs), located at a Multiple Service Operator's (MSO's) head-end office, that provide broadband Internet access to subscribers connected via Cable Modems (CMs), through the Hybrid Fiber/Coax (HFC) cable plant. These Cable Data Systems comply with the Data-Over-Cable Service Interface Specifications (DOCSIS) sponsored by Cable Television Laboratories, Inc. The IPDR format for Cable Data Systems Subscriber Usage Billing Records specified herein, support the DOCSIS 1.1, 2.0 and 3.0 Operations Support System Interface Specification (OSSI). The DOCSIS 1.1, 2.0 and 3.0 OSSI specifications require the CMTS to provide usage-billing records for all bandwidth consumed by the subscribers connected to it by their Cable Modems, when polled by the MSO's billing or mediation system.

B.1.1 DOCSIS Service Requirements

1. Cable Data Service is "always on". Thus, from the CMTS perspective, there are no subscriber log-on events to track, but rather, in a manner similar to electric power utilities, there are only data traffic flows to meter and police.
2. Cable Data Subscribers are uniquely identified by their Cable Modem MAC addresses (i.e., Ethernet addresses). Note that a CM is usually assigned a dynamic IP address via DHCP, so the IP address of a subscriber may change over time. Since the CM MAC address is constant, it is used to identify the subscriber's usage billing records. All Internet traffic generated by the subscriber's CPE is bridged by the CM to and from the CMTS. The subscriber's packet and byte (octet) traffic counts are recorded by the CMTS in Service Flow counters associated with the CM MAC address. A CM may have two or more Service Flows active during a collection interval. Note that the current IP addresses of the CM and all the CPE in use during the collection interval are recorded for auditing purposes.
3. Cable Data Service is metered and enforced against a Service Level Agreement (SLA) that specifies the Quality of Service (QoS) that an MSO provides to a subscriber. An MSO typically has several Service Packages to offer to their subscribers, such as "Gold", "Silver", or "Bronze". Each of the Service Packages implements a specific SLA and is available for a specific price. A Service Package is implemented by a set of Service Flows that are known to the billing system by their Service Flow IDs (SFIDs) and Service Class Names (SCNs). Service Flows are the unit of billing data collection for a Cable Data Subscriber. In addition, since a subscriber may change their Service Package over time, it is very likely that a given subscriber will have several IPDRs, one for each Service Flow they have used during the collection interval.
4. Bandwidth in a Cable Data System is measured separately in both the downstream and upstream directions (relative to the CMTS). Each Service Flow is unidirectional and may be associated with packet traffic of a specific type (e.g., TCP or UDP). Since most SLAs provide for asymmetric bandwidth guarantees, it is necessary to separate the downstream and upstream traffic flows in the billing usage records. Bandwidth used is measured in both packets and octets.
5. The bandwidth guarantee component of the SLA is enforced and metered by the CMTS with the assistance of the CM. However, the CM is not considered a trusted device because of its location on the Customer's Premises, so the CMTS is expected to provide all of the usage billing information for each subscriber connected to it.
6. Since an SLA may require the CMTS to enforce bandwidth limits by dropping or delaying packets that exceed the maximum throughput bandwidth for a Service Flow, the SLA dropped packets counters and delayed packets counters are also included in the usage records for each Service Flow. These counters are not intended to compute billable subscriber usage but rather are available to the billing and customer care systems to enable "up-selling" to subscribers who consistently exceed their subscribed service level. Thus, subscribers whose usage patterns indicate a large number of dropped octets are probably candidates for an upgrade to a higher SLA that supports their true application bandwidth demands which, in turn, generates more revenue for the MSO.
7. The packet and octet values in the usage billing records are based on absolute 64-bit counters maintained in the CMTS. These counters may be reset when the CMTS system resets, therefore the CMTS system up time (see

CmtsSysUpTime in Annex C) is included in the IPDRDoc so that the billing or mediation system can correlate counters that appear to regress.

8. Group Service Flows are Service Flows received by one or more Cable Modems. A single record is created for a Group Service flow.

B.1.2 SAMIS Usage Attribute List

A DOCSIS SAMIS IPDR record is constructed from a number of attributes that describe the IPDR itself, the CMTS that is serving the subscriber, the subscriber's CM, and the QoS attributes and counters.

B.1.2.1 CMTS Information

A DOCSIS SAMIS IPDR record contains attributes that identify the CMTS that is serving the subscriber. The CMTS attributes are defined in the CMTS Information section of Annex C. Note that the CMTS information attributes defined in Annex C can be streamed independently (i.e., in other IPDR record types) from the SAMIS IPDR and then correlated at the Collector using the CmtsHostName attribute.

DOCSIS SAMIS Type 1 IPDR records contain the following CMTS attributes:

- CmtsHostName
- CmtsSysUpTime
- CmtsIpv4Addr
- CmtsIpv6Addr
- CmtsMdIfName
- CmtsMdIfIndex

DOCSIS SAMIS Type 2 IPDR records contain the following CMTS attributes:

- CmtsHostName
- CmtsSysUpTime
- CmtsMdIfName
- CmtsMdIfIndex

B.1.2.2 CM Information

A DOCSIS SAMIS IPDR record contains attributes that uniquely identify the CM or Group Service Flow. Each SAMIS IPDR for a given CM or Group Service Flow within the IPDRDoc will contain identical values for these attributes. The CM attributes are defined in the CM or Group Service Flow Information section of Annex C. Note that the CM information attributes defined in Annex C can be streamed independently (i.e., in other IPDR record types) from the SAMIS IPDR and then correlated at the Collector.

DOCSIS SAMIS Type 1 IPDR records contain the following CM attributes:

- CmMacAddr
- CmIpv4Addr
- CmIpv6Addr
- CmIpv6LinkLocalAddr
- CmQosVersion
- CmRegStatusValue
- CmLastRegTime

DOCSIS SAMIS Type 2 IPDR records contain the following CM attribute:

- CmMacAddr

B.1.2.3 Record Information

A DOCSIS SAMIS IPDR record contains attributes that identify the type of record and creation time. The Record attributes are defined in the Record Information section of Annex C.

DOCSIS SAMIS Type 1 and Type 2 IPDR records contain the following record attributes:

- RecType
- RecCreationTime

B.1.2.4 QoS Information

A DOCSIS SAMIS IPDR record contains the following attributes that identify the service flow and contain the counters maintained by the CMTS for that service flow (i.e., QoS attributes). The QoS attributes are defined in the QoS Information section of Annex C.

DOCSIS SAMIS Type 1 and Type 2 IPDR records contain the following service flow attributes:

- ServiceFlowChSet
- ServiceAppId
- ServiceDsMulticast
- ServiceIdentifier
- ServiceGateId
- ServiceClassName
- ServiceDirection
- ServiceOctetsPassed
- ServicePktsPassed
- ServiceSlaDropPkts
- ServiceSlaDelayPkts
- ServiceTimeCreated
- ServiceTimeActive

B.2 IPDR Service Definition Schemas

Refer to [DOCSIS-SAMIS-TYPE-1] and [DOCSIS-SAMIS-TYPE-2] for the IPDR Service Definition XML schemas for the SAMIS feature.

Annex C Auxiliary Schemas for DOCSIS IPDR Service Definitions (Normative)

C.1 Overview

This annex defines a set of auxiliary schema files for the DOCSIS IPDR Service Definitions referenced in Section 2.1. In some cases, the auxiliary schema element definitions are derived from attributes defined in information models from other annexes within this specification. Otherwise the attributes are defined within this annex before the inclusion of the auxiliary schema file.

An auxiliary schema file defines global elements that are referenced in various DOCSIS IPDR Service Definition schemas. The purpose for defining auxiliary schemas is to allow defining global elements that can be externally referenced in multiple DOCSIS IPDR Service Definition schemas. This allows for modularization of schema documents and easier extensibility.

C.2 XML Semantics

C.2.1 Import Element

DOCSIS IPDR Service Definition schemas are often composed from multiple schema documents (called auxiliary schemas). This is accomplished through the import mechanism since the Service Definition schema and auxiliary schemas have different namespaces.

Auxiliary schemas are imported in any one of the DOCSIS IPDR Service Definition schemas using the import element as follows:

```
<import namespace="<Auxiliary Schema Namespace>" schemaLocation="<Auxiliary Schema Location>"/>
```

The import element appears at the top level of the Service Definition schema document. Figure 111 shows an example of the import mechanism.

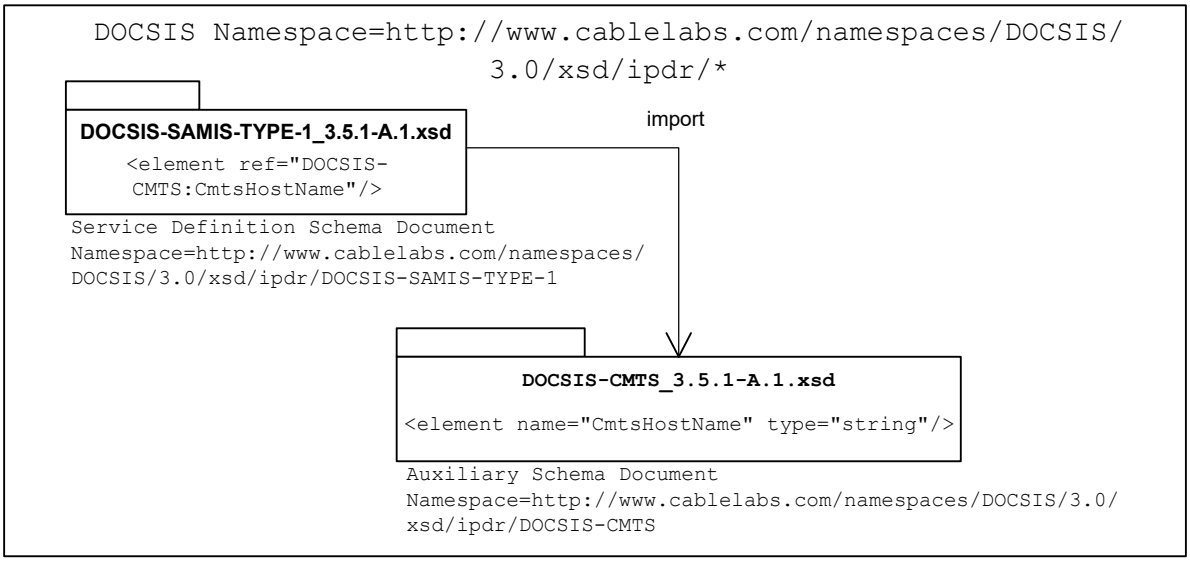


Figure 111 - Auxiliary Schema Import

C.2.2 Element References

In many instances, an information model defines a group of objects where each object defines a set of attributes. Attributes are then realized in XML schemas as element definitions (not XML attribute definitions). Therefore, the terms 'attribute' and 'element' are often interchangeable). It should be clarified that information model attributes (as

defined in this specification) are not the same as XML attributes (as often used in XML Schemas). IPDR schemas do not define XML attributes.

DOCSIS IPDR Service Definition schema documents reference global element declarations from auxiliary schemas using a ref attribute. For example, a Service Definition schema references the CmtsHostName global element using the ref attribute as follows:

```
<element ref="DOCSIS-CMTS:CmtsHostName"/>
```

Figure 111 shows the CmtsHostName global element declaration in the auxiliary schema DOCSIS-CMTS_3.5.1-A.1.xsd and the element reference in the Service Definition schema DOCSIS-SAMIS-TYPE-1_3.5.1-A.1.xsd.

C.3 CMTS Information

The DOCSIS CMTS Information auxiliary schema contains the following attributes that identify a CMTS.

Table 623 - CMTS Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
Who	CmtsHostName	String	Required	FQDN
When	CmtsSysUpTime	unsignedInt	Required	nnnnnnnnn
Who	CmtsIpv4Addr	ipV4Addr	Required	nnn.nnn.nnn.nnn
Who	CmtsIpv6Addr	ipV6Addr	Required	xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx
What	CmtsMdIfName	String	Required	SIZE (0..50)
What	CmtsMdIfIndex	unsignedInt	Required	nnnnnnnnn

C.3.1 CmtsHostName

CmtsHostName is the fully qualified domain name (FQDN) of the CMTS. This attribute will contain an empty string only if the CMTS does not have a domain name. A null FQDN will be represented as <CmtsHostName></CmtsHostName > or < CmtsHostName />. An example FQDN is "cmts01.mso.com.".

References: [RFC 2821].

C.3.2 CmtsSysUpTime

CmtsSysUpTime is the sysUpTime value taken from the CMTS at the time the IPDR record is created, formatted in decimal notation and represented in XDR compact representation as a 32-bit integer. This is the number of 100ths of a second since initialization of the CMTS system or CMTS interface module, whichever is most appropriate for a given CMTS architecture. For any given Service Flow reported in an IPDRDoc, it is required that the value be monotonically increased to minimize SFIDs and SIDs reusage within two reporting intervals, unless the system or interface represented by the sysUpTime value has been reinitialized. If the value has decreased, this can be used by the Collector as a hint that the service flow counters are likely to have regressed. It is specifically not required that the value of CmtsSysUpTime be the same for all records in an IPDRDoc.

References: [RFC 3418].

C.3.3 CmtsIpv4Addr

CmtsIpv4Addr is the IPv4 address for the CMTS. This element is formatted in standard decimal dotted notation such as 10.10.100.1. The XDR compact representation of this element is a 32-bit integer.

C.3.4 CmtsIpv6Addr

CmtsIpv6Addr is the IPv6 address for the CMTS. This element is formatted in colon separated 2-byte block hexadecimal notation such as FEDC:AB19:12FE:0234:98EF:1178:8891:CAFF. The XDR compact representation of this element is a 32-bit integer.

C.3.5 CmtsMdIfName

CmtsMdIfName contains the first 50 characters of the ifName from the Interfaces Group MIB for the row entry corresponding to the CMTS MAC Domain interface (ifType = 127) for this CM. The ifName is defined as: "The textual name of the interface. The value of this object should be the name of the interface as assigned by the local device and should be suitable for use in commands entered at the device's 'console'. This might be a text name, such as 'le0' or a simple port number, such as '1', depending on the interface naming syntax of the device. If several entries in the ifTable together represent a single interface as named by the device, then each will have the same value of ifName. Note that for an agent which responds to SNMP queries concerning an interface on some other (proxied) device, then the value of ifName for such an interface is the proxied device's local name for it. If there is no local name, or this attribute is otherwise not applicable, then this attribute contains a zero-length string.

References: [RFC 2863].

C.3.6 CmtsMdIfIndex

CmtsMdIfIndex is the ifIndex from the Interfaces Group MIB for the CMTS MAC Domain interface (described in CmtsMdIfName). This value makes the ServiceIdentifier unique.

References: [RFC 2863].

C.4 CM Information Schema

Refer to Section 2.1 Normative References for this service definition XML schema.

C.5 Record Information

The DOCSIS Record Information auxiliary schema contains the following attributes which define information about an IPDR record. Refer to Section 2.1 Normative References for this service definition XML schema.

Table 624 - Record Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
What	RecType	Integer	Required	Interim(1) Stop(2) Start(3) Event(4)
When	RecCreationTime	dateTimeMsec	Required	yyyy-mm-ddThh:mm:ss.mmmZ

C.5.1 RecType

The service flow type may be either Interim or Stop. An Interim type indicates a running service flow. A Stop type indicates a terminated service flow. A terminated service flow is only reported once in the IPDRDoc that is created on the cycle after the service flow is deleted. An Interim service flow is reported in each IPDRDoc that is created while it is running.

The CMTS MUST include in the IPDR record the current sample of the active counters for a running service flow.

The CMTS MUST include in the IPDR record the final, logged counter values for a terminated service flow.

C.5.2 RecCreationTime

The RecCreationTime ="yyyy-mm-ddThh:mm:ssZ" UTC time stamp at the time the data for the record was acquired based on CmtsSysUpTime (see CMTS Information section) value. The compact representation of this attribute is the 64-bit Long value since Epoch Time.

The CMTS MUST NOT delete the internal logged SF counters until after the terminated service flow has been recorded into an IPDR record that has been transmitted to a collector and acknowledged or stored in non-volatile memory, regardless of any other capability to manage them via SNMP through the DOCS-QOS3-MIB.

The time zone is always GMT for DOCSIS IPDRs.

For event-based records, the CMTS SHOULD report the time at which the event occurred, unless the data may have changed between the time the event occurred and the time the record was created. In the latter case, the CMTS SHOULD report the time at which the data was collected.

C.6 QoS Information

The DOCSIS QoS Information auxiliary schema contains the following attributes which define QoS information such as service flow information and counters. Refer to Section 2.1 Normative References for this service definition XML schema.

Table 625 - QoS Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
Where	ServiceFlowChSet	hexBinary	Required	SIZE (1..255)
What	ServiceAppId	unsignedInt	Required	32-bit integer
What	ServiceDsMulticast	Boolean	Required	true, false
What	ServiceIdentifier	unsignedInt	Required	32-bit integer
What	ServiceGateId	unsignedInt	Required	32-bit integer
What	ServiceClassName	String	Required	ASCII string identifier
What	ServiceDirection	Integer	Required	Downstream(1) Upstream(2)
What	ServiceOctetsPassed	unsignedLong	Required	64-bit counter, in decimal notation
What	ServicePktsPassed	unsignedLong	Required	64-bit counter, in decimal notation
What	ServiceSlaDropPkts	unsignedInt	Required	32-bit counter, in decimal notation
What	ServiceSlaDelayPkts	unsignedInt	Required	32-bit integer, in decimal notation
When	ServiceTimeCreated	unsignedInt	Required	32-bit integer
When	ServiceTimeActive	unsignedInt	Required	32-bit integer

C.6.1 ServiceFlowChSet

The ServiceFlowChSet attribute contains the set of channels configured for the service flow. Each octet represents the channel id of a channel.

C.6.2 ServiceAppId

The ServiceAppId attribute contains the application identifier associated with the service flow.

C.6.3 ServiceDsMulticast

The ServiceDsMulticast attribute indicates whether the service flow is multicast or unicast. A value of 'true' indicates a multicast service flow. A value of 'false' indicates a unicast service flow.

C.6.4 ServiceIdentifier

The ServiceIdentifier attribute contains the internal service flow identifier (SFID) for DOCSIS 1.1 QoS provisioned CMs known to the CMTS. This attribute is needed to correlate the IPDRs for an individual service flows between adjacent IPDR records when computing delta counters. To avoid potential confusion in the billing system, it is desirable that the CMTS not reuse the ServiceIdentifier component for a minimum of two collection cycles. Depending of the collection interval and services dynamics, this goal may not be practical. As an intermediate solution, a CMTS MAY assign ServiceIdentifier (SFIDs/SIDs) values with a monotonically increasing pattern.

C.6.5 ServiceGateId

The "GateID" associated with the service flow (SFID). For non-Dynamic service flows, a zero value is reported.

References: [PKT-DQOS]; [PCMM]; [MULPIv4.0].

C.6.6 ServiceClassName

The ServiceClassName attribute contains the name associated with the QoS parameter set for this service flow in the CMTS. The SCN is an ASCII string identifier, such as "GoldUp" or "SilverDn", which can be used by external operations systems to assign, monitor, and bill for different levels of bandwidth service without having to interpret the details of the QoS parameter set itself. A service flow is associated with an SCN whenever a cable modem configuration file uses the SCN to define an active service flow. A dynamic service flow application such as PacketCable may also assign an SCN to a service flow as a parameter during the dynamic creation of the service flow. Note that the use of SCNs is optional within the context of the DOCSIS 4.0 MAC and Upper Layer Protocols Interface Specification; however, for operational purposes, especially when billing for tiered data services per this specification, their use often becomes mandatory. Since this policy is within the control of the operator, the use of SCNs is not mandatory in this specification, but rather highly recommended.

The CMTS MUST include the ServiceClassName attribute in the IPDR record. The CMTS MUST encode this attribute as a zero-length string if no SCN is used to identify the service flow.

References: [PKT-DQOS]; [MULPIv4.0].

C.6.7 ServiceDirection

The CMTS MUST include the ServiceDirection attribute, which identifies the service flow direction relative to the CMTS RFI interface, as follows:

- Identifies DOCSIS 1.1 downstream service flows passing packets from the CMTS to the CM.
- Identifies upstream DOCSIS 1.1 service flows passing packets from the cable modem to the CMTS.

C.6.8 ServiceOctetsPassed

The CMTS MUST create an instance of ServiceOctetsPassed attribute for each DOCSIS QoS Service Flow with the current 64-bit count, formatted in decimal notation, of the number of octets passed by the Service Flow.

If the RecType is Interim, then this is the current value of the running counter. If the RecType is Stop, then this is the final value of the terminated counter. The 64-bit counter value will not wrap around within the service lifetime of the CMTS.

C.6.9 ServicePktsPassed

The CMTS MUST create an instance of ServicePktsPassed attribute for each DOCSIS QoS Service Flow containing the current 64-bit count in decimal notation, of the number of packets passed by the service flow.

If the RecType is Interim, then this is the current value of the running counter. If the RecType is Stop, then this is the final value of the terminated counter. The 64-bit counter value will not wrap around within the service lifetime of the CMTS.

C.6.10 ServiceSlaDropPkts

The CMTS MUST create an instance of ServiceSlaDropPkts attribute for each DOCSIS QoS service flow containing the current count of packets dropped by the service flow.

This is based on a 32-bit counter value maintained in the CMTS where it is unlikely to overflow within the service lifetime of the DOCSIS QoS service. Note that this value is the count of packets dropped by the CMTS for upstream service flows. Upstream packets dropped by the CM are not counted here.

C.6.11 ServiceSlaDelayPkts

The CMTS MUST create an instance of ServiceSlaDelayPkts attribute for each DOCSIS QoS Service Flow that contains the current count of packets delayed by this service flow.

This is based on a 32-bit counter value maintained in the CMTS where it is unlikely to overflow within the service lifetime of the DOCSIS QoS service. This counter value will not overflow within the service lifetime of the CMTS. Note that this value is the count of packets delayed by the CMTS for upstream service flows. Upstream packets delayed by the CM are not counted here.

C.6.12 ServiceTimeCreated

The CMTS MUST include the ServiceTimeCreated attribute which contains the value of CmtsSysUpTime or CMTS interface module, whichever is most appropriate for a given CMTS architecture when service flow was created. For a given service flow instance, this value is required to be the same in every IPDRDoc file until the service flow is deleted and no longer being reported. If the value is not consistent between IPDRDoc files, this needs to be interpreted by the Collector as a completely new service flow instance.

C.6.13 ServiceTimeActive

The CMTS MUST create an instance of the ServiceTimeActive attribute for each DOCSIS QoS Service Flow containing the total time, in seconds, the service flow is active.

If RecType is 'Stop(2)', the CMTS MUST report the total number of active seconds when the service flow was deleted.

C.7 CPE Information

The DOCSIS CPE Information auxiliary schema contains the following attributes that uniquely identify a CPE. Refer to Section 2.1 Normative References for this service definition XML schema.

Table 626 - CPE Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
Who	CpeMacAddr	macAddress	Required	nn:nn:nn:nn:nn:nn
Who	CpeIpv4AddrList	hexBinary	Required	nnn.nnn.nnn.xxx nnn.nnn.nnn.yyy
Who	CpeIpv6AddrList	hexBinary	Required	xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:yyyy xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:zzzz
Who	CpeFqdn	String	Required	FQDN

C.7.1 CpeMacAddr

The Ethernet MAC address of each CPE using this CM during the reporting interval. The CMTS normally tracks CPE MAC addresses per CM, but there may be cases where they are not reported in this element, in which case the value of this element is encoded as macAddress type with value of all zeros.

C.7.2 CpeIpv4AddrList

List of IPv4 address assigned to each CPE using this CM during the reporting interval. If the CMTS is not tracking CPE IP addresses, then the value of this element is encoded as zero length list. This element may be non-null only for the default upstream SID/service flow for a CM and gives the current known CPE IP addresses on the CM's Ethernet interface regardless of the SID/SF from which the CPE IP address was learned. All CPE IP addresses maintained in an ARP table for a cable MAC interface need to be reported in this field of at least one IPDR record. It is not expected that CpeIpv4AddrList values reported are unique to a single CM, since the CMTS may implement multiple overlapping private IP address spaces.

The XDR encoding type is hexBinary consisting of consecutive 32-bit unsigned integers each one being an ipV4Addr data type. Thus, the encoding of multiple CPE IP Addresses in the CpeIpv4AddrList corresponds to a multiple of 4-octet string.

NOTE: The configuration state of the DOCS-SUBMGT3-MIB influences whether CPE IP addresses are being tracked by the CMTS and are thus being reported in the IPDRs (the DOCS-SUBMGT3-MIB controls the CM and CPE filters on the CMTS). Other mechanisms such as the ARP table may also be used in this case.

C.7.3 CpeIpv6AddrList

List of IPv6 address assigned to each CPE using this CM during the reporting interval. If the CMTS is not tracking CPE IP addresses, then the value of this element is encoded as zero length list. This element may be non-null only for the default upstream SID/service flow for a CM and gives the current known CPE IP addresses on the CM's Ethernet interface regardless of the SID/SF from which the CPE IP address was learned. All CPE IP addresses maintained in an ARP table for a cable MAC interface need to be reported in this field of at least one IPDR record. It is not expected that CpeIpv6AddrList values reported are unique to a single CM, since the CMTS may implement multiple overlapping private IP address spaces.

The XDR encoding type is hexBinary consisting of consecutive ipV6Addr data types (4-byte length + 16-byte address encoding). Thus, the encoding of multiple CPE IP Addresses in the CpeIpv6AddrList corresponds to a multiple of 20-octet string.

C.7.4 CpeFqdn

The Fully Qualified Domain Name (FQDN) assigned to each CPE using this CM during the reporting interval. If the CMTS is not tracking CPE FQDNs, then this element will be the zero-length string. This element includes only CPE FQDNs gleaned by the CMTS, such as from DHCP relay, and otherwise stored in the CMTS for reporting or other purposes. It is not required for the CMTS to query perform reverse DNS query to obtain the FQDN of a CPE IP address otherwise reported in the CpeIpv4AddrList or CpeIpv6AddrList field. An example FQDN is "Cpe1@cm1.cmts2.com."

References: [RFC 2821].

Refer to Section 2.1 Normative References for this service definition XML schema.

C.8 Spectrum Measurement Information

Refer to the CmtsSpectrumAnalysisMeas object of Section 6.6.1.2 for the definition of the Spectrum Measurement attributes.

Refer to Section 2.1 for this service definition XML schema.

C.9 Diagnostic Log Information

Refer to the DiagLog and DiagLogDetail objects of Annex A for the definition of the Diagnostic Log attributes.

Refer to Section 2.1 for this service definition XML schema.

C.10 CMTS CM Upstream Status Information

Refer to the CmtsCmUsStatus object of Section 7.2.2.2.2 for the definition of the CMTS CM Upstream Status attributes.

Refer to Section 2.1 for this service definition XML schema.

C.11 CMTS CM Node Channel Information

Refer to the CmtsCmRegStatus object in Section 7 for the definition of the CMTS CM Node Channel attributes.

C.12 CMTS MAC Domain Node Information

Refer to the MdNodeStatus, MdDsSgStatus and MdUsSgStatus objects in Section PERFORMANCE MANAGEMENT for the definition of the MAC Domain (MD) Node attributes.

Refer to Section 2.1 for this service definition XML schema.

C.13 CMTS Upstream Utilization Information

Refer to Section 2.1 for this service definition XML schema.

The DOCSIS CMTS Upstream Utilization Information auxiliary schema contains the following attributes which define upstream logical channel utilization counters.

Table 627 - CMTS Upstream Utilization Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
Which	IfIndex	unsignedInt	Required	nnnnnnnnn
What	IfName	String	Required	SIZE(0..50)
What	UsChId	unsignedByte	Required	1..255
What	Interval	unsignedInt	Required	0..86400
What	IndexPercentage	unsignedByte	Required	0..100
What	TotalMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	UcastGrantedMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	TotalCntnMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	UsedCntnMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	CollCntnMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	TotalCntnReqMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	UsedCntnReqMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	CollCntnReqMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	TotalCntnReqDataMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	UsedCntnReqDataMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	CollCntnReqDataMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	TotalCntnInitMaintMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	UsedCntnInitMaintMslots	unsignedLong	Required	64-bit counter, in decimal notation
What	CollCntnInitMaintMslots	unsignedLong	Required	64-bit counter, in decimal notation

C.13.1 IfIndex

The ifIndex from the Interfaces Group MIB for the CMTS upstream logical channel interface.

C.13.2 ifName

The ifName from the Interfaces Group MIB for the CMTS upstream interface.

C.13.3 UsChId

This attribute represents the upstream channel id.

C.13.4 Interval

This attribute represents the time interval, in seconds, over which the channel utilization index is calculated.

References: [RFC 4546] docsIfCmtsChannelUtilizationInterval.

C.13.5 IndexPercentage

For SC-QAM channels, this attribute represents the calculated and truncated utilization index percentage for the upstream logical channel interface.

For OFDMA channels, this is the OfdmaChannelUtilization attribute as defined in Section 7.2.2.8.1.24.

References: [RFC 4546] docsIfCmtsChannelUtUtilization.

C.13.6 TotalMslots

This attribute represents the current count, from CMTS initialization, of all minislots defined for this upstream logical channel interface. This count includes all IUCs and SIDs, even those allocated to the NULL SID for a logical channel that is inactive.

Reference: [RFC 4546] docsIfCmtsUpChnlCtrExtTotalMslots.

C.13.7 UcastGrantedMslots

This attribute represents the current count, from CMTS initialization, of unicast granted minislots on the upstream logical channel regardless of burst type. Unicast granted minislots are those in which the CMTS assigned bandwidth to any unicast SID on the logical channel. However, this object does not include minislots for reserved IUCs, or grants to SIDs designated as meaning 'no CM'.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtUcastGrantedMslots.

C.13.8 TotalCntnMslots

This attribute represents the current count, from CMTS initialization, of contention minislots defined for this upstream logical channel. This count includes all minislots assigned to a broadcast or multicast SID on the logical channel.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtTotalCntnMslots.

C.13.9 UsedCntnMslots

This attribute represents the current count, from CMTS initialization, of contention minislots utilized on the upstream logical channel. For contention regions, utilized minislots are those in which the CMTS correctly received an upstream burst from any CM on the upstream logical channel.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtUsedCntnMslots.

C.13.10 CollCntnMslots

This attribute represents the current count, from CMTS initialization, of collision contention minislots on the upstream logical channel. For contention regions, these are the minislots applicable to burst that the CMTS detected but could not correctly receive.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtCollCntnMslots.

C.13.11 TotalCntnReqMslots

This attribute represents the current count, from CMTS initialization, of contention request minislots defined for this upstream logical channel. This count includes all minislots for IUC1 assigned to a broadcast or multicast SID on the logical channel.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtTotalCntnReqMslots.

C.13.12 UsedCntnReqMslots

This attribute represents the current count, from CMTS initialization, of contention request minislots utilized on this upstream logical channel. This count includes all contention minislots for UIC1 applicable to bursts that the CMTS correctly received.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtUsedCntnReqMslots.

C.13.13 CollCntnReqMslots

This attribute represents the current count, from CMTS initialization, of contention request minislots subjected to collisions on this upstream logical channel. This includes all contention minislots for IUC1 applicable to bursts that the CMTS detected but could not correctly receive.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtCollCntnReqMslots.

C.13.14 TotalCntnReqDataMslots

This attribute represents the current count, from CMTS initialization, of contention request data minislots defined for this upstream logical channel. This count includes all minislots for IUC2 assigned to a broadcast or multicast SID on the logical channel.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtTotalCntnReqMslots.

C.13.15 UsedCntnReqDataMslots

This attribute represents the current count, from CMTS initialization, of contention request data minislots utilized on this upstream logical channel. This includes all contention minislots for IUC2 applicable to bursts that the CMTS correctly received.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtUsedCntnReqMslots.

C.13.16 CollCntnReqDataMslots

This attribute represents the current count, from CMTS initialization, of contention request data minislots subjected to collisions on this upstream logical channel. This includes all contention minislots for IUC2 applicable bursts that the CMTS detected but could not correctly receive.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtCollCntnReqMslots.

C.13.17 TotalCntnInitMaintMslots

This attribute represents the current count, from CMTS initialization, of initial maintenance minislots defined for this upstream logical channel. This count includes all minislots for IUC3 assigned to a broadcast or multicast SID on the logical channel.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtTotalCntnInitMaintMslots.

C.13.18 UsedCntnInitMaintMslots

This attribute represents the current count, from CMTS initialization, of initial maintenance minislots utilized on this upstream logical channel. This includes all contention minislots for IUC3 applicable to bursts that the CMTS correctly received.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtUsedCntnInitMaintMslots.

C.13.19 CollCntnInitMaintMslots

This attribute represents the current count, from CMTS initialization, of contention initial maintenance minislots subjected to collisions on this upstream logical channel. This includes all contention minislots for IUC3 applicable to bursts that the CMTS detected but could not correctly receive.

References: [RFC 4546] docsIfCmtsUpChnlCtrExtCollCntnInitMaintMslots.

C.14 CMTS Downstream Utilization Information

Refer to Section 2.1 Normative References for this service definition XML schema.

The DOCSIS CMTS Downstream Utilization Information auxiliary schema contains the following attributes which define downstream utilization counters.

Table 628 - CMTS Downstream Utilization Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
Which	IfIndex	unsignedInt	Required	nnnnnnnnn
What	DsChId	unsignedByte	Required	1..255
What	IfName	String	Required	SIZE(0..50)
What	Interval	unsignedInt	Required	0..86400
What	IndexPercentage	unsignedByte	Required	0..100
What	TotalBytes	unsignedLong	Required	64-bit counter, in decimal notation
What	UsedBytes	unsignedLong	Required	64-bit counter, in decimal notation

C.14.1 IfIndex

The ifIndex from the Interfaces Group MIB for the CMTS downstream interface.

C.14.2 IfName

The ifName from the Interfaces Group MIB for the CMTS downstream interface.

C.14.3 DsChId

This attribute represents the downstream channel id.

C.14.4 Interval

This attribute represents the time interval, in seconds, over which the channel utilization index is calculated.

References: [RFC 4546] docsIfCmtsChannelUtilizationInterval.

C.14.5 IndexPercentage

For SC-QAM channels, this attribute represents the calculated and truncated utilization index percentage for the downstream interface.

For OFDM channels, this is the OfdmChannelUtilization attribute as defined in Section 7.2.2.9.1.22.

References: [RFC 4546] docsIfCmtsChannelUtUtilization.

C.14.6 TotalBytes

For SC-QAM channels, this attribute represents the total number of bytes in the payload portion of MPEG Packets, not including MPEG header or pointer_field, transported by the downstream interface.

For OFDM channels, this is the largest ProfileFullChanSpeed assigned to this channel * the DsUtilInterval /8. Refer to Section 7.2.2.9.4.3.

Reference: [RFC 4546] docsIfCmtsDownChnlCtrExtTotalBytes.

C.14.7 UsedBytes

For SC-QAM channels, this attribute represents the total number of DOCSIS data bytes transported by the downstream interface. The number of data bytes is defined as the total number of bytes transported in DOCSIS payloads minus the number of stuff bytes transported in DOCSIS payloads.

For OFDM channels, this is DsUtilTotalBytes * DsUtilIndexPercentage.

References: [RFC 4546] docsIfCmtsDownChnlCtrExtUsedBytes.

C.15 Service Flow Information

For the full text of this auxiliary schema, refer to[DOCSIS-SERVICE-FLOW].

The DOCSIS Service Flow Information auxiliary schema contains attribute references to the QoS Information Models which provides the link between the IPDR schema data models and the UML Information Models.

C.16 IP Multicast Information

For the full text of this schema, refer to [DOCSIS-IP-MULTICAST].

The DOCSIS IP Multicast Information auxiliary schema contains the following attributes that describe the joined (S,G) IP multicast session parameters.

Table 629 - IP Multicast Information Attributes

Category	Attribute Name	Type	Presence	Permitted Values
What	IpMcastSrcIpv4Addr	InetAddressIpv4	Required	
What	IpMcastSrcIpv6Addr	InetAddressIpv6	Required	
What	IpMcastGrpIpv4Addr	InetAddressIpv4	Required	
What	IpMcastGrpIpv6Addr	InetAddressIpv6	Required	
What	IpMcastGsfId	unsignedInt	Required	
What	IpMcastDsid	unsignedInt	Required	
What	IpMcastSessionProtocolType	Integer	Required	0 Reserved 1 for IGMP 2 for MLD
What	IpMcastCpeMacAddrList	hexBinary	Required	
When	IpMcastJoinTime	dateTimeMsec	Required	yyyy-mm-ddThh:mm:ss:mmmZ
When	IpMcastLeaveTime	dateTimeMsec	Required	yyyy-mm-ddThh:mm:ss:mmmZ

C.16.1 IpMcastSrcIpv4Addr

The value of the IPv4 address of 'S' as the source address for a particular (S,G) IP multicast session. For the case of Any Source Multicast (ASM), this attribute reports a value of 0.0.0.0.

C.16.2 IpMcastSrcIpv6Addr

The value of the IPv6 address of 'S' as the source address for a particular (S,G) IP multicast session. For the case of Any Source Multicast (ASM), this attribute reports a value of 0::/0.

C.16.3 IpMcastGrpIpv4Addr

The value of the IPv4 address of 'G' as the group address for a particular (S,G) IP multicast session.

C.16.4 IpMcastGrpIpv6Addr

The value of the IPv6 address of 'G' as the group address for a particular (S,G) IP multicast session.

C.16.5 IpMcastGsfId

The value of the Group Service Flow Id. This element is associated with the ServiceIdentifier element from the SAMIS-TYPE-1 and SAMIS-TYPE-2 Service Definition Schemas.

C.16.6 IpMcastDsid

The value of the Downstream Service ID (DSID) label with which the CMTS labels all packets of a particular (S,G) IP multicast session.

C.16.7 IpMcastSessionProtocolType

The value of the type of IP multicast session (Reserved, IGMP or MLD).

C.16.8 IpMcastCpeMacAddrList

The value of the list of CPE MAC addresses joining the (S,G) IP multicast session. The associated CPE IPv4 and IPv6 address information can be obtained with the CPE-TYPE Service Definition Schema.

C.16.9 IpMcastJoinTime

The value of the UTC time stamp "yyyy-mm-ddThh:mm:ssZ" at the time the IP multicast JOIN request from this CPE for this multicast session was processed by the CMTS. The compact representation of this attribute is the 64-bit Long value of milliseconds since Epoch Time.

C.16.10 IpMcastLeaveTime

The value of the UTC time stamp "yyyy-mm-ddThh:mm:ssZ" at the time the "LeaveMulticastSession" request from this CPE for this multicast session was processed by the CMTS or the CMTS determines that this CPE has left the IP multicast session. The compact representation of this attribute is the 64-bit Long value of milliseconds since Epoch Time.

If the multicast session is active (i.e., the CMTS has yet to determine that the CPE has left the IP multicast session) when this record is generated, the compact representation of the IpMcastLeaveTime value MUST be set to 0.

Reference: [MULPIv3.0] Downstream Multicast Forwarding section.

C.17 CMTS CM Downstream OFDM Information

Refer to the CmtsCmRegStatus object of Section 7.2.2.2.1 for the definition of the attributes found in the CMTS CM Downstream OFDM Information Schema.

Refer to Section 2.1 for this service definition XML schema.

C.18 CMTS CM Partial Channel/Service Information

Refer to the attributes related to Partial Channel and Partial Service conditions in the CmtsCmRegStatus, CmtsCmDsOfdmStatus, CmtsCmDsOfdmProfileStatus, CmtsCmUsOfdmaStatus and CmtsCmUsOfdmaProfile objects of Section 7.2.2 for the definition of the attributes found in the CMTS CM Partial Channel/Service Information Schema.

Refer to Section 2.1 for this service definition XML schema.

C.19 CMTS CM Upstream OFDMA Information

Refer to the CmtsCmUsOfdmaChannelStatus object of Section 7.2.2.2.3 for the definition of the attributes found in the CMTS CM Upstream OFDMA Information Schema.

Refer to Section 2.1 for this service definition XML schema.

C.20 OFDM Profile Status Information

Refer to the CmtsCmRegStatus, CmtsCmDsOfdmProfileStatus and CmtsCmUsOfdmaProfile objects of Section 7.2.2 as well as the UsOfdmaChannelDataIucStats object of Section 7.2.2.8.3 and the DsOfdmProfileStats object of Section 7.2.2.9.4 for the definition of the OFDM Profile Status attributes. Note: in this case the term "OFDM Profile" is used generically to apply to either a downstream OFDM profile or an upstream OFDMA profile/data IUC.

Refer to Section 2.1 for this service definition XML schema.

Annex D Format and Content for Event, SYSLOG, and SNMP Notification (Normative)

Table 619 in this Annex summarizes the format and content for event, syslog, and SNMP notifications required for DOCSIS 4.0-compliant CMTS and CCAP.

Each row specifies a possible event that may appear in the CMTS and CCAP. These events are to be reported by a cable device through local event logging and may be accompanied by syslog or SNMP notification.

The "Process" and "Sub-Process" columns indicate in which stage the event happens. The "CMTS/CCAP Priority" column indicates the priority the event is assigned in the CMTS and CCAP. These priorities are the same as is reported in the docsDevEvLevel object in the cable device MIB [RFC 4639] and in the LEVEL field of the syslog.

The "Event Message" column specifies the event text, which is reported in the docsDevEvText object of the cable device MIB and the text field of the syslog. The "Message Notes and Details" column provides additional information about the event text in the "Event Message" column. Some of the text fields include variable information, which are often specified as key-value pairs. The variables are explained in the "Message Notes and Details" column. For some events the "Message Notes and Details" column may include the keyword <Deprecated> to indicate this event is being deprecated and its implementation is optional. For events where the "Event Message" or "Message Notes and Details" column includes either <P1>, <P2>, or <Pn>, there is a colon and single space between the value as defined by the <P1>, <P2>, or <Pn> and the preceding key text.

The key-value parameters are thus formatted as: [key]: [value]. Key value pairs are delimited by a semi-colon followed by a single space, as the following example indicates:

[key 1]: [value 1]; [key 2]: [value 2]; [key n]: [value n]

The “Event Message” field structure is defined as follows:

<Initial Event Message Text>; [key 1]: [value 1]; [key 2]: [value 2]; [key n]: [value n]; <TAGS>;

Keys which contain values which represent strings can enclose those strings within double-quotations to prevent confusion if those string values contain a delimiter (colon or semicolon). Key strings should capitalize each word (e.g., “Sensor Unit”)If a key’s value is not present, the key is present but the value is omitted (using a single space). For example:

key 1: ;

It is recommended that <Initial Event Message Text> string does not contain a semicolon since this is used as a delimiter. The <Initial Event Message Text> string follows a normal sentence capitalization scheme where the first word is capitalized as well as any defined terms and acronyms. Refer to Annex D.3 for examples.

This specification defines the following keywords as part of the "Event Message" column:

"<TAGS>" (without the quotes) corresponds to:

For the CMTS (without the quotes):";<CM-MAC>;<CM-QOS>;<CM-VER>;<CMTS-VER>;"

Where:

```
<CM-MAC>:CM MAC Address;
Format*: "CM-MAC=xx:xx:xx:xx:xx:xx"

<CM-QOS>:CM DOCSIS QOS Version;
Format*: "CM-QOS=1.0" or "CM-QOS=1.1"

<CM-VER>:CM DOCSIS Version;
Format*: "CM-VER=1.1" or "CM-VER=2.0" or "CM-VER=3.0" or "CM-VER=3.1" or "CM-VER=4.0"

<CMTS-VER>:CMTS DOCSIS Version;
Format*: "CMTS-VER=1.1" or "CMTS-VER=2.0" or "CMTS-VER=3.0" or "CMTS-VER=3.1" or
"CMTS-VER=4.0"
```

(*) without the quote

The CCAP MUST support all mandatory events as defined in Table 630 - Event Format and Content, as well as the list of events defined in Table 631 - CCAP Events. The CMTS MUST support all mandatory events defined in Table 631 - CCAP Events.

The CMTS and CCAP MAY append additional vendor-specific text to the end of the event text reported in the docsDevEvText object and the syslog text field.

The "Error Code Set" column specifies the error code. The "Event ID" column indicates a unique identification number for the event, which is assigned to the docsDevEvId object in the cable device MIB and the <eventId> field of the syslog. Refer to [CANN] for the rules to generate unique Event IDs from the Error Code Set. The "Notification Name" column specifies the SNMP notification, which notifies this event to an SNMP notification receiver.

The syslog format, as well as the rules to uniquely generate an event ID from the error code, are described in Section 9.2.2.1.3 of this specification.

Table 630 - Event Format and Content

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Authentication and Encryption							
			<Reserved>			0	
BPKM	AUTH-FSM	Error	Auth Reject - No Information<TAGS>		B301.2	66030102	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Reject - Unauthorized CM<TAGS>		B301.3	66030103	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Reject - Unauthorized SAID<TAGS>		B301.4	66030104	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Reject - Permanent Authorization Failure<TAGS>		B301.8	66030108	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Reject - Time of Day not acquired<TAGS>		B301.9	66030109	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Informational	Auth Reject - EAE disabled<TAGS>		B301.10	66030110	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	CM Certificate Error<TAGS>		B301.11	66030111	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Invalid - No Information<TAGS>		B302.2	66030202	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Invalid - Unauthorized CM<TAGS>		B302.3	66030203	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Invalid - Unsolicited<TAGS>		B302.5	66030205	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Invalid - Invalid Key Sequence Number<TAGS>		B302.6	66030206	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Auth Invalid - Message (Key Request) Authentication Failure<TAGS>		B302.7	66030207	CMTS: docsIf3CmtsEventNotif
BPKM	AUTH-FSM	Error	Unsupported Crypto Suite<TAGS>		B303.0	66030300	CMTS: docsIf3CmtsEventNotif
BPKM	CERTIFICATE REVOCATION	Warning	Failed to retrieve CRL from <P1>; <TAGS>;	P1 = CRL Server IP	B304.0	66030400	CMTS: docsIf3CmtsEventNotif
BPKM	CERTIFICATE REVOCATION	Warning	Failed to retrieve OCSP status; <TAGS>;		B304.1	66030401	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
BPKM	CERTIFICATE REVOCATION	Warning	CRL data not available when validating CM certificate chain<TAGS>		B304.2	66030402	CMTS: docsIf3CmtsEventNotif
BPKM	TEK-FSM	Error	Key Reject - No Information<TAGS>		B501.2	66050102	CMTS: docsIf3CmtsEventNotif
BPKM	TEK-FSM	Error	Key Reject - Unauthorized SAID<TAGS>		B501.3	66050103	CMTS: docsIf3CmtsEventNotif
BPKM	TEK-FSM	Error	TEK Invalid - No Information<TAGS>		B502.3	66050203	CMTS: docsIf3CmtsEventNotif
BPKM	TEK-FSM	Error	TEK Invalid - Invalid Key Sequence Number<TAGS>		B502.6	66050206	CMTS: docsIf3CmtsEventNotif
Dynamic SA	SA MAP-FSM	Error	Unsupported Crypto Suite<TAGS>		B602.0	66060200	CMTS: docsIf3CmtsEventNotif
Dynamic SA	SA MAP-FSM	Informational	Map Reject - Downstream Traffic Flow Not Mapped to BPI+ SAID (EC=8)<TAGS>		B605.10	66060510	CMTS: docsIf3CmtsEventNotif
Dynamic SA	SA MAP-FSM	Error	Map Reject - Not Authorized for Requested Downstream Traffic Flow (EC=7)<TAGS>		B605.9	66060509	CMTS: docsIf3CmtsEventNotif
Dynamic SA	SA MAP-FSM	Error	Mapped to Existing SAID<TAGS>		B606.0	66060600	CMTS: docsIf3CmtsEventNotif
Dynamic SA	SA MAP-FSM	Error	Mapped to New SAID<TAGS>		B607.0	66060700	CMTS: docsIf3CmtsEventNotif
Init (BPI+)	DOCSIS 1.0 CONFIG FILE	Notice	Missing BP Configuration Setting TLV Type: <P1><TAGS>	P1 = missing required TLV Type	B101.0	66010100	CMTS: docsIf3CmtsEventNotif
Init (BPI+)	DOCSIS 1.0 CONFIG FILE	Notice	Invalid BP Configuration Setting Value: <P1> for Type: <P2><TAGS>	P1=The TLV Value for P2. P2 = The first Configuration TLV Type that contain invalid value.	B102.0	66010200	CMTS: docsIf3CmtsEventNotif
TLS	Mutual Authentication	Notice	Successfully completed TLS Mutual Authentication; Client IP: <P1>; Server IP: <TAGS>;	P1 = Client IP address P2 = Server IP address	B600.00	66060000	CMTS: docsIf3CmtsEventNotif
TLS	Mutual Authentication	Error	Failed to complete TLS Mutual Auth due to timeout; Client IP: <P1>; Server IP: <P2>; TLS Ver: <P3>; Timeout: <P4>; <TAGS>;	P1 = Client IP Address P2 = Server IP Address P3 = TLS version P4 = Timeout value	B600.01	66060001	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
TLS	Mutual Authentication	Error	Failed to complete TLS Mutual Auth due to cert error; Client IP: <P1>; Server IP:<P2>; TLS Ver: <P3>; Cert Error Text: <P4>; Cert Level: <P5>; Key Validity Period: <P6>; <TAGS>;	P4 uses parameters from Table 623 P5 uses parameters from Table 623 P1 = Client IP address P2 = Server IP address P3 = TLS version P4 = Certificate Error text P5 = Certificate level P6 = Key validity period	B600.02	66060002	CMTS: docsIf3CmtsEventNotif
TLS	Mutual Authentication	Error	Failed to complete TLS Mutual Auth due to attempt to downgrade TLS version below 1.2; Client IP: <P1>; Server IP: <P2>; TLS Version: <P3>; TLS Version Attempted: <P4>; Descr: <P5>; <TAGS>;	P5 is optional and vendor specific P1 = Client IP address P2 = Server IP address P3 = TLS version P4 = TLS version attempted P5 = vendor specific	B600.03	66060003	CMTS: docsIf3CmtsEventNotif
TLS	Mutual Authentication	Error	Failed to complete TLS Mutual Auth due to attempt to connect using TLS version below 1.2; Client IP: <P1>; Server IP: <P2>; TLS Version: <P3>; TLS Version Attempted: <P4>; Descr: <P5>; <TAGS>;	P5 is optional and vendor specific P1 = Client IP address P2 = Server IP address P3 = TLS version P4 = TLS version attempted P5 = vendor specific	B600.04	66060004	CMTS: docsIf3CmtsEventNotif
TLS	Mutual Authentication	Error	Failed to complete TLS Mutual Auth due to mismatched ciphers, connection rejected; Client IP: <P1>; Server IP: <P2>; TLS Ver: <P3>; Reject Reason: <P4>; <TAGS>;	P4 uses parameters from Table 623 P1 = Client IP address P2 = Server IP address P3 = TLS version P4 = Reject reason	B600.05	66060005	CMTS: docsIf3CmtsEventNotif
TLS	Mutual Authentication	Error	Failed to complete TLS Mutual Auth due to mismatched algorithms, connection rejected; Client IP: <P1>; Server IP: <P2>; TLS Ver: <P3>; Reject Reason: <P4>; <TAGS>;	P4 uses parameters from Table 623 P1 = Client IP address P2 = Server IP address P3 = TLS version P4 = Reject reason	B600.06	66060006	CMTS: docsIf3CmtsEventNotif
DBC and DCC							
DBC	DBC Response	Notice	Unknown DBC transaction<TAGS>		C601.0	67060100	

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DBC	DBC Response	Warning	DBC-REQ rejected - confirmation code <P1>: <P2><TAGS>	P1=<Confirmation Code> P2=<Confirmation>	C602.0	67060200	
DBC	DBC Response	Warning	DBC-RSP not received<TAGS>		C603.0	67060300	
DBC	DBC Response	Warning	Bad CM DBC-RSP: <P1><TAGS>	P1="unspecified reason" | "authentication failure" | "msg syntax error"	C604.0	67060400	
DBC	DBC Response	Warning	DBC-RSP Partial Service <P1><TAGS>	P1=<reason>	C605.0	67060500	
DCC	DCC Request	Warning	DCC rejected already there<TAGS>		C201.0	67020100	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Notice	DCC depart old<TAGS>		C202.0	67020200	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Notice	DCC arrive new<TAGS>		C203.0	67020300	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC aborted unable to acquire new downstream channel<TAGS>		C204.0	67020400	
DCC	DCC Request	Warning	DCC aborted no UCD for new upstream channel<TAGS>		C205.0	67020500	
DCC	DCC Request	Warning	DCC aborted unable to communicate on new upstream channel<TAGS>		C206.0	67020600	
DCC	DCC Request	Warning	DCC rejected unspecified reason<TAGS>		C207.0	67020700	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected permanent - DCC not supported<TAGS>		C208.0	67020800	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected service flow not found<TAGS>		C209.0	67020900	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected required parameter not present<TAGS>		C210.0	67021000	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected authentication failure<TAGS>		C211.0	67021100	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected multiple errors<TAGS>		C212.0	67021200	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected, duplicate SF reference-ID or index in message<TAGS>		C215.0	67021500	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DCC	DCC Request	Warning	DCC rejected parameter invalid for context<TAGS>		C216.0	67021600	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected message syntax error<TAGS>		C217.0	67021700	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected message too big<TAGS>		C218.0	67021800	CMTS: docsIf3CmtsEventNotif
DCC	DCC Request	Warning	DCC rejected 2.0 mode disabled<TAGS>		C219.0	67021900	CMTS: docsIf3CmtsEventNotif
DCC	DCC Response	Warning	DCC-RSP not received on old channel<TAGS>		C301.0	67030100	CMTS: docsIf3CmtsEventNotif
DCC	DCC Response	Warning	DCC-RSP not received on new channel<TAGS>		C302.0	67030200	CMTS: docsIf3CmtsEventNotif
DCC	DCC Response	Warning	DCC-RSP rejected unspecified reason<TAGS>		C303.0	67030300	CMTS: docsIf3CmtsEventNotif
DCC	DCC Response	Warning	DCC-RSP rejected unknown transaction ID<TAGS>		C304.0	67030400	CMTS: docsIf3CmtsEventNotif
DCC	DCC Response	Warning	DCC-RSP rejected authentication failure<TAGS>		C305.0	67030500	CMTS: docsIf3CmtsEventNotif
DCC	DCC Response	Warning	DCC-RSP rejected message syntax error<TAGS>		C306.0	67030600	CMTS: docsIf3CmtsEventNotif
DCC	DCC Acknowledgement	Warning	DCC-ACK not received<TAGS>		C401.0	67040100	CMTS: docsIf3CmtsEventNotif
DCC	DCC Acknowledgement	Warning	DCC-ACK rejected unspecified reason<TAGS>		C402.0	67040200	CMTS: docsIf3CmtsEventNotif
DCC	DCC Acknowledgement	Warning	DCC-ACK rejected unknown transaction ID<TAGS>		C403.0	67040300	CMTS: docsIf3CmtsEventNotif
DCC	DCC Acknowledgement	Warning	DCC-ACK rejected authentication failure<TAGS>		C404.0	67040400	CMTS: docsIf3CmtsEventNotif
DCC	DCC Acknowledgement	Warning	DCC-ACK rejected message syntax error<TAGS>		C405.0	67040500	CMTS: docsIf3CmtsEventNotif
Profile Change							
DBC	DBC Request	Notice	Changed DS profile. MAC address: <P1>; DS Chan ID: <P2>; Previous Profile: <P3>; New Profile: <P4>; <TAGS>;	P1: MAC Address of CM P2: Downstream channel ID P3: Previous OFDM Profile ID P4: New OFDM Profile ID	C606.0	67060600	CCAP: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DBC	DBC Request	Notice	Changed US profile. MAC address: <P1>; US Chan ID: <P2>; Previous Profile: <P3>; New Profile: <P4>; <TAGS>;	P1: MAC address of CM P2: Upstream channel ID P3: Previous OFDMA Profile ID P4: New OFDMA Profile ID	C606.1	67060601	CCAP: docsIf3CmtsEventNotif
DHCP, TOD and TFTP							
Init	IPv6 Address Acquisition	Warning	Link-Local address failed DAD<TAGS>		D001.1	68000101	
Init	IPv6 Address Acquisition	Warning	Link-Local address incorrectly formatted<TAGS>		D001.2	68000102	
Secure Software Download							
Registration and TLV-11							
Init	REGISTRATION REQUEST	Warning	Service unavailable - Other<TAGS>		I04.0	73000400	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Service unavailable - Unrecognized configuration setting<TAGS>		I04.1	73000401	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Service unavailable - Temporarily unavailable<TAGS>		I04.2	73000402	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Service unavailable - Permanent<TAGS>		I04.3	73000403	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Registration rejected authentication failure: CMTS MIC invalid<TAGS>		I05.0	73000500	CMTS: docsIf3CmtsEventNotif
Init	3.0 SPECIFIC REGISTRATION REQUEST	Warning	Registration authentication failure: REG REQ rejected - TLV parameters do not match learned config file TLV parameters<TAGS>		I05.1	73000501	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	REG REQ has Invalid MAC header<TAGS>		I101.0	73010100	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	REG REQ has Invalid SID or not in use<TAGS>		I102.0	73010200	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	REG REQ missed Required TLVs<TAGS>		I104.0	73010400	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Init	REGISTRATION REQUEST	Warning	Bad DS FREQ - Format Invalid<TAGS>		I105.0	73010500	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad DS FREQ - Not in use<TAGS>		I105.1	73010501	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad DS FREQ - Not Multiple of 62500 Hz<TAGS>		I105.2	73010502	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad US CH - Invalid or Unassigned<TAGS>		I106.0	73010600	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad US CH - Change followed with (RE-) Registration REQ<TAGS>		I106.1	73010601	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad US CH - Overload<TAGS>		I107.0	73010700	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Network Access has Invalid Parameter<TAGS>		I108.0	73010800	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Class of Service - Invalid Configuration<TAGS>		I109.0	73010900	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Class of Service - Unsupported class<TAGS>		I110.0	73011000	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Class of Service - Invalid class ID or out of range<TAGS>		I111.0	73011100	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Max DS Bit Rate - Invalid Format<TAGS>		I112.0	73011200	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Max DS Bit Rate Unsupported Setting<TAGS>		I112.1	73011201	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Max US Bit - Invalid Format<TAGS>		I113.0	73011300	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Max US Bit Rate - Unsupported Setting<TAGS>		I113.1	73011301	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad US Priority Configuration - Invalid Format<TAGS>		I114.0	73011400	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad US Priority Configuration - Setting out of Range<TAGS>		I114.1	73011401	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Guaranteed Min US CH Bit Rate Configuration setting - Invalid Format<TAGS>		I115.0	73011500	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Init	REGISTRATION REQUEST	Warning	Bad Guaranteed Min US CH Bit Rate Configuration setting - Exceed Max US Bit Rate<TAGS>		I115.1	73011501	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Guaranteed Min US CH Bit Rate Configuration setting - Out of Range<TAGS>		I115.2	73011502	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Max US CH Transmit Burst configuration setting - Invalid Format<TAGS>		I116.0	73011600	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Bad Max US CH Transmit Burst configuration setting - Out of Range<TAGS>		I116.1	73011601	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Invalid Modem Capabilities configuration setting<TAGS>		I117.0	73011700	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	Configuration file contains parameter with the value outside of the range<TAGS>		I118.0	73011800	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Unspecified reason<TAGS>		I201.0	73020100	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Unrecognized configuration setting<TAGS>		I201.1	73020101	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Major service flow error<TAGS>		I201.10	73020110	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Major classifier error<TAGS>		I201.11	73020111	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Multiple major errors<TAGS>		I201.13	73020113	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Message syntax error <P1><TAGS>	P1 = Message	I201.14	73020114	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Primary service flow error <P1><TAGS>	P1 = Service Flow Reference	I201.15	73020115	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - temporary no resource<TAGS>		I201.2	73020102	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Permanent administrative<TAGS>		I201.3	73020103	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Required parameter not present <P1><TAGS>	P1 = TLV parameter	I201.4	73020104	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Header suppression setting not supported<TAGS>		I201.5	73020105	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Multiple errors<TAGS>		I201.6	73020106	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - duplicate reference-ID or index in message<TAGS>		I201.7	73020107	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - parameter invalid for context <P1><TAGS>	P1 = TLV parameter	I201.8	73020108	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Authorization failure<TAGS>		I201.9	73020109	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION ACKNOWLEDGEMENT	Warning	REG aborted no REG-ACK<TAGS>		I301.0	73030100	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION Acknowledgement	Warning	REG ACK rejected unspecified reason<TAGS>		I302.0	73030200	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION ACKNOWLEDGEMENT	Warning	REG ACK rejected message syntax error<TAGS>		I303.0	73030300	CMTS: docsIf3CmtsEventNotif
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Message too big <P1><TAGS>	P1 = Number of characters	I201.16	73020116	CMTS: docsIf3CmtsEventNotif
Init	Waiting for REG-REQ or REG-REQ-MP	Warning	T9 Timeout - Never received REG-REQ or all REG-REQ-MP fragments<TAGS>		I211.0	73021100	
Init	CMTS Registration	Error	Missing RCP in REG-REQ or REG-REQ-MP<TAGS>		I551.0	73055100	

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Init	CMTS Registration	Notice	Received Non-Queue-Depth Based Bandwidth Request and Multiple Transmit Channel mode is enabled<TAGS>		I552.0	73055200	
Init	CMTS Registration	Notice	Received Queue-Depth Based Bandwidth Request when Multiple Transmit Channel mode is not enabled<TAGS>		I553.0	73055300	
Init	CMTS Registration	Notice	Received REG-ACK with TCS - Partial Service<TAGS>		I554.0	73055400	
Init	CMTS Registration	Notice	Received REG-ACK with RCS - Partial Service<TAGS>		I555.0	73055500	
Init	CMTS Registration	Warning	T6 Timer expires and Retries Exceeded<TAGS>		I556.0	73055600	
Init	CMTS Registration	Warning	Initializing Channel Timeout<TAGS>		I557.0	73055700	
Init	CMTS Registration	Warning	REG-REQ-MP received when no MDD present<TAGS>		I558.0	73055800	
Init	CMTS Registration	Warning	REG-REQ rejected invalid Energy Management parameters<TAGS>		I559.0	73055900	
Init	REGISTRATION REQUEST	Warning	REG-REQ rejected - ASF QoS parameter cannot be supported <P1><P2><TAGS>	P1 = US or DS service flow reference P2 = Unsupported TLV type	I560.0	73056000	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	REG-REQ rejected - the number of <P1> ASF instances cannot be supported <TAGS>	P1 = US or DS	I561.0	73056100	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Warning	REG-REQ rejected - ASF Classifier Merge Conflict <P1> <P2> <TAGS>	P1 = Classifier Reference P2 = Classifier sub-TLV type	I562.0	73056200	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Notice	AQP Expansion aborted <P1> <TAGS>	P1 = US or DS service flow reference	I563.0	73056300	CMTS: docsIf3CmtsEventNotif
Init	REGISTRATION REQUEST	Notice	GGR exceeds allowed rate <P1> <TAGS>.	P1 = US or DS service flow reference	I564.0	73056400	CMTS: docsIf3CmtsEventNotif
QoS							
Service Flow	Service Flow Assignment	Notice	Attribute Masks for SF (SFID <P1>) do not satisfy those in the SCN <P2>; <TAGS>;	P1 = SFID P2 = SCN	K101.0	75010100	

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
General							
Ranging							
Init	RANGING	Warning	No Ranging Requests received from POLLED CM (CMTS generated polls);<CM-MAC>; <TAGS>;		R101.0	82010100	
Init	RANGING	Warning	Retries exhausted for polled CM (report MAC address). After 16 R101.0 errors<CM-MAC>; <TAGS>;		R102.0	82010200	
Init	RANGING	Warning	Unable to Successfully Range CM (report MAC address) Retries Exhausted;<CM-MAC>; <TAGS>;	NOTE: this is different from R102.0 in that it was able to try, i.e., got REQs but failed to Range properly.	R103.0	82010300	
Init	RANGING	Warning	Failed to receive Periodic RNG-REQ from modem (SID X), timing-out SID;<CM-MAC>; <TAGS>;		R104.0	82010400	
Init	RANGING	Informational	CM transmitted B-INIT-RNG-REQ with MD-DS-SG ID of zero;<CM-MAC>; <TAGS>;	For CMTS SYSLOG only, append: MAC addr: <P1> P1 = Mac Addr of CM	R105.0	82010500	
Dynamic Services							
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Unspecified reason<TAGS>		S01.0	83000100	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Unrecognized configuration setting<TAGS>		S01.1	83000101	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Classifier not found<TAGS>		S01.10	83000110	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Classifier exists<TAGS>		S01.11	83000111	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Duplicated reference-ID or index in message<TAGS>		S01.14	83000114	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Multiple upstream flows<TAGS>		S01.15	83000115	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Multiple downstream flows<TAGS>		S01.16	83000116	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Classifier for another flow<TAGS>		S01.17	83000117	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Parameter invalid for context<TAGS>		S01.19	83000119	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Temporary no resource<TAGS>		S01.2	83000102	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Authorization failure<TAGS>		S01.20	83000120	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Major service flow error<TAGS>		S01.21	83000121	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Major classifier error<TAGS>		S01.22	83000122	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Multiple major errors<TAGS>		S01.24	83000124	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Message syntax error<TAGS>		S01.25	83000125	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Message too big<TAGS>		S01.26	83000126	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Temporary DCC<TAGS>		S01.27	83000127	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Permanent administrative<TAGS>		S01.3	83000103	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Required parameter not present<TAGS>		S01.4	83000104	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Header suppression setting not supported<TAGS>		S01.5	83000105	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Service flow exists<TAGS>		S01.6	83000106	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - HMAC Auth failure<TAGS>		S01.7	83000107	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Add aborted<TAGS>		S01.8	83000108	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Multiple errors<TAGS>		S01.9	83000109	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Unspecified reason<TAGS>		S02.0	83000200	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Unrecognized configuration setting<TAGS>		S02.1	83000201	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Classifier not found<TAGS>		S02.10	83000210	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Classifier exists<TAGS>		S02.11	83000211	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Duplicated reference-ID or index in message<TAGS>		S02.14	83000214	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Multiple upstream flows<TAGS>		S02.15	83000215	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Multiple downstream flows<TAGS>		S02.16	83000216	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Classifier for another flow<TAGS>		S02.17	83000217	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Invalid parameter for context<TAGS>		S02.19	83000219	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Temporary no resource<TAGS>		S02.2	83000202	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Authorization failure<TAGS>		S02.20	83000220	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Major service flow error<TAGS>		S02.21	83000221	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Major classifier error<TAGS>		S02.22	83000222	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Multiple major errors<TAGS>		S02.24	83000224	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Message syntax error<TAGS>		S02.25	83000225	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Message too big<TAGS>		S02.26	83000226	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Temporary DCC<TAGS>		S02.27	83000227	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Permanent administrative<TAGS>		S02.3	83000203	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Requester not owner of service flow<TAGS>		S02.4	83000204	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Service flow not found<TAGS>		S02.5	83000205	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Required parameter not present<TAGS>		S02.6	83000206	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Header suppression setting not supported<TAGS>		S02.7	83000207	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - HMAC Auth failure<TAGS>		S02.8	83000208	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Multiple errors<TAGS>		S02.9	83000209	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Delete rejected - Unspecified reason<TAGS>		S03.0	83000300	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Delete rejected - Requester not owner of service flow<TAGS>		S03.1	83000301	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Delete rejected - Service flow not found<TAGS>		S03.2	83000302	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Delete rejected - HMAC Auth failure<TAGS>		S03.3	83000303	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Delete rejected - Message syntax error<TAGS>		S03.4	83000304	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Invalid transaction ID<TAGS>		S101.0	83010100	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add aborted - No RSP<TAGS>		S101.1	83010101	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Duplicate reference_ID or index in message<TAGS>		S101.11	83010111	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Classifier for another flow<TAGS>		S101.12	83010112	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Parameter invalid for context<TAGS>		S101.13	83010113	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Major service flow error<TAGS>		S101.14	83010114	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Major classifier error<TAGS>		S101.15	83010115	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Multiple major errors<TAGS>		S101.17	83010117	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Message too big<TAGS>		S101.18	83010118	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - HMAC Auth failure<TAGS>		S101.2	83010102	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Message syntax error<TAGS>		S101.3	83010103	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Unspecified reason<TAGS>		S101.4	83010104	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Unrecognized configuration setting<TAGS>		S101.5	83010105	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Required parameter not present<TAGS>		S101.6	83010106	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Service Flow exists<TAGS>		S101.7	83010107	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Multiple errors<TAGS>		S101.8	83010108	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Classifier exists<TAGS>		S101.9	83010109	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Invalid transaction ID<TAGS>		S102.0	83010200	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change aborted - No RSP<TAGS>		S102.1	83010201	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Duplicated reference-ID or index in<TAGS>		S102.10	83010210	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Invalid parameter for context<TAGS>		S102.11	83010211	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Major classifier error<TAGS>		S102.12	83010212	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Multiple Major errors<TAGS>		S102.14	83010214	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Message too big<TAGS>		S102.15	83010215	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - HMAC Auth failure<TAGS>		S102.2	83010202	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Message syntax error<TAGS>		S102.3	83010203	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Unspecified reason<TAGS>		S102.4	83010204	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Unrecognized configuration setting<TAGS>		S102.5	83010205	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Required parameter not present<TAGS>		S102.6	83010206	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Multiple errors<TAGS>		S102.7	83010207	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Classifier exists<TAGS>		S102.8	83010208	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Delete Response rejected - Invalid transaction ID<TAGS>		S103.0	83010300	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Add Response rejected - Invalid Transaction ID<TAGS>		S201.0	83020100	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Add Aborted - No ACK<TAGS>		S201.1	83020101	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Add ACK rejected - HMAC auth failure<TAGS>		S201.2	83020102	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Add ACK rejected- Message syntax error<TAGS>		S201.3	83020103	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Change ACK rejected - Invalid transaction ID<TAGS>		S202.0	83020200	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Change Aborted - No ACK<TAGS>		S202.1	83020201	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Change ACK rejected - HMAC Auth failure<TAGS>		S202.2	83020202	CMTS: docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE ACKNOWLEDGEMENT	Warning	Service Change ACK rejected - Message syntax error<TAGS>		S202.3	83020203	CMTS: docsIf3CmtsEventNotif
Downstream Acquisition							
Diagnostic Log							
Diag	LogSize	Warning	Diagnostic log size reached high threshold. Enabled detectors: <P1>;Log maximum size: <P2>; <TAGS>;	P1 = (ASCII hex representation of enabled diagnostic log detectors bit mask) P2 = maximum size of the diagnostic log	V001.0	86000100	docsDiagLogSizeHighThrshldReached
Diag	LogSize	Notice	Diagnostic log size dropped to low threshold. Enabled detectors: <P1>;Log maximum size: <P2>; <TAGS>;	P1 = (ASCII hex representation of enabled diagnostic log detectors bit mask) P2 = maximum size of the diagnostic log	V002.0	86000200	docsDiagLogSizeLowThrshldReached
Diag	LogSize	Warning	Diagnostic log size reached full threshold. Enabled detectors: <P1>;Log maximum size: <P2>; <TAGS>;	P1 = (ASCII hex representation of enabled diagnostic log detectors bit mask) P2 = maximum size of the diagnostic log	V003.0	86000300	docsDiagLogSizeFull
IPDR							
IPDR	IPDR/SP Protocol	Notice	IPDR Connection Terminated. Collector IP:<P1>;Session ID: <P2>;Error Code: <P3>; Error Description: <P4>; <TAGS>;	P1 = Collector Host Name P2 = Session ID P3 = Error Code P4 = Error Description	W001.0	87000100	
IPDR	IPDR/SP Redundancy	Warning	IPDR Collector Failover Error: Backup Collector IP: <P1>; <TAGS>;	P1 = Backup Collector IP	W002.0	87000200	

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Multicast							
Multicast	QoS	Warning	Aggregate Session Limit defined by GC,GQC entry (<P1>) exceeded by join for (<P2>)<TAGS>	P1 = GC ID,GQC ID P2 = S,G of the join Note: The event only records the CM MAC Addr though the Join could be from a CM or a CPE behind it.	Y101.0	89010100	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Warning	Admitted Multicast Aggregate Bandwidth Increased Above Low Water Mark <P1> on Interface <P2>:<P3><TAGS>	P1 = Low Water Mark Threshold P2 = ifName.ifIndex P3 = ifIndex	Y101.1	89010101	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Notice	Admitted Multicast Aggregate Bandwidth Dropped Below Low Water Mark <P1> on Interface <P2>:<P3><TAGS>	P1 = Low Water Mark Threshold P2 = ifName.ifIndex P3 = ifIndex	Y101.2	89010102	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Error	Admitted Multicast Aggregate Bandwidth Increased to High Water Mark <P1> on Interface <P2>:<P3><TAGS>	P1 = High Water Mark Threshold P2 = ifName.ifIndex P3 = ifIndex	Y101.3	89010103	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Warning	Multicast Group Service Flow <P1> on Interface <P2>:<P3> Dropping Packets;<P4>:<P5>:<P6><TAGS>	P1 = Service Flow ID associated with GSF P2 = MAC Domain ifName.ifIndex P3 = MAC Domain ifIndex P4 = Service Class Name P5 = Max Traffic Rate P6 = GC ID, GQC ID	Y101.4	89010104	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Notice	Multicast Group Service Flow <P1> on Interface <P2>:<P3> No Longer Dropping Packets;<P4>:<P5>:<P6><TAGS>	P1 = Service Flow ID associated with GSF P2 = MAC Domain ifName.ifIndex P3 = MAC Domain ifIndex P4 = Service Class Name P5 = Max Traffic Rate P6 = GC ID, GQC ID	Y101.5	89010105	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Multicast	QoS	Warning	Ingress IGMP Protocol Messages Increased to Threshold <P1> on Interface <P2>:<P3><TAGS>	P1 = Threshold P2 = MAC Domain ifName.ifIndex P3 = MAC Domain ifIndex	Y101.6	89010106	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Notice	Ingress IGMP Protocol Messages Dropped Below Threshold <P1> on Interface <P2>:<P3><TAGS>	P1 = Threshold P2 = MAC Domain ifName.ifIndex P3 = MAC Domain ifIndex	Y101.7	89010107	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Warning	Ingress MLD Protocol Messages Increased to Threshold <P1> on Interface <P2>:<P3><TAGS>	P1 = Threshold P2 = MAC Domain ifName.ifIndex P3 = MAC Domain ifIndex	Y101.8	89010108	CMTS: docsIf3CmtsEventNotif
Multicast	QoS	Notice	Ingress MLD Protocol Messages Dropped Below Threshold <P1> on Interface <P2>:<P3><TAGS>	P1 = Threshold P2 = MAC Domain ifName.ifIndex P3 = MAC Domain ifIndex	Y101.9	89010109	CMTS: docsIf3CmtsEventNotif
Multicast	Authorization	Notice	Multicast session <P1> not authorized for Client <P2> behind CM <P3><TAGS>	P1 = S,G of the join P2 = IPv4 or IPv6 Address of Client P3 = CM MAC Addr	Y102.0	89010200	CMTS: docsIf3CmtsEventNotif
Multicast	Authorization	Warning	Maximum Multicast Session <P1> Threshold <P2> Reached for CM <P3><TAGS>	P1 = S,G of the join P2 = Multicast Session Limit P3 = CM MAC Addr	Y102.1	89010201	CMTS: docsIf3CmtsEventNotif
Multicast	Authorization	Informational	Multicast Profile <P1> created for CM <P2><TAGS>	P1 = Profile Name P2 = CM MAC Addr	Y103.0	89010300	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Streaming Telemetry							
Streaming Telemetry	Streaming Telemetry Connection	Notice	Connection between Telemetry Client and Server successfully established; Telemetry Client IP: <P1>; Telemetry Server IP: <P2>; Source TCP port: <P3>; Destination TCP port: <P4>; <TAGS>;	P1 = IP address of Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port	Y200.00	89020000	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry Dial-In	Error	Dial-in connection attempt from Telemetry Client rejected; Telemetry Client IP: <P1>; Telemetry Server IP: <P2>; Source TCP port <P3>; Destination TCP port: <P4>; Reason: <P5>; <TAGS>;	P1 = IP address of the Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port P5 = vendor specific	Y200.01	89020001	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry Dial-In	Error	Dial-in connection from Telemetry Client failed; Telemetry Client IP: <P1>; Telemetry Server IP: <P2>; Source TCP port: <P3>; Destination TCP port: <P4>; Reason: <P5>; <TAGS>;	P1 = IP address of the Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port P5 = vendor specific	Y200.02	89020002	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry Dial-Out	Error	Dial-out connection from Telemetry Server failed; Telemetry Server IP: <P1>; Telemetry Client IP: <P2>; Source TCP port: <P3>; Destination TCP port: <P4>; Reason: <P5>; <TAGS>;	P1 = IP address of the Streaming Telemetry Server P2 = IP address of Streaming Telemetry Client P3 = Source TCP port P4 = Destination TCP port P5 = vendor specific	Y200.03	89020003	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Streaming Telemetry	Streaming Telemetry Dial-In	Error	Dial-In Security Association failure during TLS negotiation; Telemetry Server IP: <P1>; Telemetry Client IP: <P2>; Source TCP port: <P3>; Destination TCP port: <P4>; Reason: <P5>; <TAGS>;	P1 = IP address of the Streaming Telemetry Server P2 = IP address of Streaming Telemetry Client P3 = Source TCP port P4 = Destination TCP port P5 = vendor specific	Y200.04	89020004	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry Dial-Out	Error	Dial-Out Security Association failure during TLS negotiation; Telemetry Client IP: <P1>; Telemetry Server IP: <P2>: Source TCP port: <P3>; Destination TCP port: <P4>: Reason: <P5>; <TAGS>;	P1 = IP address of the Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port P5 = vendor specific	Y200.05	89020005	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry (gNMI)	Notice	Subscription(s) successfully started between Telemetry Client and Server; Telemetry Client IP:<P1>; Telemetry Server IP:<P2>; Source TCP port:<P3>; Destination TCP port:<P4>; <TAGS>;	P1 = IP address of the Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port	Y200.06	89020006	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry (gNMI)	Error	Subscription(s) failed; Telemetry Client IP:<P1>; Telemetry Server IP:<P2>; Source TCP port; :<P3>; Destination TCP port:<P4>; Reason: <P5>;<TAGS>;	P4 is optional and vendor specific P1 = IP address of the Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port: P5 = vendor specific	Y200.07	89020007	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Streaming Telemetry	Streaming Telemetry Connection	Error	Connection failed between Telemetry Client and Server due to max connection count reached; Telemetry Client IP: <P1>; Telemetry Server IP: <P2>; Source TCP port: <P3>; Destination TCP port: <P4>; <TAGS>;	P1 = IP address of Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port	Y200.08	89020008	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry (gNMI)	Notice	Subscription(s) cancelled by Telemetry Client; Telemetry Client IP:<P1>; Telemetry Server IP:<P2>; Source TCP port: <P3>; Destination TCP port: <P4>; <TAGS>;	P1 = IP address of the Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port	Y200.09	89020009	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry Connection	Notice	Connection terminated and subscription(s) closed by Telemetry Client; Telemetry Client IP: <P1>; Telemetry Server IP: <P2>; Source TCP port: <P3>; Destination TCP port: <P4>; <TAGS>;	P1 = IP address of Streaming Telemetry Client P2 = IP address of Streaming Telemetry Server P3 = Source TCP port P4 = Destination TCP port	Y200.10	89020010	CMTS: docsIf3CmtsEventNotif
Streaming Telemetry	Streaming Telemetry Connection	Notice	Dial Out connection retry attempt between Telemetry Server and Client unsuccessful. Attempt: <P1>; Telemetry Client IP: <P2>; Server IP: <P3>; Src TCP port: <P4>; Dst TCP port: <P5>; <TAGS>;	P1 = "first"|"MaxRetries. Telemetry Server has stopped attempting to connect with Client." P2 = IP address of Streaming Telemetry Client P3 = IP address of Streaming Telemetry Server P4 = Source TCP port P5 = Destination TCP port	Y200.11	89020011	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
CM-STATUS							
CM-STATUS	CM-STATUS	Notice	CM-STATUS received prior to REG-ACK<TAGS>		J01.0	74000100	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received while enable bit cleared<TAGS>		J02.0	74000200	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - secondary channel MDD timeout<TAGS>		J03.0	74000300	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - QAM/FEC lock failure<TAGS>		J04.0	74000400	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - sequence out-of-range<TAGS>		J05.0	74000500	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - MDD recovery<TAGS>		J06.0	74000600	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - QAM/FEC recovery<TAGS>		J07.0	74000700	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - T4 timeout<TAGS>		J08.0	74000800	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - T3 retries exceeded<TAGS>		J09.0	74000900	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - DS OFDM profile failure<TAGS>		J10.0	74001000	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - Primary DS change<TAGS>		J11.0	74001100	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - DPD out of sync<TAGS>		J12.0	74001200	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - Invalid DPD<TAGS>		J13.0	74001300	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - NCP profile failure<TAGS>		J14.0	74001400	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - Loss of PLC channel<TAGS>		J15.0	74001500	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - Loss of data on all profiles<TAGS>		J16.0	74001600	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - US OFDMA profile failure <TAGS>		J17.0	74001700	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - MAP storage overflow<TAGS>		J18.0	74001800	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
CM-STATUS	CM-STATUS	Notice	CM-STATUS received - MAP storage almost full<TAGS>		J19.0	74001900	CMTS: docsIf3CmtsEventNotif
CM-STATUS	CM-STATUS	Emergency	CM-STATUS received - Dying Gasp alarm<TAGS>		J20.0	74002000	CMTS: docsIf3CmtsEventNotif
CM-CTRL							
CM-CTRL	CM-CTRL	Debug	CM-CTRL - Command: <P1> (if P1= mute Add Interval: <P2> ChannelID: <P3>) (If P1 = forwarding Add Action: <P4>) <TAGS>	P1 = mute, or cmReinit, or forwarding P2= mute interval, Value 0 indicate unmute operation P3= Channel ID or 0 P4 = enable, or disable	L01.0	76000100	CMTS: docsIf3CmtsEventNotif
CM-CTRL	CM-CTRL	Debug	CM-CTRL- Invalid message format<TAGS>		L02.0	76000200	CMTS: docsIf3CmtsEventNotif
Energy Management							
EM	EM-RSP	Warning	EM-RSP sent, Reject Temporary: Bonded Multicast Conflict<TAGS>		L105.0	76010500	
EM	EM-RSP	Warning	EM-RSP sent, Reject Temporary: UGS/RTPS Grant Conflict<TAGS>		L106.0	76010600	
EM	EM-RSP	Warning	EM-RSP sent, Reject Temporary: Attribute Mask Conflict<TAGS>		L107.0	76010700	
EM	EM-RSP	Warning	EM-RSP sent, Reject Temporary: Deferred<TAGS>		L108.0	76010800	
EM	EM-RSP	Warning	EM-RSP sent, Reject Permanent, Requested Low Power Mode(s) Not Supported<TAGS>		L109.0	76010900	
EM	EM-RSP	Warning	EM-RSP sent, Reject Permanent, Requested Low Power Mode(s) Disabled<TAGS>		L110.0	76011000	
EM	EM-RSP	Warning	EM-RSP sent, Reject Permanent, Other<TAGS>		L111.0	76011100	
EM	EM-RSP	Notice	CM allowed into 1x1 Mode while Attribute Masks not met<TAGS>		L112.0	76011200	
EM	DBC	Informational	CM entered EM 1x1 mode; Reason: <P1><TAGS>	P1=Unknown, Activity Detection, eSAFE, CMTS Initiated	L113.0	76011300	CMTS: docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
EM	DBC	Informational	CM exited EM 1x1 mode<TAGS>		L114.0	76011400	CMTS: docsIf3CmtsEventNotif
Data Collection							
Data Collection	Data File	Warning	Bulk data file size reached high threshold. Data collection type: <P1>; Filename: <P2>; File maximum size: <P3>; <TAGS>;	P1 = (Type of data collection such as PNM test type, e.g., Upstream Triggered Spectrum Capture) P2 = Filename assigned to the PNM data file P3 = maximum size of PNM capture file in bytes	F007.01	70000701	docsIf3CmtsEventNotif
Data Collection	Data File	Warning	Bulk data file size reached full threshold. Data collection type: <P1>; Filename: <P2>; File maximum size: <P3>; <TAGS>;	P1 = (Type of data collection such as PNM test type, e.g., Upstream Triggered Spectrum Capture) P2 = Filename assigned to the PNM data file P3 = maximum size of PNM capture file in bytes	F007.02	70000702	docsIf3CmtsEventNotif
Data Collection	PNM Test	Informational	PNM test complete; Test Id: <P1>; Test Type: <P2>; Test Status: <P3>; <TAGS>;	P1 = PNM Test Id P2 = PNM Test Type P3 = PNM Test Status	F007.03	70000703	docsIf3CmtsEventNotif
Data Collection	Data File	Informational	Bulk data file status update; File Index: <P1>; Filename: <P2>; File Status: <P3>; <TAGS>;	P1 = FileStatus::Index P2 = FileStatus::LocalFilename P3 = FileStatus::FileStatus	F007.04	70000704	docsIf3CmtsEventNotif
DSG Reserved Events (See [DSG] for Event Definitions)							
					Gxxxx.xx		
eDOCSIS Reserved Events (See [eDOCSIS] for Event Definitions)							
					Hxxxx.xx		
M-CMTS Reserved Events (See [M-OSSI] for Event Definitions)							
					Mxxxx.xx		
DPoE Reserved Events (See [DPoE OSSIv2.0] for Event Definitions)							
					Pxxxx.xx		

Process	Sub-Process	CMTS/ CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
EQAM Reserved Events (See [PMI] for Event Definitions)							
					Qxxxx.xx		

Table 631 - CCAP Events

Process	Sub-Process	CCAP Priority	Event Message	Message Notes and Details	Error Code Set	Event ID	Trap Name
CCAP ERMI							
CCAP-ERMI		Critical	Session Loss type=<P1>; sessionId = <P2>; <TAGS>;	P1 = session loss type P2 = sessionID	F002.1	70000201	docsIf3CmtsEventNotif
CCAP-ERMI		Critical	Link Down Loss of Service; Interface=<P1>; <TAGS>;	for syslog & local-log Mandatory Add: ; Error Code = 0; P1= MapPath	F002.2	70000202	docsIf3CmtsEventNotif
CCAP-ERMI		Critical	Sessions Lost=<P1>; Sessions failed-over=<P2>; <TAGS>;	P1 = number of sessions lost P2 = number of failed-over sessions for syslog & local-log Mandatory Add: ; Error Code = 0;	F002.3	70000203	docsIf3CmtsEventNotif
CCAP-ERMI		Critical	Excessive network jitter in session, jitter buffer overflow; sessionID=<P1>; <TAGS>;	P1 = sessionID for syslog & local-log Mandatory Add: ; Error Code = 0;	F002.4	70000204	docsIf3CmtsEventNotif
CCAP Physical & Environmental							
CCAP- PE	Cooling	Critical	Cooling - Fan unit <P1> Failure; <P2>; <TAGS>;	P1 = entPhysicalIndex of fan unit P2 = entPhysicalName	F003.1	70000301	docsIf3CmtsEventNotif
CCAP-PE	Cooling	Warning	Cooling - Sensor unit=<P1> - High Temperature Threshold Exceeded <P2>; <TAGS>;	P1 = entPhysicalIndex of temperature sensor P2 = Temp (F/C)	F003.2	70000302	docsIf3CmtsEventNotif
CCAP-PE	Cooling	Warning	Cooling - Sensor unit=<P1> - Normal Operating Temperature Exceeded: <P2>; <TAGS>;	P1 = entPhysicalIndex of temperature sensor P2 = Temp (F/C)	F003.3	70000303	docsIf3CmtsEventNotif

Process	Sub-Process	CCAP Priority	Event Message	Message Notes and Details	Error Code Set	Event ID	Trap Name
CCAP-PE	Power	Critical	Power - Power Supply unit-<P1> - Bus Failure; <TAGS>;	P1 = entPhysicalIndex of power supply unit	F003.4	70000304	docsIf3CmtsEventNotif
CCAP-PE	Power	Warning	Power - Power supply unit=<P1>: <P2> - Below 95%; <TAGS>;	P1= entPhysicalIndex of power supply unit P2 = entPhysicalName of power supply unit	F003.5	70000305	docsIf3CmtsEventNotif
CCAP-PE	Power	Notice	Power - Power Supply Switchover, Previous unit=<P1>: <P2>, New unit=<P2>: <P4>; <TAGS>;	P1 = entPhysicalIndex of power supply unit P2 = entPhysicalName of power supply unit P3 = entPhysicalIndex of power supply unit P4 = entPhysicalName of power supply unit	F003.6	70000306	docsIf3CmtsEventNotif
CCAP-PE	Power	Critical	Power - Power Supply unit=<P1>: <P2> - Improper Input Voltage; <TAGS>;	P1 = entPhysicalIndex of power supply unit P2 = entPhysicalName of power supply unit	F003.7	70000307	docsIf3CmtsEventNotif
CCAP-PE	Power	Critical	Power - Power Supply unit=<P1>: <P2> - Power Phase Disconnected; <TAGS>;	P1= entPhysicalIndex of power supply unit P2 = entPhysicalName of power supply unit e For Syslog and Local Log, append: CCAP shut down due to multiphase power problem	F003.8	70000308	docsIf3CmtsEventNotif
CCAP-PE	Power	Notice	Power - Power Supply unit=<P1>: <P2>; Operational; <TAGS>;	P1 = entPhysicalIndex of power supply unit P2 = entPhysicalName of power supply unit	F003.9	70000309	docsIf3CmtsEventNotif
CCAP-PE	Redundancy	Alert	Line Card Failure in slot=<P1> - No Redundancy; <TAGS>;	P1 = entPhysicalIndex of the slot number	F003.10	70000310	docsIf3CmtsEventNotif
CCAP-PE	Redundancy	Critical	Line Card Failure in slot=<P1> failed over to redundant card in slot=<P2>; <TAGS>;	P1 = entPhysicalIndex of slot number of the failed line card P2 = entPhysicalIndex of slot number of the redundant line card	F003.11	70000311	docsIf3CmtsEventNotif
CCAP-PE	Redundancy	Notice	Line Card Operational in slot=<P1>; <TAGS>;	<P1>=entPhysicalIndex of slot number	F003.12	70000312	docsIf3CmtsEventNotif

Process	Sub-Process	CCAP Priority	Event Message	Message Notes and Details	Error Code Set	Event ID	Trap Name
CCAP-PE	Interface Status	Critical	Failover of interface ifIndex=<P1>, ifAlias=<P2> to interface ifIndex=<P3>, ifAlias<P4>; <TAGS>;	P1/P3 = ifIndex from ifTable for Ethernet Interface P2/P4 = ifAlias from ifTable for Ethernet Interface	F003.13	70000313	docsIf3CmtsEventNotif
CCAP-PE	Interface Status	Notice	Interface ifIndex=<P1>, ifAlias=<P2> Operational; <TAGS>;	P1 = ifIndex from ifTable for Ethernet Interface P2 = ifAlias from ifTable for Ethernet Interface	F003.14	70000314	docsIf3CmtsEventNotif
CCAP COPS Interface							
CCAP-COPS	Status	Critical	COPS Connection Limit Threshold Exceeded <TAGS>		F004.1	70000401	docsIf3CmtsEventNotif
CCAP Content Protection							
CCAP-CP	Encryptor	Alert	Stream not Restored; Manual intervention required: video traffic sessionId = <P1>; <TAGS>;	P1 = Video sessionId	F005.1	70000501	docsIf3CmtsEventNotif
CCAP Denial of Service Protection							
CCAP-DOS	Traffic	Error	Protocol throttling initiated: <P1>; <TAGS>;	P1 = Protocol being throttled	F006.1	70000601	docsIf3CmtsEventNotif

D.1 Error Strings

The following tables contain parameters for security events found in the Event Format and Content Table.

Table 632 - Certificate Level Parameters

Error Strings	Extended Description
End Entity Certificate	The error generated while validating the end entity certificate
Intermediate CA certificate	The error generated while validating the intermediate CA certificate
Root CA certificate	The error generated while validating the root CA certificate

Table 633 - Certificate Error Parameters

Error Strings	Extended Description
Incomplete DOCSIS 4.0 Certificate chain	Certificate is missing
Certificate is expired	Certificate is expired

Error Strings	Extended Description
Certificate is revoked	Certificate is revoked via CRL
	Certificate is revoked via OCSP
Cannot fetch revocation info	Missing URL in certificate or configuration
	Misconfigured URL or network unavailability
Certificate has Invalid format	Certificate has improper format
Certificate is not trusted	Certificate does not chain to a valid trusted root
Domain mismatch	The certificate does not contain the FQDN or the server IP address
Certificate public key algorithm is not supported	The algorithm of the public key inside this certificate is not supported

Table 634 - TLS Protocol Error Parameters

Error Strings	Extended Description
TLS version incompatibility	MAC-NE and server use incompatible TLS version
TLS cipher suites incompatibility	MAC-NE and server use incompatible cipher suites

Table 635 - SSH Protocol Error Parameters

Error Strings	Extended Description
SSH version incompatibility	MAC-NE and server use incompatible SSH version
SSH cipher suites incompatibility	MAC-NE and server use incompatible cipher suites

D.2 Deprecated Events

Table 625 in this annex lists deprecated events, including any associated syslog and SNMP trap notifications for the events, for a DOCSIS 4.0-compliant CMTS/CCAP. Implementation of deprecated events is optional.

Table 636 - Deprecated Events

Process	Sub-Process	CMTS/CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Registration and TLV-11							
Init	1.1 and 2.0 SPECIFIC REGISTRATION REQUEST	Warning	REG REQ rejected - Major PHS rule error<TAGS>		I201.12	73020112	docsIf3CmtsEventNotif
Dynamic Services							
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - PHS rule exists<TAGS>		S01.13	83000113	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - PHS rule for another flow<TAGS>		S01.18	83000118	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Add rejected - Major PHS rule error<TAGS>		S01.23	83000123	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - PHS rule not found<TAGS>		S02.12	83000212	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - PHS rule exists<TAGS>		S02.13	83000213	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - PHS rule for another flow<TAGS>		S02.18	83000218	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE REQUEST	Warning	Service Change rejected - Major PHS error<TAGS>		S02.23	83000223	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - PHS rule exists<TAGS>		S101.10	83010110	docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Add Response rejected - Major PHS Rule error<TAGS>		S101.16	83010116	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - Major PHS rule error<TAGS>		S102.13	83010213	docsIf3CmtsEventNotif
DYNAMIC SERVICES	DYNAMIC SERVICE RESPONSE	Warning	Service Change Response rejected - PHS rule exists<TAGS>		S102.9	83010209	docsIf3CmtsEventNotif
UCC							
UCC	UCC Response	Warning	UCC-RSP not received on previous channel ID<TAGS>		C101.0	67010100	
UCC	UCC Response	Warning	UCC-RSP received with invalid channel ID<TAGS>		C102.0	67010200	
UCC	UCC Response	Warning	UCC-RSP received with invalid channel ID on new channel<TAGS>		C103.0	67010300	
CCAP XML Configuration File Processing							
CCAP-Config	Login	Error	Inbound interactive login failed: Protocol: <P1>, Username: <P2>	P1=Protocol from 6.5.7.5 ServerType attribute (section 6.5.7.5) P2=Username	F001.1	70000101	docsIf3CmtsEventNotif
CCAP-Config	File Transfer	Error	File transfer failed: Protocol: <P1>, Username: <P2>, Destination host/path: <P3>:<P4>	P1=Protocol from Section 6.2.6 6.2.6 P2=Username P3=Destination host name or IP address P4=Path to filename	F001.2	70000102	docsIf3CmtsEventNotif
CCAP-Config	Validate	Info	XML Configuration File - Validation Passed: <P1>	P1=configuration file name	F001.3	70000103	docsIf3CmtsEventNotif
CCAP-Config	Validate	Notice	XML Configuration File - Validation Failed: <P1>	P1=configuration file name	F001.4	70000104	docsIf3CmtsEventNotif
CCAP-Config	Execute	Notice	XML Configuration File - Execution Success: <P1>	P1=configuration file name	F001.5	70000105	docsIf3CmtsEventNotif
CCAP-Config	Validate	Error	XML Configuration File - Unsupported Cipher Algorithms - Configuration Continued: <P1>;<P2>	P1=configuration file name, P2=unsupported Cipher algorithm(s)	F001.10	70000110	docsIf3CmtsEventNotif

Process	Sub-Process	CMTS/CCAP Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
CCAP-Config	Validate	Error	XML Configuration File - Unsupported Message Authentication Algorithms - Configuration Continued: <P1>;<P2>	P1=configuration file name, P2=unsupported Message Authentication algorithm(s)	F001.11	70000111	docsIf3CmtsEventNotif
CCAP-Config	Execute	Error	XML Configuration File - Unsupported Elements - Configuration Continued: <P1>	P1=configuration file name	F001.6	70000106	docsIf3CmtsEventNotif
CCAP-Config	Execute	Error	XML Configuration File - Non-fatal Error - Configuration Continued: <P1>	P1=configuration file name	F001.7	70000107	docsIf3CmtsEventNotif
CCAP-Config	Execute	Warning	XML Configuration File - Fatal Operation Value Error - Configuration Aborted: <P1>	P1=configuration file name	F001.8	70000108	docsIf3CmtsEventNotif
CCAP-Config	Execute	Warning	XML Configuration File - Fatal Error - Configuration Aborted: <P1>; <P2>	P1=configuration file name P2=error description	F001.9	70000109	docsIf3CmtsEventNotif

D.3 Example SNMP Notification and Syslog Event Message

This section defines several DOCSIS-defined Event Message constructs which can be encoded in SNMP Notifications and Syslog messages.

The following is an example "Event Message" text string for Event ID 70000304:

```
Power - Power Supply unit-23 Bus - Failure
```

Where the value "23" represents the entPhysicalIndex of the power supply experiencing the bus failure.

The corresponding Syslog formatted event for Event ID 70000304 is encoded as follows when the value of SyslogServer::Format is "rfc3164":

```
<130>Oct 11 22:14:15 CCAP-HOST-123 CCAP[DOCSIS]: <70000304> Power - Power
Supply unit-23 - Bus Failure
```

Where

<130> represents the level which is derived from the OR of the default Facility (128) and the zero-based event priority of Critical=2.
"Oct 11 22:14:15" represents the TIMESTAMP when the CCAP logged the event.
"CCAP-HOST-123" represents the CCAP HOSTNAME.
[DOCSIS] indicates the event is a DOCSIS-defined event.

The corresponding Syslog formatted event for Event ID 70000304 is encoded as follows when the value of SyslogServer::Format is "rfc5424":

```
<130> 1 2022-10-11T22:14:15-07:00 CCAP-HOST-123 DOCSIS – 70000304 - Power -
Power Supply unit-23 - Bus Failure
```

Where

"<130>" represents the level which is derived from the OR of the default Facility (128) and the zero-based event priority of Critical=2. This field corresponds to the PRI field defined in [RFC 5424].

"1" represents the version of the Syslog protocol specification and corresponds to the VERSION field defined in [RFC 5424].

"2022-10-11T22:14:15.44-07:00" represents the TIMESTAMP when the CCAP logged the event and corresponds to the TIMESTAMP field defined in [RFC 5424].

"CCAP-HOST-123" represents the CCAP HOSTNAME and corresponds to the HOSTNAME field defined in [RFC 5424].

"DOCSIS" indicates the event is a DOCSIS-defined event and corresponds to the APP-NAME field defined in [RFC 5424].

"-" in the PROCID field indicates there is no Procedure ID.

"70000304" is the Event ID and corresponds to the MSGID field defined in [RFC 5424].

"-" in the STRUCTURED-DATA field indicates there is no structured data in the message.

"Power - Power Supply unit-23 - Bus Failure" is the Event Message and corresponds to the MSG field defined in [RFC 5424].

The following is an example "Event Message" text string for Event ID 76011300:

```
CM entered EM 1x1 mode; Reason: CMTS Initiated;CM-MAC=00:22:ce:03:f4:da;CM-
QOS=1.1;CM-VER=4.0;CMTS-VER=4.0;
```

Where the value "CMTS Initiated" represents the Reason code for the CM entering the Energy Management 1x1 mode.

The corresponding Syslog formatted event for Event ID 76011300 is encoded as follows when the value of SyslogServer::Format is "rfc3164":

```
<135>Dec 31 20:16:10 CCAP-HOST-456 CCAP[DOCSIS]: <76011300> CM entered EM 1x1
mode; Reason: CMTS Initiated;CM-MAC=00:22:ce:03:f4:da;CM-QOS=1.1;CM-VER=4.0;
CMTS-VER=4.0;
```

Where

"<135>" represents the level which is derived from the OR of the default Facility (128) and the zero-based event priority of Information=6.
"Dec 31 20:16:10" represents the TIMESTAMP when the CCAP logged the event.
"CCAP-HOST-456" represents the CCAP HOSTNAME.
"[DOCSIS]" indicates the event is a DOCSIS-defined event.

Annex E Extending the Configuration Data Model (Normative)

While the majority of the CCAP configuration data model is standardized in the YANG module, it is anticipated that vendors will extend the configuration data model to support vendor-proprietary functionality. This appendix summarizes the guidelines that should be followed when extending the configuration data model and provides examples of how the configuration data model can be extended in YANG.

E.1 YANG Configuration Model Extension

Any extensions to the YANG configuration data model are required to adhere to the requirements in Section 6.5.2.

E.1.1 YANG Extension Principles

Extensions to the YANG configuration data structure are required to be defined in a separate module, rather than within one of the standard CCAP module files. Doing so leaves the standard configuration information model intact and helps to ensure interoperability.

Vendor-proprietary sub-node extensions to standard "list", "choice", and "container" elements are permitted via the use of the "augment" syntax within the vendor-proprietary YANG module. These extensions are only allowed to the "yang-ext" container (which is included in elements eligible for extension). This requirement is to ensure that when the vendor-proprietary YANG module (which imports the standard module) is converted to XML schema, that instance documents valid against the resulting schema are also valid against the standard schema.

In general, vendor-proprietary extensions to the standard YANG module should not use "deviation" statements to alter standard configuration objects. As the fundamental requirement is that nothing be done via YANG extension that would cause configurations valid against the vendor's XML schema to be invalid against the standard schema, deviations are only viable when they place tighter restrictions on an element than the standard schema does.

Vendor-proprietary extensions to the standard YANG modules are required to use a vendor-specific, globally-unique URI for the XML namespace for that vendor. Namespace URIs are chosen so that they cannot collide with standard or other enterprise namespaces; for example, the enterprise or organization name could be used in the namespace.

E.1.2 Creating Vendor Extensions

This section provides a few illustrative examples of creating vendor extensions in YANG. Refer to [RFC 6020] for a complete reference to the extension mechanisms of the YANG language.

E.1.2.1 Specifying the Vendor-Proprietary Namespace in YANG

When creating a vendor-specific YANG extension file, the vendor's namespace is required. Vendors that intend to extend the standard YANG module will use a unique URI to define the XML namespace. The following example depicts this concept.

```
module example-ccap-extension {
    yang-version 1;
    namespace "http://www.example.com/ccap-extension";
    prefix "vendor-ext";
    import ccap { prefix "ccap";  revision-date "2012-04-01";  }
    organization "EXAMPLE VENDOR";
    contact
        "WG-email:  example@vendor.com";
    description
        "Vendor Specific";
    revision "2012-04-01" {
        description "Initial version ";
    }

    container ccap {
        uses ccap:ccap-group;
    }
```

```
} //  vendor-module
```

E.1.2.2 Extending a Container or List in YANG

To extend standard configuration objects with vendor-proprietary objects, the "augment" syntax is used to define the location where new nodes are inserted into the standard YANG module, as well as to define the new nodes to be inserted. An "augment" statement always adds a new node to the configuration model and is only allowed, per this specification, in the "yang-ext" elements that are provided in the standard YANG module precisely for this purpose.

Note that using the "deviation" syntax to extend the YANG configuration data model is only allowed in the cases outlined below.

The following tables summarize the acceptable ways to extend CCAP configuration data model objects.

Table 637 - Extending CCAP Configuration Objects with the Augment Statement

Object	Extension Use Case	Method to Extend

Container	Add new data node (leaf, list, etc.) to container	Augment the container with new data node. The following example adds a new leaf to the chassis container.
		augment "/ccap:ccap/ccap:chassis/yang-ext" {
		leaf contact-name {
		type string;
		description "Contact name";
		}
		}

List	Add new data node (leaf, list, etc.) to list	Augment a list with new data node. The following example adds a new leaf to the ds-rf-port - group object.
		augment "/ccap:ccap/ccap:chassis/ccap:slot/ccap:line-card-type/ccap:rf-line-card/ccap:rf-line-card/ccap:ds-rf-port/yang-ext" {
		leaf super-spectrum {
		type boolean;
		mandatory false;
		description "Turns on or off the
		super spectrum feature.";
		}
		}

Choice	Add a new case to an existing choice object	Augment a choice with a new case data definition. The following example adds a new line card type to the line-card choice node.
		augment "/ccap:ccap/ccap:chassis/
		ccap:slot/ccap:line-card-type/yang-ext/yang-choice-ext" {
		case vendor-new-line-card {
		list rf-port {
		key "port-number"
		uses ccap:port-group;
		}
		}
		}

type	Change the range attribute associated with a typedef	The range specified for an existing typedef can be altered when included in a new leaf, as long as the new range specified is more narrow than the default range. The following example sets a smaller range for the InetPortNumber typedef when used in the new port-number leaf.
		augment "/ccap:ccap/ccap:chassis/ccap:slot/ccap:line-card-type/
		ccap:rf-line-card/ccap:rf-line-card/yang-ext" {
		leaf admin-port-number {
		type inet:port-number {
		range "1..45";
		}
		}

Table 638 - Extending CCAP Configuration Objects with the Deviation Statement

Extension Use Case	Method to Extend

Add a range where one did not exist or replace an existing range	deviation "/ccap:ccap/ccap:chassis/ccap:slot/ccap:slot-number" {
	deviate replace {
	type int8 {
	range "0..13";
	}
	}
	}

Put a bound on the total number of items supported, where no max-elements existed	deviation "/ccap:ccap/ccap:docsis/ccap:docs-mac-domain/ccap:mac-domain " {
	deviate add {
	max-elements 100;
	}
	}

Replace the bound on the total number of items supported, where a max-elements definition existed	deviation "/ccap:ccap/ccap:docsis/ccap: docs-mac-domain/ccap:mac-domain" {
	deviate replace {
	max-elements 100;
	}
	}

Remove a default value and make the item mandatory	// First remove the default
	deviation "/ccap:ccap/ccap:docsis/ccap:docs-mac-domain/ccap:mac-domain/ccap:mdd-interval" {
	deviate delete {
	default "2000";
	}
	}
	//Now add the mandatory true property
	deviation "/ccap:ccap/ccap:docsis/ccap:docs-mac-domain/ccap:mac-domain/ccap:mdd-interval" {
	deviate add {
	mandatory "true";
	}
	}

E.1.3 Example Vendor-Proprietary Extensions in YANG Configuration Messages

The following examples show a vendor-extension YANG module and a partial CCAP configuration that uses those vendor extensions.

E.1.3.1 Sample Vendor-Extension YANG Module

In this example, the following elements are extended:

- A contact-name leaf is added to the chassis container
- The InetPortNumber typedef has its range narrowed in the port-number leaf
- A new case is added to the card-type choice definition

```
module example-ccap-extension {
    yang-version 1;
    namespace "http://www.example.com/ccap-extension";
    prefix "ccap-extension";
    import ccap                  { prefix "ccap";    }
    organization
        "Example Vendor";
    contact
```

```
        "WG-email:  example@vendor.com";
    description
        "Vendor Specific";
    revision "2013-04-04" {
        description "Initial version ";
    }
  augment "/ccap/chassis/slot/line-card-type/rf-line-card/yang-ext1"  {
      leaf admin-port-number {
          type inet:port-number {
              range "1..45";
          }
      }
  }
augment "/ccap/chassis/slot/line-card-type/yang-choice-ext" {
        choice vendor-line-card {
            case vendor-turbo-card {
               list rf-port {
                 key "port-number";
                 uses ccap:port-group;
               }
            }
        }
  }
augment "/ccap/chassis/yang-ext" {
        leaf contact-name {
           type string;
           description "Contact name";
        }
  }
```

E.1.3.2 Sample Partial Configuration Message Using Vendor Extensions

```
<ccap:ccap nc:operation="merge" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  SchemaVersion="2013-04-04"
  xsi:schemaLocation="urn:arris:ns:yang:1.0:vendor ccap-vendor-yang-ext.xsd"
           xmlns:ccap="urn:arris:ns:yang:1.0:vendor">
<chassis>
    <slot>
        <slot-number>3</slot-number>
        <yang-choice-ext>
            <vendor-turbo-card>
                <rf-port>
                    <port-number>6</port-number>
                </rf-port>
            </vendor-turbo-card>
        </yang-choice-ext>
    </slot>
    <slot>
        <slot-number>4</slot-number>
        <rf-line-card>
             <yang-ext1>
                  <admin-port-number>27</admin-port-number>
             </yang-ext1>
        </rf-line-card>
    </slot
    <yang-ext>
        <contact-name>customer support</contact-name>
    </yang-ext>
  </chassis>
</ccap>
```

Annex F CCAP Data Type Definitions (Normative)

F.1 Overview

This annex includes the data type definitions for the Information Models defined for use in the CCAP. The Unified Modeling Language (UML) is used for modeling the management requirements. The data types defined in this annex are mapped for use with YANG data types.

The data types defined in this Annex are mapped for use with SNMP MIBs, IPDR XML schemas, YANG modules and XSD Schemas.

Basic UML notation used in this specification is explained in Information Model Notation (Informative).

F.2 Data Types Mapping

XML is becoming the standard for data definition models. With XML data transformations can be done with or without a model (DTD or Schema definition). DTDs and XML schemas provides additional data validation layer to the applications exchanging XML data. There are several models to map formal notation constructs like ASN.1 to XML [ITU-T X.692], UML to XML, YANG to XML, or XML by itself can be used for modeling purposes.

Each area of data information interest approaches XML and defines data models and/or data containment structures and data types. Similarly, SNMP took and modified a subset of ASN.1 for defining the Structured Management Information SMIv1 and SMIv2.

Due to the lack of a unified data model and data types for Network Management a neutral model would be appropriated to allow capturing specific requirements and methodologies from existing protocols and allow forward or reverse engineering of those standards like SNMP to the general information model and vice versa.

F.3 Data Types Requirements and Classification

The Information Model has to provide seamless translation for SMIv2 requirements, in particular when creating MIB modules based on the Information Model, this specification needs to provide full support of [RFC 2578], [RFC 2579], and the clarifications and recommendations of [RFC 4181].

The Information Model has to provide seamless translation for IPDR modeling requirements which is by itself a subset of XML representations with some IPDR extensions.

The Information Model has to provide seamless translation for YANG modeling requirements, in particular when creating YANG modules based on the Information Model.

Thus, there are two data type groups defined for modeling purposes and mapping to protocol data notation roundtrip.

- General data types

  Required data types to cover all the management syntax and semantic requirement for all OSSI supported data models. In this category are data types defined in SNMP SMIv2 [RFC 2578], IPDR data types [IPDR/XDR] and [IPDR/SSDG], and YANG common data types [RFC 6991].

- Extended data types

  Management protocols specialization based on frequent usage or special semantics. Required data types to cover all the syntax requirement for all OSSI supported data models. In this category are SNMP TEXTUAL-CONVENTION clauses [RFC 2579] of mandatory or recommended usage by [RFC 2579] and [RFC 4181] when modeling for SNMP MIB modules.

F.4 Data Type Mapping Methodology

The specification "XML Schema Part 2: Data types Second Edition" is based on [ISO 11404] which provides a language-independent data types (see XML Schema reference). The mapping proposed below uses a subset of the XML schema data types to cover both SNMP forward and reverse engineering and as well IPDR types. Any additional protocol being added should be feasible to provide the particular mappings.

SMIv2 has an extensive experience of data types for management purposes, for illustration consider Counter32 and Counter64 SMIv2 types [RFC 2578]. The XML schema data types makes no distinction of derived 'decimal' types and the semantics that are associated to counters, e.g., counters do not necessarily start at 0.

Most of the SNMP information associated to data types are reduced to size and range constraints and specialized enumerations.

F.5 General Data Types (SNMP and IPDR Mapping)

Table 628 represents the mapping between the OSSI information model General Types and their equivalent representation for SNMP MIB Modules and IPDR Service Definitions. The permitted values for the data types are indicated in terms of value ranges and string length when applicable. The IM Data Type column includes the data types to map either to IPDR or SNMP or both, using the appropriated type in the corresponding protocol if applicable or available. The SNMP Mapping references to SNMP data types are defined in [RFC 2578] or as described below. The IPDR Mappings are referenced in [IPDR/XDR] and [IPDR/SSDG], or as specified below.

Note that SNMP does not provide float, double or long XML-Schema data types. Also, SNMP might map a type to a SNMP subtyped value. For example, UnsignedByte data type maps to Unsigned32 subtyped to the appropriate range indicated by the Permitted Values (0..255 in this case). Other data types are mapped to SNMP TEXTUAL-CONVENTIONS as indicated by the references.

Table 639 - General Data Types

IM Data Type	XML-Schema data type	Permitted Values	SNMP Mapping	IPDR Mapping
Boolean	Boolean	true = 1 false = 0	TruthValue [RFC 2579]	Boolean
Byte	byte	-128..127	Integer32	byte
Counter32	unsignedInt		Counter32	
Counter64	unsignedLong		Counter64	
DateTime	dateTime		DateAndTime	dateTime
DateTimeMsec	unsignedLong		CounterBasedGauge64 [RFC 2856]	ipdr:dateTimeMsec
Enum	int	-2147483648..2147483647	INTEGER	integer
EnumBits	hexBinary		BITS	hexBinary
Gauge32	unsignedInt		Gauge32	
HexBinary	hexBinary		OCTET STRING	hexBinary
InetAddress (Deprecated)	string	SIZE (0..255)	InetAddress [RFC 4001]	N/A
InetAddressIpv4 (Deprecated)	string	SIZE (4)	InetAddressIPv4 [RFC 4001]	ipdr:ipV4Addr
InetAddressIpv6 (Deprecated)	string	SIZE (16)	InetAddressIPv6 [RFC 4001]	ipdr:ipV6Addr
InetAddressType (Deprecated)	Enum	unknown(0), ipv4(1), ipv6(2), ipv4z(3), ipv6z(4), dns(16)	InetAddressType [RFC 4001]	N/A
Ipv4Address	string	IPv4 Address	InetAddressIPv4 [RFC 4001]	ipdr:ipV4Addr
Ipv6Address	string	IPv6 Address	InetAddressIPv6 [RFC 4001]	ipdr:ipV6Addr
IpAddress	string	IPv4 Address or IPv6 Address	InetAddress + InetAddressType [RFC 4001]	ipdr:ipV4Addr or ipdr:ipV6Addr
IpPrefix	string		InetAddress + InetAddressType + InetAddressPrefixLength [RFC 4001]	
Int	int	-2147483648..2147483647	Integer32	int
Long	long	-9223372036854775808..-9223372036854775807	N/A	long
MacAddress	hexBinary	SIZE (6)	MacAddress	ipdr:macAddress
Opaque	hexBinary		Opaque	

IM Data Type	XML-Schema data type	Permitted Values	SNMP Mapping	IPDR Mapping
Short	short	-32768..32767	Integer32	short
String	string		SnmpAdminString [RFC 3411]	string
UnsignedByte	unsignedByte	0..255	Unsigned32	unsignedByte
UnsignedInt	unsignedInt	0..4294967295	Unsigned32	unsignedInt
UnsignedLong	unsignedLong	0..18446744073709551615	CounterBasedGauge64 [RFC 2856]	unsignedLong
UnsignedShort	unsignedShort	0..65535	Unsigned32	unsignedShort
Uuid	hexBinary	SIZE (16)	OCTET STRING	ipdr:uuid

F.6 Primitive Data Types (YANG Mapping)

Table 629 represents the mapping between the CCAP primitive data types and their equivalent representation in YANG. The permitted values for the data types are indicated in terms of value ranges and string length when applicable. The UML Primitive Data Type column includes the data types to map to YANG, using the appropriated type in YANG. The YANG Built-In Data Type Mapping references YANG data types defined in [RFC 6991] or as described below.

Table 640 - Primitive Data Types

UML Primitive Data Type	YANG Data Type Mapping	Permitted Values
Boolean	Boolean	true, false
Byte	int8	-128..127
Enum	enumeration	-2147483648..2147483647
EnumBits	bits	
HexBinary	ccap-octet-data-type	([0-9a-fA-F]{2})*
Int	int32	-2147483648..2147483647
Long	int64	-9223372036854775808..9223372036854775807
Short	int16	-32768..32767
String	string	
UnsignedByte	uint8	0..255
UnsignedInt	uint32	0..4294967295
UnsignedLong	uint64	0..18446744073709551615
UnsignedShort	uint16	0..65535

F.7 Extended Data Types (SNMP and IPDR Mapping)

There are two sources of Extended Data Types: Protocol specific data types, and OSSI data types.

The subset of IPDR derived DataTypes [IPDR/SSDG] and [IPDR/XDR] are included in the General Data Types section as they are few. SNMP derived types are defined in SNMP MIB Modules. The most important are in [RFC 2579] which is part of SNMP STD 58 and are considered in many aspects part of the SNMP protocol. Other MIB modules TEXTUAL-CONVENTION definitions have been adopted and recommended (e.g., [RFC 4181]) for re-usability and semantics considerations in order to unify management concepts; some relevant RFCs that include common used textual conventions are [RFC 4001], [RFC 2863], [RFC 3411], and [RFC 3419] among others (see [RFC 4181]).

Table 630 includes the most relevant data types taken from SNMP to provide a direct mapping of the OSSI information model to SNMP MIB modules. A few have taken a more general name as they are used across the information models and may apply to IPDR high level modeling as well. For example, TagList comes from [RFC 3413] SnmpTaglist and preserves its semantics, AdminString comes from [RFC 3411] SnmpAdminString.

In general when an OSSI information model needs to reference an existing SNMP textual convention for the purpose of round-trip design from UML to SNMP, these textual conventions can be added to this list. Other sources of textual conventions not listed here are from MIB modules specific to DOCSIS either as RFCs or Annex documents in this specification. Some of those are [RFC 4546] and Annex A.

OSSI data types are also defined in this specification in the Data Type section of various sections; for example, in Annex A and in Section 7.

Table 641 - Extended Data Types

IM Data Type	XML-Schema data type	Permitted Values	SNMP Mapping	IPDR Mapping
AdminString	string	SIZE (0..255)	SnmpAdminString	string
DocsEqualizerData	hexBinary		DocsEqualizerData [RFC 4546]	hexBinary
DocsisQosVersion	int		DocsisQosVersion [RFC 4546]	int
DocsisUpstreamType	int		DocsisUpstreamType [RFC 4546]	int
DscpOrAny	int	-1 | 0..63	DscpOrAny [RFC 3289]	int
Duration	unsignedInt	0..2147483647	TimeInterval	unsignedInt
InetAddressPrefixLength (Deprecated)	unsignedInt	0..2040	InetAddressPrefixLength [RFC 4001]	unsignedInt
InetPortNumber (per [RFC 4001])	unsignedInt	0..65535	Unsigned32	unsignedInt
PhysicalIndexOrZero	unsignedInt	0..2147483647	Integer32	unsignedInt
RowStatus	int		RowStatus	int
StorageType	int		StorageType	int
TagList	string	SIZE (0..255)	SnmpTaglist	string
TenthdB	int		TenthdB [RFC 4546] (Note 1)	Int
TenthdBmV	int		TenthdBmV [RFC 4546] (Note 1)	int
TimeStamp	unsignedInt		TimeStamp	unsignedInt
TimeTicks	unsignedInt		TimeTicks [RFC 2578]	unsignedInt

Note 1: SYNTAX TenthdB (or TenthdBmV) has a DISPLAY-HINT of "d1" meaning it displays the integer 123 as "12.3", hence the UNITS string for displaying the value should be the whole units of "dB" or "dBmV". Note that RFC 4546 incorrectly defines the UNITS string of several objects with TenthdB/TenthdBmV SYNTAX with fractional "UNITS TenthdB" or "UNITS TenthdBmV" instead of whole units.

F.8 Derived Data Types (YANG Mapping)

Table 631 represents the mapping between the CCAP derived data types and their equivalent representation in YANG. The permitted values for the data types are indicated in terms of value ranges and string length when applicable. The UML Derived Data Type column includes the data types to map to YANG, using the appropriated type in YANG. The YANG Derived Data Type Mapping references YANG data types defined in [RFC 6991] or as described below.

Table 642 - Derived Data Types

UML Derived Data Type	YANG Derived Data Type Mapping	Permitted Values
AdminStateType	admin-state-type	other(1), up(2), down(3), testing(4)
Counter32	counter32	
Counter64	counter64	
DateTime	date-and-time	
DscpOrAny	int32	-1 | 0..63
Gauge32	gauge32	

UML Derived Data Type	YANG Derived Data Type Mapping	Permitted Values
Host	host	Union of IpAddress and DomainName
InetAddressPrefixLength (Deprecated)	address-prefix-len-type	0..2040
InetPortNumber (per [RFC 4001])	port-number	0..65535
IpAddress	ip-address	IPv4 or IPv6 Address
IpPrefix	ip-prefix	Union of Ipv4Prefix and Ipv6Prefix
Ipv4Address	ipv4-address	IPv4 Address
Ipv6Address	ipv6-address	IPv6 Address
Ipv4Prefix	ipv4-prefix	IPv4 Address "/" IPv4 Prefix Length
Ipv6Prefix	ipv6-prefix	IPv6 Address "/" IPv6 Prefix Length
MacAddress	mac-address	e.g., 01:23:45:67:89:ab
TagList	snmp-tag-list-type	String(SIZE(0..255))
TenthdB	Int32	(Note 1)
TenthdBmV	Int32	(Note 1)
TimeStamp	timestamp	
TimeTicks	timeticks	
Uri	uri	
Uuid	uuid	

Note 1: Object should be displayed with one decimal point, e.g., the integer 123 displayed as "12.3", with displayed whole units of "dB" or "dBmV".

F.9 Common Terms Shortened

The following table lists common terms which have been shortened to allow shorter SNMP MIB names. These shortened names are desired to be used consistently throughout the information models, SNMP MIBs and IPDR schemas. However, in some cases it might not be possible to maintain parity with pre-3.0 DOCSIS requirements.

Table 643 - Shortened Common Terms

Original Word	Shortened Word
Address	Addr
Aggregate	Agg
Algorithm	Alg
Application	App
Attribute	Attr
Authorization	Auth
Channel	Ch
Command	Cmd
Config*	Cfg
Control	Ctrl
Default	Def
Destination	Dest
Direction	Dir
Downstream	Ds
Encryption	Encrypt
Equalization	Eq
Group	Grp
Leakage Detection	LeakDet
Length	Len

Original Word	Shortened Word
Maximum	Max
Minimum	Min
Multicast	Mcast
Provision*	Prov
Receive	Rx
Registration	Reg
Replication	Repl
Request	Req
Resequence	Reseq
Resequencing	Reseq
Response	Rsp
Segment	Sgmt
Sequence	Seq
Service	Svc
ServiceFlow	Sf
Session(s)	Sess
Source	Src
Threshold	Thrshld
Total	Tot
Transmit	Tx
Upstream	Us
* indicates a wildcard	

F.9.1 Exceptions

Data types and managed objects do not consistently use the shortened names. Also, the term ServiceFlowId remains unchanged. Service and ServiceFlow are often not shortened to retain backward compatibility with QoS managed objects.

Annex G Diagnostic Log (Normative)

G.1 Overview

The Diagnostic Log allows operators to diagnose and troubleshoot potential problems with CCAP/CMTS cable interfaces, Cable Modems (CMs), or the cable plant by detecting and tracking CMs that have intermittent connectivity problems or unstable operations including:

- CM repeated registration
- Station Maintenance retry

Only detected CMs are reported in the Diagnostic Log for further analysis. Diagnostic Log entries are aged out based on the configuration of the specific aging attributes.

G.2 Information Model

This section describes the object definitions for the Diagnostic Log Information Model.

The DOCSIS Diagnostic Log information model is depicted in Figure 112. This diagram graphically presents the individual DOCSIS Diagnostic Log objects and their attributes. The DOCSIS Diagnostic Log MIB and the DOCSIS Diagnostic Log IPDR Service Definition schema are derived from the information model.

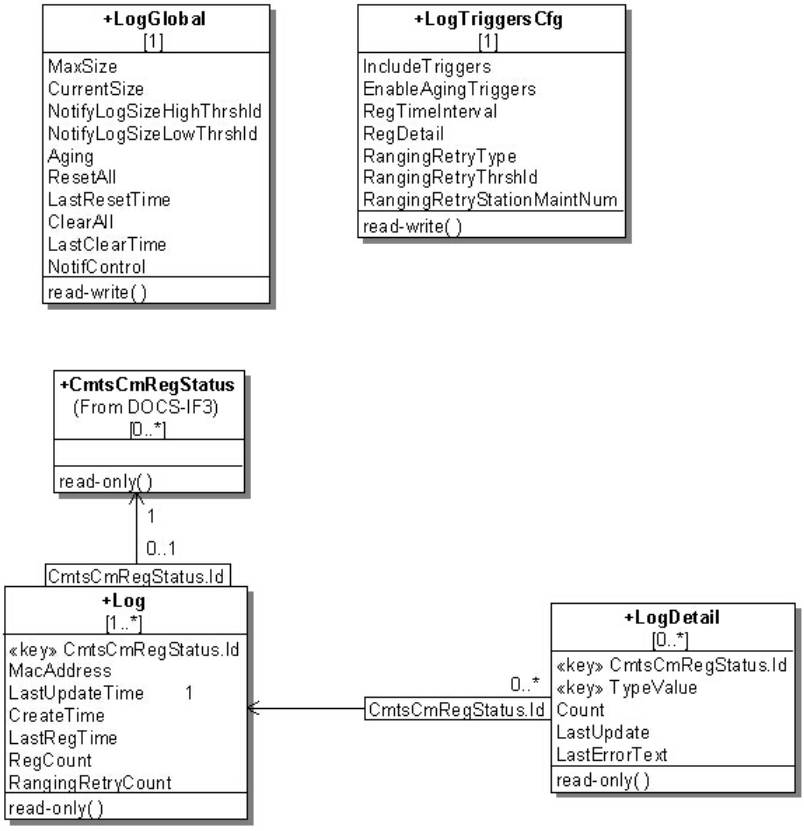


Figure 112 - Diagnostic Log Information Model

G.2.1 Type Definitions

This section defines data types used in the object definitions for the Diagnostic Log information model.

Table 644 - Data Type Definitions

Data Type Name	Base Type	Permitted Values
TriggerFlag	EnumBits	registration(0) rangingRetry(1)
RegistrationDetailFlag	EnumBits	other(0) initialRanging(1) rangingAutoAdjComplete(2) startEae(3) startDhcpv4(4) startDhcpv6(5) dhcpv4Complete(6) dhcpv6Complete(7) startConfigFileDownload(8) configFileDownloadComplete(9) startRegistration(10) registrationComplete(11) bpiInit(12) operational(13)

G.2.1.1 TriggerFlag

This data type defines the union of Diagnostic Log trigger types. Bit 0 represents the registration trigger; Bit 1 represents the ranging retry trigger.

G.2.1.2 RegistrationDetailFlag

This data type defines an enumerated union of CM states used for the registration trigger detection.

The named bits associated with this type correspond to a subset of the names for the enumerations in CmtsCmRegState data type.

G.2.2 LogGlobal

This object defines the parameters to manage and control the instantiation of CMs in the Diagnostic Log object.

The CMTS MUST persist the values of the attributes of the LogGlobal object across reinitializations.

Table 645 - LogGlobal Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
MaxSize	UnsignedInt	read-write	1..4294967295	instances	100
CurrentSize	Gauge32	read-only	0..4294967295	instances	N/A
NotifyLogSizeHighThrshld	UnsignedInt	read-write	1..4294967295	instances	80
NotifyLogSizeLowThrshld	UnsignedInt	read-write	1..4294967295	instances	60
Aging	UnsignedInt	read-write	15..86400	minutes	10080
ResetAll	Boolean	read-write		N/A	N/A
LastResetTime	DateTime	read-only		N/A	N/A
ClearAll	Boolean	read-write		N/A	N/A
LastClearTime	DateTime	read-only		N/A	N/A

Attribute Name	Type	Access	Type Constraints	Units	Default
NotifCtrl	EnumBits	read-write	highThresholdReached(0) lowThresholdReached(1) full(2)	N/A	"H

G.2.2.1 MaxSize

This attribute indicates the maximum number of CM instances that can be reported in the Log.

G.2.2.2 CurrentSize

This attribute indicates the number of CM instances currently reported in the Log. It will not exceed MaxSize.

G.2.2.3 NotifyLogSizeHighThrshld

This attribute is the Log high threshold value. When the number of instances in the Log exceeds this value, the CMTS will trigger a HighThreshold event.

G.2.2.4 NotifyLogSizeLowThrshld

This attribute is the Log low threshold value. When the number of instances in Log drops to this value, the CMTS will trigger a LowThreshold event, but only if the Log number of instances previously exceeded the NotifyLogSizeHighThrshld value.

G.2.2.5 Aging

This attribute defines a period of time after which an instance in the Log and its corresponding LogDetail instance (if present) are removed unless the Log instance is updated by an enabled trigger detection process.

G.2.2.6 ResetAll

This attribute, when set to 'true', causes all counter attributes for all instances in Log and LogDetail to be reset to zero. When read, this attribute always returns 'false'.

G.2.2.7 LastResetTime

This attribute returns the date and time that all the counters in the Log, LogDetail and all the trigger- related objects were reset to 0 due to the ResetAll attribute being set to 'true'. The special value of all '00'Hs indicates that the entries in the Log have never been reset.

G.2.2.8 ClearAll

This attribute, when set to 'true', removes all instances from the Log and LogDetail. When read, this attribute always returns 'false'.

G.2.2.9 LastClearTime

This attribute returns the date and time that all the instances in the Log and LogDetail, and all trigger-related objects were removed due to the ClearAll attribute being set to 'true'. The special value of all '00'Hs indicates that the entries in the Log have never been destroyed.

G.2.2.10 NotifCtrl

This attribute is used to enable diagnostic log related notifications. Setting bit 0 enables notification for reaching log size high threshold. Setting bit 1 enables notification for returning back to log size low threshold after reaching log size high threshold. Setting bit 2 enables notification for Diagnostic Log size full.

G.2.3 LogTriggersCfg

This object defines the parameters to configure the Diagnostic Log triggers. One or more triggers can be configured to define the actions of creating or updating CM entries into the Diagnostic Log.

The CMTS MUST persist the values of the attributes of the LogTriggersCfg object across reinitializations.

Table 646 - LogTriggersCfg Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
IncludeTriggers	TriggerFlag	read-write		N/A	'C0'H
EnableAgingTriggers	TriggerFlag	read-write		N/A	''H
RegTimeInterval	UnsignedInt	read-write	60..86400	seconds	90
RegDetail	RegistrationDetailFlag	read-write		N/A	''H
RangingRetryType	Enum	read-write	consecutiveMiss(1) missRatio(2)	N/A	1
RangingRetryThrshld	UnsignedByte	read-write	3..12	N/A	6
RangingRetryStationMaintNum	UnsignedShort	read-write	60..65535	N/A	90

G.2.3.1 IncludeTriggers

This attribute turns individual diagnostic triggers on and off at a given time when each trigger is set to '1' or '0', respectively.

G.2.3.2 EnableAgingTriggers

This attribute enables and disables the aging of individual triggers at a given time when each trigger is set to '1' or '0', respectively. If a log entry is added by multiple triggers, and aging is disabled for one of those triggers, the CMTS MUST NOT age out such entry.

G.2.3.3 RegTimeInterval

This attribute is an operator empirically derived, worst-case number of seconds which the CM requires to complete registration. If the CM has not completed the registration stage within this registration time interval, the CM will be added to the Diagnostic Log.

G.2.3.4 RegDetail

This attribute provides for setting a bit representing a CM registration state to enable counting the number of times the CMTS determines that such CM reaches that state as the last state before failing to proceed further in the registration process and within the time interval considered for the CM registration trigger detection.

G.2.3.5 RangingRetryType

This attribute selects the type of ranging retry trigger to be enabled in the Diagnostic Log. A CM failure to perform ranging when a ranging opportunity is scheduled by the CMTS is counted as ranging miss. The ranging retry trigger can be configured to either look at consecutive ranging misses or ranging miss ratio over total number of station maintenance opportunities for a certain time period. Setting this object to 'consecutiveMiss' will select consecutive ranging misses as ranging retry trigger criteria. Setting this object to 'missRatio' will select ranging miss ratio as ranging retry criteria.

G.2.3.6 RangingRetryThrshld

This attribute indicates the maximum number of consecutive intervals in which the CMTS does not detect a CM acknowledgement of a MAC-layer station maintenance message before the CM is added to the Diagnostic Log. The value of RangingRetryType decides if consecutive ranging miss or ranging miss ratio is used as trigger.

G.2.3.7 RangingRetryStationMaintNum

This attribute indicates the number of station maintenance opportunities to monitor for the ranging retry trigger. This value implies time intervals in a certain range. DOCSIS specifies that the CMTS schedules ranging opportunities to CMs be sufficiently smaller than T4. There is no fixed formula to derive at a fixed time interval, that is, how many ranging opportunities may be offered to a CM by the CMTS; hence, using the number of station maintenance opportunities provides a ratio with the fixed denominators, while also taking the time factor into consideration.

G.2.4 Log

This object represents the diagnostic information for a CM. An instance of this object represents a single CM summary of the diagnostic information detected by one or more triggers. When the CM object instance already exists and a trigger occurs, the LastUpdateTime and corresponding counter attributes are updated for that CM.

Table 647 - Log Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Id	UnsignedInt	key	1..4294967295	N/A	N/A
CmMacAddr	MacAddress	read-only		N/A	N/A
LastUpdateTime	DateTime	read-only		N/A	N/A
CreateTime	DateTime	read-only		N/A	N/A
LastRegTime	DateTime	read-only		N/A	N/A
RegCount	Counter32	read-only		flaps	N/A
RangingRetryCount	Counter32	read-only		retries	N/A

G.2.4.1 Id

This attribute contains an instance of the CmtsCmRegStatusId.

G.2.4.2 CmMacAddr

This attribute is the MAC address of the CM.

G.2.4.3 LastUpdateTime

This attribute is the date and time value that indicates when this instance was last updated.

G.2.4.4 CreateTime

This attribute is the date and time value that indicates when this instance was created. When a CM is detected by one of the diagnostic triggers, a new instance will be created provided that there is not already an instance for that CM. If an instance is removed and then re-created, there may be a discontinuity in the statistical objects associated with the instance. This timestamp can be used to detect those discontinuities.

G.2.4.5 LastRegTime

This attribute indicates the last date and time the CM registered.

G.2.4.6 RegCount

This attribute counts the number of times the registration trigger condition was detected for the CM.

G.2.4.7 RangingRetryCount

This attribute counts the number of times the ranging retry trigger condition was detected for the CM.

G.2.5 LogDetail

This object represents the detailed diagnostic information for a CM. There may be multiple instances for a given CM if more than one state from DetailType is enabled.

This object extends the Log object.

Table 648 - LogDetail Object Attributes

Attribute Name	Type	Access	Type Constraints	Units	Default
Id	UnsignedInt	key	1..4294967295	N/A	N/A
TypeValue	CmtsCmRegState	key		N/A	N/A
Count	Counter32	read-only		last state	N/A
LastUpdate	DateTime	read-only		N/A	N/A
LastErrorText	AdminString	read-only		N/A	N/A

G.2.5.1 Id

This attribute contains an instance of the Id attribute from the Log object.

G.2.5.2 TypeValue

This attribute indicates the detail type this instance is tracking and logging information for a particular CM. For the registration trigger, this list indicates the CM registration state prior to the trigger occurrence. There are no enumerated values for the ranging retry trigger.

G.2.5.3 Count

This attribute counts the number of times a particular state or process is detected by a trigger to be the last state or process before it failed to proceed further within the threshold values of that trigger.

G.2.5.4 LastUpdate

This attribute indicates the date and time when this instance was last updated.

G.2.5.5 LastErrorText

This attribute indicates the Event ID and Event Text (DOCSIS-defined or vendor-specific) of the event condition that triggered the update of the LogDetail object for the TypeValue this instance represents.

The CMTS MAY leave the Event ID empty if the Event ID is not defined.

The format to represent the error text is <Event ID> Event Text

Examples:

<2500001> Failure during state X

<> Unspecified

Appendix I Example NETCONF Message Exchanges (Informative)

I.1 Sample NETCONF Message Exchanges

The following sections show examples of how messages flow between a NETCONF client and the NETCONF server on the CCAP. In the first example, the changes are communicated, but the configuration is not locked. In the second example, the NETCONF client locks the configuration while the session is active. While the session is locked, other users are unable to make changes. If the CCAP is unable to "promote" the candidate configuration to running-config before the timeout period, the changes will be rolled back.

I.1.1 Changes Made to running-config without Locks or Timeouts

In this example, changes are made directly to the running-config. No timeout is set, so the Client waits until the CCAP completes the configuration change.

NETCONF Client and the CCAP send <hello> messages and the CCAP advertises support for its supported version of NETCONF and of the CCAP configuration modules.

```
Client: <hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client: <capabilities>
Client: <capability>urn:ietf:params:netconf:base:1.0</capability>
Client: </capabilities>
Client: </hello>
CCAP: <hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP: <capabilities>
CCAP: <capability>
CCAP: urn:ietf:params:xml:ns:netconf:base:1.0
CCAP: </capability>
CCAP: <capability>
CCAP: urn:cablelabs:params:xml:ns:yang:ccap?revision=2012-08-09?module=ccap
CCAP: </capability>
CCAP: <session-id>101</session-id>
CCAP: </capabilities>
CCAP: </hello>
```

The client successfully updates the running-config with the updated name, description, and location parameters and EPON parameters. The change takes effect immediately.

```
Client: <rpc message-id="1"
Client xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client: <edit-config>
Client: <target>
Client: <running/>
Client: </target>
Client: <config>
Client: <ccap xmlns="urn:cablelabs:params:xml:ns:yang:ccap">
Client: <epon>
Client: <oam-config>
Client: <min-oam-rate>2</min-oam-rate>
Client: <max-oam-rate>31</max-oam-rate>
Client: <oam-response-timeout>2</oam-response-timeout>
Client: </oam-config>
Client: <loop-timing-config>
Client: <min-propagation-delay>1</min-propagation-delay>
Client: <max-propagation-delay>6251</max-propagation-delay>
Client: <onu-delay>3126</onu-delay>
Client: </loop-timing-config>
Client: <mpcp-config>
Client: <discovery-period>1001</discovery-period>
Client: <grant-size-in-discovery-gate>16320</grant-size-in-discovery-gate>
Client: <deregistration-timeout>1</deregistration-timeout>
Client: </mpcp-config>
Client: </epon>
```

```
Client: </ccap>
Client: </config>
Client: </edit-config>
Client: </rpc>
CCAP: <rpc-reply message-id="1" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP: <ok/>
CCAP: </rpc-reply>
```

The CCAP copies the running-config to the startup-config.

```
Client: <rpc message-id="2" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client: <copy-config>
Client: <target>
Client: <startup/>
Client: </target>
Client: <source>
Client: </running>
Client: </source>
Client: </copy-config>
Client: </rpc>
CCAP: <rpc-reply message-id="2" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP: <ok/>
CCAP: </rpc-reply>
```

The client then closes the session by sending the <close-session> operation.

```
Client: <rpc message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client:   <close-session/>
Client: </rpc>
```

The CCAP acknowledges the request and the transport session is subsequently terminated.

```
CCAP: <rpc-reply message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

I.1.2 Changes Made to candidate-config with a Lock

In this example, the Client makes updates to a candidate-config, then instructs the CCAP to copy it to the running-config. If the CCAP is unable to complete this task by the timeout set, then the changes will be rolled back.

NETCONF Client and the CCAP send <hello> messages and the CCAP advertises support for its supported version of NETCONF and of the CCAP configuration modules.

```
Client: <hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client: <capabilities>
Client: <capability>urn:ietf:params:netconf:base:1.0</capability>
Client: </capabilities>
Client: </hello>
CCAP: <hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP: <capabilities>
CCAP: <capability>
CCAP: urn:ietf:params:xml:ns:netconf:base:1.0
CCAP: </capability>
CCAP: <capability>
CCAP: urn:cablelabs:params:xml:ns:yang:ccap?revision=2012-08-09?module=ccap
CCAP: </capability>
CCAP: <session-id>101</session-id>
CCAP: </capabilities>
CCAP: </hello>
```

Client takes a lock on the running datastore.

```
Client: <rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="1">
Client:   <lock>
Client:     <target>
```

```
Client:       <running/>
Client:     </target>
Client:   </lock>
Client: </rpc>
CCAP: <rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="1">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

The Client successfully updates the candidate-config with the changes to the CCAP parameters and EPON parameters.

```
Client: <rpc message-id="2" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client: <edit-config>
Client: <target>
Client: <candidate/>
Client: </target>
Client: <config>
Client: <ccap xmlns="urn:cablelabs:params:xml:ns:yang:ccap">
Client: <epon>
Client: <oam-config>
Client: <min-oam-rate>2</min-oam-rate>
Client: <max-oam-rate>31</max-oam-rate>
Client: <oam-response-timeout>2</oam-response-timeout>
Client: </oam-config>
Client: <loop-timing-config>
Client: <min-propagation-delay>1</min-propagation-delay>
Client: <max-propagation-delay>6251</max-propagation-delay>
Client: <onu-delay>3126</onu-delay>
Client: </loop-timing-config>
Client: <mpcp-config>
Client: <discovery-period>1001</discovery-period>
Client: <grant-size-in-discovery-gate>16320</grant-size-in-discovery-gate>
Client: <deregistration-timeout>1</deregistration-timeout>
Client: </mpcp-config>
Client: </epon>
Client: </ccap>
Client: </config>
Client: </edit-config>
Client: </rpc>
CCAP: <rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="2">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

The Client commits the configuration in the candidate-config to the running-config. This is done with a timeout of 120 seconds. The CCAP is expected to come back with a confirming commit before the timeout expires, otherwise the configuration change will roll back.

```
Client: <rpc message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client:     <commit>
Client:       <confirmed/>
Client:       <confirm-timeout>120</confirm-timeout>
Client:     </commit>
Client:   </rpc>
CCAP: <rpc-reply message-id="3" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

The Client does any external tests required and then comes back with a confirming commit.

```
Client: <rpc message-id="4" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client:   <commit/>
Client: </rpc>
CCAP: <rpc-reply message-id="4" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

The Client releases the lock on the running data store allowing other applications to access the configuration.

```
Client: <rpc message-id="5" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client:   <unlock>
Client:     <target>
Client:       <running/>
Client:     </target>
Client:   </unlock>
Client: </rpc>
CCAP: <rpc-reply message-id="5" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

The Client then closes the session by sending the <close-session> operation.

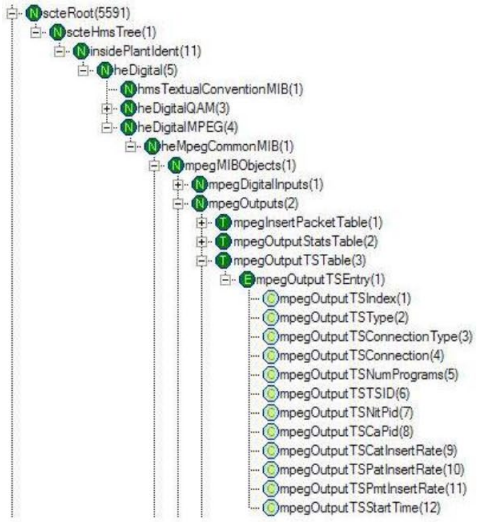
```
Client: <rpc message-id="6" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
Client:   <close-session/>
Client: </rpc>
```

The CCAP acknowledges the request and the transport session is subsequently terminated.

```
CCAP: <rpc-reply message-id="6" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
CCAP:   <ok/>
CCAP: </rpc-reply>
```

Appendix II Identifying Replicated QAMs Example (Informative)

A replicated QAM can be identified by looking at the data presented in the SCTE-HMS-MPEG-MIB. In the mpegOutputTsTable the replicated QAM can be identified by locating instances that have the same mpegOutputTSTSID values. In the following example, QAM instance 100 and 137 are replicated - they both have an mpegOutputTSTSID of 1000.



	Instance	mpegOutputTSIndex	mpegOutputTSType	mpegOutputTSConnectionType	mpegOutputTSConnection	mpegOutputTSNumPrograms	mpegOutputTSTSID	mpegOutputTSNitPid	n
1	100	100	mpts(2)	qam(2)	1.3.6.1.4.1.5591.1.11.5.4.2.6.1.100.1	2	1000	16	
2	137	137	mpts(2)	qam(2)	1.3.6.1.4.1.5591.1.11.5.4.2.6.1.137.1	2	1000	16	
3	138	138		qam(2)	1.3.6.1.4.1.5591.1.11.5.4.2.6.1.138.1	0	1038	16	

Figure 113 - Identifying a Replicated QAM by Looking at mpegOutputTSTSID

Appendix III DOCSIS IPDR Sample Instance Documents (Informative)

This appendix provides a sampling of the XML Instance Documents which conform to the corresponding DOCSIS IPDR Service Definition schemas defined in Section ACCOUNTING MANAGEMENT.

III.1 Collector Aggregation

IPDRDoc is expected to be aggregated by the Collector with the IPDR/SP data streamed within the session start stop boundary.

III.2 Schema Location

The schemaLocation attribute [W3XSD1.0] is used to associate an XML Instance Document to a published schema XSD document.

The DOCSIS XML Schema location is defined and maintained by CableLabs as:

http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/<Service-Definition-Schema>_3.5.1-A.1.xsd

NOTE: The schema location is a Uniform Resource Locator (URL) which points to the actual schema file.

III.3 DIAG-LOG-TYPE

This section provides a sample XML Instance Document for the Diagnostic Log Service Definition, DIAG-LOG-TYPE and corresponding XML Schema DOCSIS-DIAG-LOG-TYPE_3.5.1-A.2.xsd.

III.3.1 Use Case

The CMTS "cmts01.mso.com" logs an entry in its diagnostic log for the CM with MAC Address 00-09-36-A7-70-89 when the CM fails to register. The CM last registered at 9:15 on 06/04/2006. The registration trigger count has reached 3. The CM was originally added to the diagnostic log at 9:30 on 06/04/2006. The latest trigger occurred at 6:30 on 06/05/2006. The CMTS streams this information to a Collector as shown in the following instance document.

III.3.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-TYPE"
xmlns:DOCSIS-DIAG-LOG="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
DIAG-LOG"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
DIAG-LOG-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-TYPE/DOCSIS-
DIAG-LOG-TYPE_3.5.1-A.2.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.2">
<ipdr:IPDR xsi:type="DIAG-LOG-TYPE">
        <DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-DIAG-LOG:LastUpdateTime>2006-06-05T06:30:00Z</DOCSIS-DIAG-LOG:LastUpdateTime>
<DOCSIS-DIAG-LOG:CreateTime>2006-06-04T09:30:00Z</DOCSIS-DIAG-LOG:CreateTime>
<DOCSIS-DIAG-LOG:LastRegTime>2006-06-04T09:15:00Z</DOCSIS-DIAG-LOG:LastRegTime>
<DOCSIS-DIAG-LOG:RegCount>3</DOCSIS-DIAG-LOG:RegCount>
<DOCSIS-DIAG-LOG:RangingRetryCount>0</DOCSIS-DIAG-LOG:RangingRetryCount>
```

```
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.4 DIAG-LOG-DETAIL-TYPE

This section provides a sample XML Instance Document for the Diagnostic Log Service Definition, DIAG-LOG-DETAIL-TYPE and corresponding XML Schema DOCSIS-DIAG-LOG-DETAIL-TYPE_3.5.1-A.2.xsd.

III.4.1 Use Case

The CMTS "cmts01.mso.com" logs an entry in its diagnostic log for the CM with MAC Address 00-09-36-A7-70-89 when the CM fails to register. The CM last triggered a registration diagnostic log entry at 6:30 on 06/05/2006. The detail Count of 1 represents the total number of times the CM had reached the startRegistration (TypeValue=11) state before failing the registration process. The corresponding event is:

<73000401> Service Unavailable - Unrecognized configuration setting

The CMTS streams this information to a Collector as shown in the following instance document.

III.4.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-DETAIL-
TYPE"
xmlns:DOCSIS-DIAG-LOG-
DETAIL="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-
DETAIL"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
DIAG-LOG-DETAIL-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-DETAIL-
TYPE/DOCSIS-DIAG-LOG-DETAIL-TYPE_3.5.1-A.2.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.2">
<ipdr:IPDR xsi:type="DIAG-LOG-DETAIL-TYPE">
        <DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-DIAG-LOG-DETAIL:TypeValue>11</DOCSIS-DIAG-LOG-DETAIL:TypeValue>
<DOCSIS-DIAG-LOG-DETAIL:Count>1</DOCSIS-DIAG-LOG-DETAIL:Count>
<DOCSIS-DIAG-LOG-DETAIL:LastUpdate>2006-06-05T06:30:00Z</DOCSIS-DIAG-LOG-
DETAIL:LastUpdate>
<DOCSIS-DIAG-LOG-DETAIL:LastErrorText>
&lt;73000401&gt; Service Unavailable - Unrecognized configuration setting
</DOCSIS-DIAG-LOG-DETAIL:LastErrorText>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.5 DIAG-LOG-EVENT-TYPE

This section provides a sample XML Instance Document for the Diagnostic Log Service Definition, DIAG-LOG-EVENT-TYPE and corresponding XML Schema DOCSIS-DIAG-LOG-EVENT-TYPE_3.5.1-A.2.xsd.

III.5.1 Use Case

At the CMTS sysUpTime "2226878", the CMTS "cmts01.mso.com" detects a diagnostic log trigger for the CM with MAC Address 00-09-36-A7-70-89 when the CM fails to register (TriggerFlagValue of 1 indicates a registration trigger). The CM had reached the startRegistration (TypeValue=11) state before failing the registration process. The corresponding event is:

<73000401> Service Unavailable - Unrecognized configuration setting

Since the RecType value of 4 indicates an event-based record, the CMTS autonomously streams this information to a Collector as shown in the following instance document.

III.5.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-EVENT-
TYPE"
xmlns:DOCSIS-DIAG-LOG="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
DIAG-LOG"
xmlns:DOCSIS-DIAG-LOG-
DETAIL="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-
DETAIL"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
DIAG-LOG-EVENT-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-DIAG-LOG-EVENT-
TYPE/DOCSIS-DIAG-LOG-EVENT-TYPE_3.5.1-A.2.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.2">
<ipdr:IPDR xsi:type="DIAG-LOG-EVENT-TYPE">
        <DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-DIAG-LOG:TriggerFlagValue>1</DOCSIS-DIAG-LOG:TriggerFlagValue>
<DOCSIS-DIAG-LOG-DETAIL:TypeValue>11</DOCSIS-DIAG-LOG-DETAIL:TypeValue>
<DOCSIS-DIAG-LOG-DETAIL:LastErrorText>
&lt;73000401&gt; Service Unavailable - Unrecognized configuration setting
</DOCSIS-DIAG-LOG-DETAIL:LastErrorText>
<DOCSIS-REC:RecType>4</DOCSIS-REC:RecType>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.6 CMTS-CM-US-STATS-TYPE

This section provides a sample XML Instance Document for the CMTS CM Upstream Statistics Service Definition, CMTS-CM-US-STATS-TYPE and corresponding XML Schema DOCSIS-CMTS-CM-US-STATS-TYPE_3.5.1-A.2.xsd.

III.6.1 Use Case

At a CMTS sysUpTime of "2226878", the CMTS "cmts01.mso.com" with MAC Domain ifName of "Int0/1" and MAC Domain ifIndex of "456", streams the upstream status information of a CM with MAC Address "00-09-36-

A7-70-89" connected to upstream channel ifName of "Int/0/1/4" and upstream channel ifIndex of "17". In addition, the CmRegStatusId of "1" and the following upstream status information of CM are included in the record:

ModulationType = 1

RxPower = -5

SignalNoise = 361

Microreflections = 0

EqData = 0x0401080000700028ff60ffa0018000783db000000080fe98ff70ffe8ff58003800480138

Unerroreds = 219678

Correcteds = 10

Uncorrectables = 5

HighResolutionTimingOffset = 5

IsMuted = 0

RangingStatus = 4

III.6.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-US-
STATS-TYPE"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xmlns:DOCSIS-CMTS-CM-
US="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-US"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS-CM-US-STATS-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-US-STATS-
TYPE/DOCSIS-CMTS-CM-US-STATS-TYPE_3.5.1-A.2.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.2">
<ipdr:IPDR xsi:type="CMTS-CM-US-STATS-TYPE">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
<DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-CM:CmRegStatusId>1</DOCSIS-CM:CmRegStatusId>
<DOCSIS-CMTS-CM-US:CmtsCmUsChIfName>Int/0/1/4</DOCSIS-CMTS-CM-US:CmtsCmUsChIfName>
<DOCSIS-CMTS-CM-US:CmtsCmUsChIfIndex>17</DOCSIS-CMTS-CM-US:CmtsCmUsChIfIndex>
<DOCSIS-CMTS-CM-US:CmtsCmUsChId>5</DOCSIS-CMTS-CM-US:CmtsCmUsChId>
<DOCSIS-CMTS-CM-US:CmtsCmUsModulationType>1</DOCSIS-CMTS-CM-US:CmtsCmUsModulationType>
<DOCSIS-CMTS-CM-US:CmtsCmUsRxPower>-5</DOCSIS-CMTS-CM-US:CmtsCmUsRxPower>
<DOCSIS-CMTS-CM-US:CmtsCmUsSignalNoise>361</DOCSIS-CMTS-CM-US:CmtsCmUsSignalNoise>
<DOCSIS-CMTS-CM-US:CmtsCmUsMicroreflections>0</DOCSIS-CMTS-CM-
US:CmtsCmUsMicroreflections>
<DOCSIS-CMTS-CM-US:CmtsCmUsEqData>
0401080000700028ff60ffa0018000783db000000080fe98ff70ffe8ff58003800480138
</DOCSIS-CMTS-CM-US:CmtsCmUsEqData>
<DOCSIS-CMTS-CM-US:CmtsCmUsUnerroreds>219678</DOCSIS-CMTS-CM-US:CmtsCmUsUnerroreds>
```

```
<DOCSIS-CMTS-CM-US:CmtsCmUsCorrecteds>10</DOCSIS-CMTS-CM-US:CmtsCmUsCorrecteds>
<DOCSIS-CMTS-CM-US:CmtsCmUsUncorrectables>5</DOCSIS-CMTS-CM-US:CmtsCmUsUncorrectables>
<DOCSIS-CMTS-CM-US:CmtsCmUsHighResolutionTimingOffset>5</DOCSIS-CMTS-CM-
US:CmtsCmUsHighResolutionTimingOffset>
<DOCSIS-CMTS-CM-US:CmtsCmUsIsMuted>0</DOCSIS-CMTS-CM-US:CmtsCmUsIsMuted>
<DOCSIS-CMTS-CM-US:CmtsCmUsRangingStatus>4</DOCSIS-CMTS-CM-US:CmtsCmUsRangingStatus>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.7 CMTS-CM-REG-STATUS-TYPE

This section provides a sample XML Instance Document for the CMTS CM Registration Status Service Definition, CMTS-CM-REG-STATUS-TYPE and corresponding XML Schema DOCSIS-CMTS-CM-REG-STATUS-TYPE_3.5.1-B.1.xsd.

III.7.1 Use Case

At a CMTS sysUpTime of "2226878", the CMTS "cmts01.mso.com" with MAC Domain ifName of "Int0/1" and MAC Domain ifIndex of "456", streams the registration status information of a CM with MAC Address "00-09-36-A7-70-89", having an ip4Address of "55.12.48.113", ipv6Address of "2001:0400:0000:0000:0209:36FF:FEA7:7089", ipv6 link local address of "FE80:0000:0000:0000:0209:36FF:FEA7:7089, registration status value of "8" and QosVersion as "2"(DOCSIS 1.1 QoS mode). The CM last registered with the CMTS at 9:15GMT on 06/04/2006. In addition, the CMTS CM Channel information consisting of MAC Domain Cable Modem Service Group Id of "17", Receive Channel Profile Id of "MYCID", Receive Channel Configuration status Id of "5", Receive Channel Set Id of "5" and Transmit Channel Set If of "5" is also included in the record.

III.7.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-REG-
STATUS-TYPE"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-CMTS-CM-NODE-
CH="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-CM-NODE-CH"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-
CMTS-CM-REG-STATUS-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-REG-STATUS-
TYPE/DOCSIS-CMTS-CM-REG-STATUS-TYPE_3.5.1-B.1.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2016-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-B.1">
<ipdr:IPDR xsi:type="CMTS-CM-REG-STATUS-TYPE">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
<DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-CMTS-CM-NODE-CH:CmtsMdCmSgId>17</DOCSIS-CMTS-CM-NODE-CH:CmtsMdCmSgId>
<DOCSIS-CMTS-CM-NODE-CH:CmtsRcpId>MYCID</DOCSIS-CMTS-CM-NODE-CH:CmtsRcpId>
<DOCSIS-CMTS-CM-NODE-CH:CmtsRccStatusId>5</DOCSIS-CMTS-CM-NODE-CH:CmtsRccStatusId>
<DOCSIS-CMTS-CM-NODE-CH:CmtsRcsId>5</DOCSIS-CMTS-CM-NODE-CH:CmtsRcsId>
<DOCSIS-CMTS-CM-NODE-CH:CmtsTcsId>5</DOCSIS-CMTS-CM-NODE-CH:CmtsTcsId>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
```

```
<DOCSIS-CM:CmIpv4Addr>55.12.48.113</DOCSIS-CM:CmIpv4Addr>
<DOCSIS-CM:CmIpv6Addr>2001:0400:0000:0000:0209:36FF:FEA7:7089</DOCSIS-CM:CmIpv6Addr>
<DOCSIS-CM:CmIpv6LinkLocalAddr>FE80:0000:0000:0000:0209:36FF:FEA7:7089</DOCSIS-
CM:CmIpv6LinkLocalAddr>
<DOCSIS-CM:CmQosVersion>2</DOCSIS-CM:CmQosVersion>
<DOCSIS-CM:CmRegStatusValue>8</DOCSIS-CM:CmRegStatusValue>
<DOCSIS-CM:CmLastRegTime>2006-06-04T09:15:00Z</DOCSIS-CM:CmLastRegTime>
        <DOCSIS-CM:CmEnergyMgtEnabled>0</DOCSIS-CM:CmEnergyMgtEnabled>
        <DOCSIS-CM:CmEnergyMgtOperStatus>0</DOCSIS-CM:CmEnergyMgtOperStatus>
        <DOCSIS-OFDM-PROFILE:DsProfileIdList>22040008090a</DOCSIS-OFDM-
PROFILE:DsProfileIdList>
        <DOCSIS-OFDM-PROFILE:UsProfileIucList>24020506</DOCSIS-OFDM-
PROFILE:UsProfileIucList>
        <DOCSIS-CMTS-CM-DS-OFDM:TcsPhigh>3</DOCSIS-CMTS-CM-DS-OFDM:TcsPhigh>
        <DOCSIS-CMTS-CM-DS-OFDM:TcsDrwTop>0</DOCSIS-CMTS-CM-DS-OFDM:TcsDrwTop>
        <DOCSIS-CMTS-CM-DS-OFDM:MinUsableDsFreq>100000000</DOCSIS-CMTS-CM-DS-
OFDM:MinUsableDsFreq>
        <DOCSIS-CMTS-CM-DS-OFDM:MaxUsableDsFreq>1200000000</DOCSIS-CMTS-CM-DS-
OFDM:MaxUsableDsFreq>
        <DOCSIS-CMTS-CM-US-OFDMA:MaxUsableUsFreq>95000000</DOCSIS-CMTS-CM-US-
OFDMA:MaxUsableUsFreq>
        <DOCSIS-CMTS-CM-PARTIAL:PartialSvcState>0</DOCSIS-CMTS-CM-
PARTIAL:PartialSvcState>
        <DOCSIS-CMTS-CM-PARTIAL:PartialChanState>0</DOCSIS-CMTS-CM-
PARTIAL:PartialChanState>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
<DOCSIS-REC:RecCreationTime>2006-06-05T07:11:00Z</DOCSIS-REC:RecCreationTime>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.8 CMTS-TOPOLOGY-TYPE

This section provides a sample XML Instance Document for the CMTS Topology Service Definition, CMTS-TOPOLOGY-TYPE and corresponding XML Schema DOCSIS-CMTS-TOPOLOGY-TYPE_3.5.1-A.3.xsd.

III.8.1 Use Case

At a CMTS sysUpTime of "2226878", the CMTS "cmts01.mso.com" with ipv4Address of "10.40.57.11", ipv6Address of "2001:0400:0000:0000:0000:FF00:FE00:0000", MAC Domain ifName of "Int0/1" and MAC Domain ifIndex of "456", streams the topology information consisting of Node Name as "DENVER288", MAC Domain Cable Modem Service Group Id of "1010", MAC Domain Downstream Service Group Id of "2", MAC Domain Upstream Service Group Id "5", MAC Domain Downstream Service Group Channel List of "01020304" and MAC Domain Upstream Service Group Channel List of "0A0B0C3D".

III.8.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-TOPOLOGY-
TYPE"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-MD-NODE="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
MD-NODE"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS-TOPOLOGY-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-TOPOLOGY-
TYPE/DOCSIS-CMTS-TOPOLOGY-TYPE_3.5.1-A.3.xsd"
```

```
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.3">
<ipdr:IPDR xsi:type="CMTS-TOPOLOGY-TYPE">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-CMTS:CmtsIpv4Addr>10.40.57.11</DOCSIS-CMTS:CmtsIpv4Addr>
<DOCSIS-CMTS:CmtsIpv6Addr>2001:0400:0000:0000:0000:FF00:FE00:0000</DOCSIS-
CMTS:CmtsIpv6Addr>
<DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
<DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-MD-NODE:CmtsNodeName>DENVER2881</DOCSIS-MD-NODE:CmtsNodeName>
<DOCSIS-MD-NODE:CmtsMdCmSgId>1010</DOCSIS-MD-NODE:CmtsMdCmSgId>
<DOCSIS-MD-NODE:CmtsMdDsSgId>2</DOCSIS-MD-NODE:CmtsMdDsSgId>
<DOCSIS-MD-NODE:CmtsMdUsSgId>5</DOCSIS-MD-NODE:CmtsMdUsSgId>
<DOCSIS-MD-NODE:CmtsMdDsSgChList>01020304</DOCSIS-MD-NODE:CmtsMdDsSgChList>
<DOCSIS-MD-NODE:CmtsMdUsSgChList>0A0B0C3D</DOCSIS-MD-NODE:CmtsMdUsSgChList>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
<DOCSIS-REC:RecCreationTime>2006-06-05T07:10:05Z</DOCSIS-REC:RecCreationTime>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.9 CPE-TYPE

This section provides a sample XML Instance Document for the CPE Service Definition, CPE-TYPE and corresponding XML Schema DOCSIS-CPE-TYPE_3.5.1-A.2.xsd.

III.9.1 Use Case

At a CMTS sysUpTime of "2226878", the CMTS "cmts01.mso.com" streams the CPE record for a CPE with MAC Address 00-08-22-B4-66-90 corresponding to a CM with MAC Address 00-09-36-A7-70-89 and a CMTS MAC Domain ifName of "Int0/1" and ifIndex of 456. In addition, the CPE IPv4 address of 192.168.0.11, IPv6 address of 2001:0400:0000:0000:0000:1000:FFFF:0000 and FQDN of "somehost.example.com." are included in the record.

III.9.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CPE-TYPE"
xmlns:DOCSIS-CPE="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CPE"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CPE-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CPE-TYPE/DOCSIS-CPE-
TYPE_3.5.1-A.2.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f" version="3.5.1-A.2" creationTime="2006-
06-05T07:11:00Z" IPDRRecorderInfo="cmts01.mso.com">
<ipdr:IPDR xsi:type="CPE-TYPE">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
<DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
<DOCSIS-CPE:CpeMacAddr>00-08-22-B4-66-90</DOCSIS-CPE:CpeMacAddr>
<DOCSIS-CPE:CpeIpv4AddrList>192.168.0.11</DOCSIS-CPE:CpeIpv4AddrList>
```

```
<DOCSIS-CPE:CpeIpv6AddrList>2001:0400:0000:0000:0000:1000:FFFF:0000</DOCSIS-
CPE:CpeIpv6AddrList>
<DOCSIS-CPE:CpeFqdn>somehost.example.com.</DOCSIS-CPE:CpeFqdn>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.10 SAMIS-TYPE-1 and SAMIS-TYPE-2

III.10.1 Use Case

The Type 1 and Type 2 XML Instance Documents defined in the following sections represent the same use case but differ in the amount of data which is streamed. Type 1 streams the full record containing all CMTS, CM and service statistics counters. The optimized record, Type 2, only streams those elements that are needed in each record instance such that correlation can be performed at the collector.

NOTE: The instance documents presented below represent one streaming record for illustrative purposes only. The full set of streaming records for the defined use case are not included.

The use case represented in this section is defined in the following section.

III.10.1.1 Example Usage Record Streaming Model Containing Diverse Services

Table 638 includes a set of records from a bigger set that contains active Service Flows/ CoS for the collection interval from 10:30 AM to 11:00 AM of a day Nov 10 2004 (30 minutes intervals) PCxx correspond to PacketCable 1.5 voice calls; FLPxx correspond to CMs flapping in the registration process after some time being online; CMxx correspond to CMs with steady registration, and passing data. Not all the statistics are presented and for simplicity, only Upstream data is shown in this example.

Table 649 - Sample of Records for the Period 10:30 to 11:00 AM

Device	Time Start	Time End	Time Last (sec)	Rec Type	Device	Time Start	Time End	Time Last (sec)	Rec Type
PC02	10:42:01	10:44:42	161	Stop	CM08	8:16:46	12:05:34	13728	Interim
PC09	10:35:11	10:36:46	95	Stop	CM09	9:47:07	11:36:04	6537	Interim
FLP01	10:44:33	11:07:30	1377	Interim	CM10	9:48:39	11:49:21	7242	Interim
FLP02	10:13:53	10:34:49	1256	Stop	CM11	9:05:29	12:30:36	12307	Interim
FLP02	10:35:25	10:58:08	1363	Stop	CM12	8:40:34	12:17:30	13016	Interim
FLP02	10:58:47	11:14:39	952	Interim	CM14	8:08:13	11:27:41	11968	Interim
FLP03	10:13:39	10:38:26	1487	Stop	CM15	8:04:46	10:44:59	9613	Stop
FLP03	10:39:00	11:05:32	1592	Interim	CM16	9:31:22	11:18:15	6413	Interim
FLP04	10:17:50	10:33:35	945	Stop	CM17	8:44:49	10:53:03	7694	Stop
FLP04	10:34:11	10:56:43	1352	Stop	CM19	9:07:13	11:28:10	8457	Interim
FLP04	10:57:18	11:13:22	964	Interim	CM24	8:02:37	10:35:35	9178	Stop
CM01	9:06:43	11:50:29	9826	Interim	CM25	10:15:27	11:38:47	5000	Interim
CM02	9:54:13	12:31:34	9441	Interim	CM26	10:57:44	11:26:00	1696	Interim
CM03	9:27:57	12:58:43	12646	Interim	CM29	10:10:35	11:34:02	5007	Interim
CM04	8:56:05	12:07:37	11492	Interim	CM32	10:12:35	11:11:12	3517	Interim
CM05	9:03:01	11:30:46	8865	Interim	CM33	10:10:13	12:20:49	7836	Interim
CM06	9:49:23	12:58:20	11337	Interim	CM34	10:57:58	10:58:41	43	Stop
CM07	8:19:37	12:59:17	16780	Interim	CM36	10:58:36	12:38:25	5989	Interim

Table 638 shows in the left side, an arbitrary set of active CM services from start to end: Basic, Premium and Business services (SCN being associated by the CMTS) are here static services and PacketCable Services (SCN =

G711) represent VoIP calls over PacketCable infrastructure. Note that CMTS have signaled in a proprietary manner a SCN = Basic for CMs in 1.0 mode of operation; this could be considered a CMTS specific feature for filling the SCN with the purpose of aggregating that service segment and does not constitute a CMTS requirement.

The right side of Figure 114 corresponds to the records that are reported for the collector interval 10:30 to 11:00 AM as RecType 'Stop' or 'Interim'.

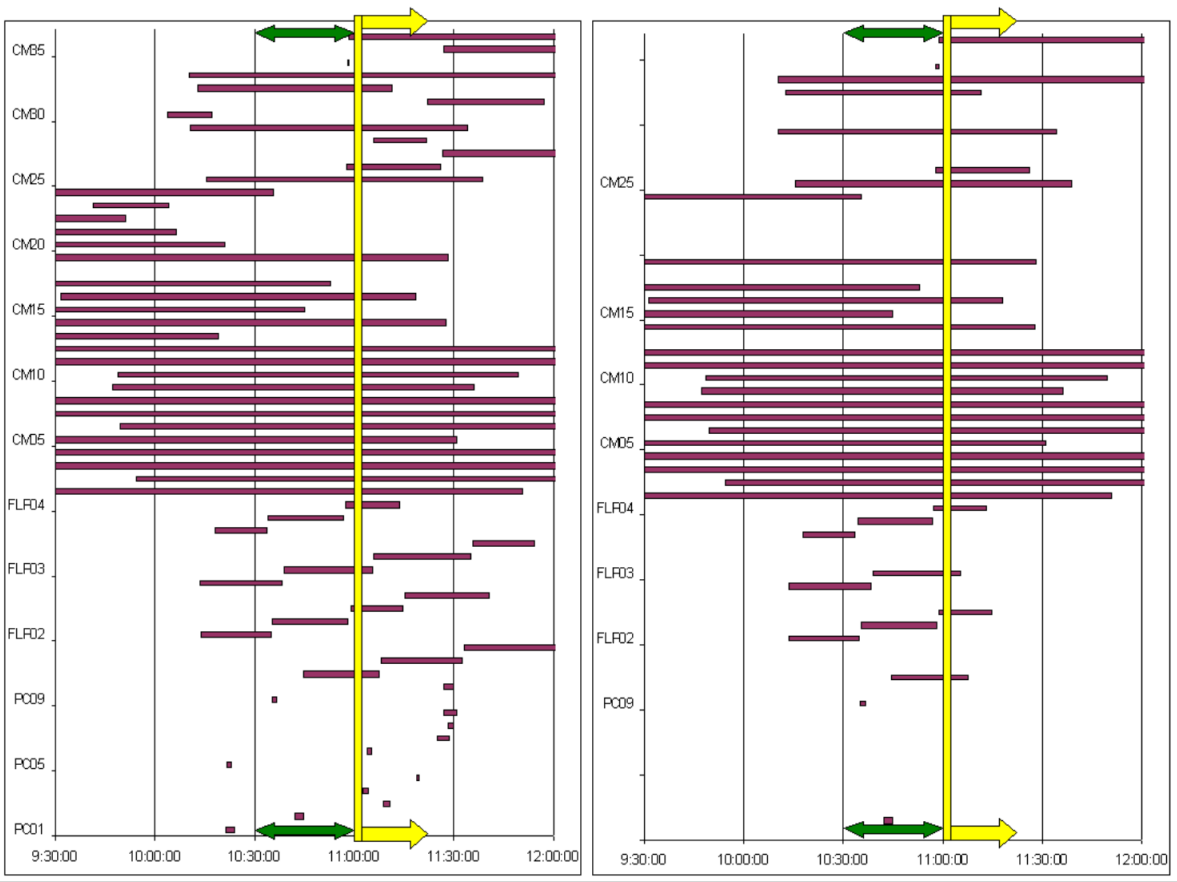


Figure 114 - Set of CM Services in an Arbitrary Period of Time (Left Graphic)Set of Records Associated to the Collection Interval 10:30 to 11:00 AM (Right Graphic)

One example instance of the corresponding records sent by exporter for the time interval 10:30 to 11:00 AM as indicated in the figures above is represented in the below IPDRDoc XML format. IPDRDoc is expected to be aggregated by the Collector with the IPDR/SP data streamed within the session start stop boundary.

III.10.2 SAMIS Type 1 Instance Document

```
<?xml version='1.0' ?>
<ipdr:IPDRDoc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-1"
xmlns:DOCSIS-QOS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-QOS"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
SAMIS-TYPE-1
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-1/DOCSIS-
SAMIS-TYPE-1_3.5.1-A.1.xsd"
```

```
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
version="3.5.1-A.1"
creationTime="2004-11-10T07:11:05Z"
IPDRRecorderInfo="cmts01.mso.com">
<ipdr:IPDR xsi:type="SAMIS-TYPE-1">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-CMTS:CmtsIpv4Addr>10.40.57.11</DOCSIS-CMTS:CmtsIpv4Addr>
<DOCSIS-CMTS:CmtsIpv6Addr>2001:0400:0000:0000:0000:FF00:FE00:0000</DOCSIS-
CMTS:CmtsIpv6Addr>
<DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
<DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-CM:CmIpv4Addr>55.12.48.113</DOCSIS-CM:CmIpv4Addr>
<DOCSIS-CM:CmIpv6Addr>2001:0400:0000:0000:0000:1000:FF00:0000</DOCSIS-CM:CmIpv6Addr>
<DOCSIS-CM:CmIpv6LinkLocalAddr>FE80:0000:0000:0000:0209:36FF:FEA7:7089</DOCSIS-
CM:CmIpv6LinkLocalAddr>
<DOCSIS-CM:CmQosVersion>2</DOCSIS-CM:CmQosVersion>
<DOCSIS-CM:CmRegStatusValue>8</DOCSIS-CM:CmRegStatusValue>
<DOCSIS-CM:CmLastRegTime>2006-06-04T09:15:00Z</DOCSIS-CM:CmLastRegTime>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
<DOCSIS-REC:RecCreationTime>2004-11-10T07:11:05Z</DOCSIS-REC:RecCreationTime>
<DOCSIS-QOS:ServiceFlowChSet>01020304</DOCSIS-QOS:ServiceFlowChSet>
<DOCSIS-QOS:ServiceAppId>10000</DOCSIS-QOS:ServiceAppId>
<DOCSIS-QOS:ServiceDsMulticast>false</DOCSIS-QOS:ServiceDsMulticast>
<DOCSIS-QOS:ServiceIdentifier>361</DOCSIS-QOS:ServiceIdentifier>
<DOCSIS-QOS:ServiceGateId>500</DOCSIS-QOS:ServiceGateId>
<DOCSIS-QOS:ServiceClassName>Premium</DOCSIS-QOS:ServiceClassName>
<DOCSIS-QOS:ServiceDirection>2</DOCSIS-QOS:ServiceDirection>
<DOCSIS-QOS:ServiceOctetsPassed>16486400</DOCSIS-QOS:ServiceOctetsPassed>
<DOCSIS-QOS:ServicePktsPassed>82431</DOCSIS-QOS:ServicePktsPassed>
<DOCSIS-QOS:ServiceSlaDropPkts>412</DOCSIS-QOS:ServiceSlaDropPkts>
<DOCSIS-QOS:ServiceSlaDelayPkts>8</DOCSIS-QOS:ServiceSlaDelayPkts>
<DOCSIS-QOS:ServiceTimeCreated>2210822</DOCSIS-QOS:ServiceTimeCreated>
<DOCSIS-QOS:ServiceTimeActive>161</DOCSIS-QOS:ServiceTimeActive>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2004-11-10T07:11:08Z"/>
</ipdr:IPDRDoc>
```

III.10.3 SAMIS Type 2 Instance Document

```
<?xml version='1.0' ?>
<ipdr:IPDRDoc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-2"
xmlns:DOCSIS-QOS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-QOS"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
xmlns:DOCSIS-CM="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CM"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
SAMIS-TYPE-2
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-SAMIS-TYPE-2/DOCSIS-
SAMIS-TYPE-2_3.5.1-A.1.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
version="3.5.1-A.1"
creationTime="2004-11-10T07:11:05Z"
IPDRRecorderInfo="cmts01.mso.com">
<ipdr:IPDR xsi:type="SAMIS-TYPE-2">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
<DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
<DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
```

```
<DOCSIS-CM:CmMacAddr>00-09-36-A7-70-89</DOCSIS-CM:CmMacAddr>
<DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
<DOCSIS-REC:RecCreationTime>2004-11-10T07:11:05Z</DOCSIS-REC:RecCreationTime>
<DOCSIS-QOS:ServiceFlowChSet>01020304</DOCSIS-QOS:ServiceFlowChSet>
<DOCSIS-QOS:ServiceAppId>10000</DOCSIS-QOS:ServiceAppId>
<DOCSIS-QOS:ServiceDsMulticast>false</DOCSIS-QOS:ServiceDsMulticast>
<DOCSIS-QOS:ServiceIdentifier>361</DOCSIS-QOS:ServiceIdentifier>
<DOCSIS-QOS:ServiceGateId>500</DOCSIS-QOS:ServiceGateId>
<DOCSIS-QOS:ServiceClassName>Premium</DOCSIS-QOS:ServiceClassName>
<DOCSIS-QOS:ServiceDirection>2</DOCSIS-QOS:ServiceDirection>
<DOCSIS-QOS:ServiceOctetsPassed>16486400</DOCSIS-QOS:ServiceOctetsPassed>
<DOCSIS-QOS:ServicePktsPassed>82431</DOCSIS-QOS:ServicePktsPassed>
<DOCSIS-QOS:ServiceSlaDropPkts>412</DOCSIS-QOS:ServiceSlaDropPkts>
<DOCSIS-QOS:ServiceSlaDelayPkts>8</DOCSIS-QOS:ServiceSlaDelayPkts>
<DOCSIS-QOS:ServiceTimeCreated>2210822</DOCSIS-QOS:ServiceTimeCreated>
<DOCSIS-QOS:ServiceTimeActive>161</DOCSIS-QOS:ServiceTimeActive>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2004-11-10T07:11:08Z"/>
</ipdr:IPDRDoc>
```

III.11 CMTS-US-UTIL-STATS-TYPE

This section provides a sample XML Instance Document for the CMTS Upstream Utilization Statistics Service Definition, CMTS-US-UTIL-STATS-TYPE and corresponding XML Schema DOCSIS-CMTS-US-UTIL-STATS-TYPE_3.5.1-A.5.xsd.

III.11.1 Use Case

At a CMTS sysUpTime of "2226878", the CMTS "cmts01.mso.com" with MAC Domain ifIndex of "456", streams (using an event-based session) the upstream utilization statistics information for the upstream logical channel with ifIndex of "17". In addition, the UsUtilInterval of "900" (15 minutes) and the following utilization information is included in the record:

IndexPercentage = 80

TotalMslots = 1403854841

UcastGrantedMslots = 33281121

TotalCntnMslots = 1370280369

UsedCntnMslots = 815830

CollCntnMslots = 1332

TotalCntnReqMslots = 311083615

UsedCntnReqMslots = 574833

CollCntnReqMslots = 1332

TotalCntnReqDataMslots = 0

UsedCntnReqDataMslots = 0

CollCntnReqDataMslots = 0

TotalCntnInitMaintMslots = 1059212846

UsedCntnInitMaintMslots = 240997

CollCntnInitMaintMslots = 0

III.11.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
```

```
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-US-UTIL-
STATS-TYPE"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
         xmlns: DOCSIS-CMTS-US-
UTIL="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-US-UTIL"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS-US-UTIL-STATS-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-US-UTIL-STATS-
TYPE/DOCSIS-CMTS-US-UTIL-STATS-TYPE_3.5.1-A.5.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.5">
<ipdr:IPDR xsi:type="CMTS-US-UTIL-STATS-TYPE">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
        <DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-CMTS-US-UTIL:UsIfIndex>17</DOCSIS-CMTS-US-UTIL:UsIfIndex>
        <DOCSIS-CMTS-US-UTIL:UsIfName> Int/0/1/4</DOCSIS-CMTS-US-UTIL:UsIfName>
<DOCSIS-CMTS-US-UTIL:UsChId>2</DOCSIS-CMTS-US-UTIL:UsChId>
        <DOCSIS-CMTS-US-UTIL:UsUtilInterval>900</DOCSIS-CMTS-US-UTIL:UsUtilInterval>
<DOCSIS-CMTS-US-UTIL:UsUtilIndexPercentage>80</DOCSIS-CMTS-US-
UTIL:UsUtilIndexPercentage>
<DOCSIS-CMTS-US-UTIL:UsUtilTotalMslots >1403854841</DOCSIS-CMTS-US-
UTIL:UsUtilTotalMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilUcastGrantedMslots>33281121</DOCSIS-CMTS-US-
UTIL:UsUtilUcastGrantedMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilTotalCntnMslots>1370280369</DOCSIS-CMTS-US-
UTIL:UsUtilTotalCntnMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilUsedCntnMslots>815830</DOCSIS-CMTS-US-
UTIL:UsUtilUsedCntnMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilCollCntnMslots>1332</DOCSIS-CMTS-US-
UTIL:UsUtilCollCntnMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilTotalCntnReqMslots>311083615</DOCSIS-CMTS-US-
UTIL:UsUtilTotalCntnReqMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilUsedCntnReqMslots>574833</DOCSIS-CMTS-US-
UTIL:UsUtilUsedCntnReqMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilCollCntnReqMslots>1332</DOCSIS-CMTS-US-
UTIL:UsUtilCollCntnReqMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilTotalCntnReqDataMslots>0</DOCSIS-CMTS-US-
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<DOCSIS-CMTS-US-UTIL:UsUtilUsedCntnReqDataMslots>0</DOCSIS-CMTS-US-
UTIL:UsUtilUsedCntnReqDataMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilCollCntnReqDataMslots>0</DOCSIS-CMTS-US-
UTIL:UsUtilCollCntnReqDataMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilTotalCntnInitMaintMslots>1059212846</DOCSIS-CMTS-US-
UTIL:UsUtilTotalCntnInitMaintMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilUsedCntnInitMaintMslots>240997</DOCSIS-CMTS-US-
UTIL:UsUtilUsedCntnInitMaintMslots>
<DOCSIS-CMTS-US-UTIL:UsUtilCollCntnInitMaintMslots>0</DOCSIS-CMTS-US-
UTIL:UsUtilCollCntnInitMaintMslots>
<DOCSIS-REC:RecType>4</DOCSIS-REC:RecType><DOCSIS-REC:RecCreationTime>2006-06-
05T07:10:05Z</DOCSIS-REC:RecCreationTime>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.12 CMTS-DS-UTIL-STATS-TYPE

This section provides a sample XML Instance Document for the CMTS Downstream Utilization Statistics Service Definition, CMTS-DS-UTIL-STATS-TYPE and corresponding XML Schema DOCSIS-CMTS-DS-UTIL-STATS-TYPE_3.5.1-A.4.xsd.

III.12.1 Use Case

At a CMTS sysUpTime of "2226888", the CMTS "cmts01.mso.com" with MAC Domain ifIndex of "456", streams (using an event-based session) the downstream utilization statistics information for the downstream channel with ifIndex of "18". In addition, the DsUtilInterval of "900" (15 minutes) and the following utilization information is included in the record:

IndexPercentage = 70

TotalBytes = 2668756233

UsedBytes = 3323829507

III.12.2 Instance Document

```
<?xml version="1.0"?>
<ipdr:IPDRDoc
xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-DS-UTIL-
STATS-TYPE"
xmlns:DOCSIS-CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS"
         xmlns: DOCSIS-CMTS-DS-
UTIL="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-DS-UTIL"
xmlns:DOCSIS-REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"
xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-
CMTS-DS-UTIL-STATS-TYPE
http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS-DS-UTIL-STATS-
TYPE/DOCSIS-CMTS-DS-UTIL-STATS-TYPE_3.5.1-A.4.xsd"
docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
creationTime="2006-06-05T07:11:00Z"
IPDRRecorderInfo="cmts01.mso.com"
version="3.5.1-A.4">
<ipdr:IPDR xsi:type="CMTS-DS-UTIL-STATS-TYPE">
<DOCSIS-CMTS:CmtsHostName>cmts01.mso.com</DOCSIS-CMTS:CmtsHostName>
<DOCSIS-CMTS:CmtsSysUpTime>2226888</DOCSIS-CMTS:CmtsSysUpTime>
        <DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
<DOCSIS-CMTS-DS-UTIL:DsIfIndex>18</DOCSIS-CMTS-DS-UTIL:DsIfIndex>
        <DOCSIS-CMTS-DS-UTIL:DsIfName> Int/0/1/1</DOCSIS-CMTS-DS-UTIL:DsIfName>
<DOCSIS-CMTS-DS-UTIL:DsChId>1</DOCSIS-CMTS-DS-UTIL:DsChId>
        <DOCSIS-CMTS-DS-UTIL:DsUtilInterval>900</DOCSIS-CMTS-DS-UTIL:DsUtilInterval>
<DOCSIS-CMTS-DS-UTIL:DsUtilIndexPercentage>70</DOCSIS-CMTS-DS-
UTIL:DsUtilIndexPercentage>
<DOCSIS-CMTS-DS-UTIL:DsUtilTotalBytes >2668756233</DOCSIS-CMTS-DS-
UTIL:DsUtilTotalBytes>
<DOCSIS-CMTS-DS-UTIL:DsUtilUsedBytes>3323829507</DOCSIS-CMTS-DS-UTIL:DsUtilUsedBytes>
<DOCSIS-REC:RecType>4</DOCSIS-REC:RecType>
<DOCSIS-REC:RecCreationTime>2006-06-05T07:10:05Z</DOCSIS-REC:RecCreationTime>
</ipdr:IPDR>
<ipdr:IPDRDoc.End count="1" endTime="2006-06-05T07:15:00Z"/>
</ipdr:IPDRDoc>
```

III.13 CMTS-CM-SERVICE-FLOW-TYPE

This section provides a sample XML Instance Document for the CMTS CM Service Flow Service Definition, CMTS-CM-SERVICE-FLOW-TYPE and corresponding XML Schema DOCSIS-CMTS-CM-SERVICE-FLOW-TYPE_3.5.1-B.1.xsd.

III.13.1 Use Case

At a CMTS sysUpTime of "2226888", the CMTS "cmts01.mso.com" with MAC Domain ifIndex of "456"and Service Identifier 361, streams (using an event-based session) the Service Flow information. The Service Flow is a statically provisioned Best Effort Service Flow. The Service Flow has the following characteristics:

Service Flow Channel Set = 01020304

MaxRate = 1000000

MaxBurst = 2000000

Peak Rate = 3000000

Service Priority = 2

Service Class Name = premium_up

III.13.2 Instance Document

```
<?xml version='1.0' ?>
<ipdr:IPDRDoc xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
           xmlns:ipdr="http://mibs.cablelabs.com/namespaces/DOCSIS/tmforum/xsd/ipdr"
           xmlns="http://www.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-
CM-SERVICE-FLOW-TYPE"
           xmlns:DOCSIS-
QOS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-QOS"
           xmlns:DOCSIS-
CMTS="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-CMTS"
         xmlns:DOCSIS-
REC="http://www.cablelabs.com/namespaces/DOCSIS/3.0/xsd/ipdr/DOCSIS-REC"

xsi:schemaLocation="http://www.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-
CMTS-CM-SERVICE-FLOW-TYPE
              http://www.cablelabs.com/namespaces/DOCSIS/3.1/xsd/ipdr/DOCSIS-CMTS-CM-
SERVICE-FLOW-TYPE_3.5.1-B.1.xsd"
           docId="3d07ba27-0000-0000-0000-1a2b3c4d5e6f"
           version="3.5.1-B.1"
           creationTime="2015-11-10T07:11:05Z"
           IPDRRecorderInfo="cmts01.mso.com">
    <ipdr:IPDR xsi:type="CMTS-CM-SERVICE-FLOW-TYPE">
        <DOCSIS-CMTS:CmtsHostName>cmts01.mso.com.</DOCSIS-CMTS:CmtsHostName>
        <DOCSIS-CMTS:CmtsSysUpTime>2226878</DOCSIS-CMTS:CmtsSysUpTime>
        <DOCSIS-CMTS:CmtsMdIfName>Int0/1</DOCSIS-CMTS:CmtsMdIfName>
        <DOCSIS-CMTS:CmtsMdIfIndex>456</DOCSIS-CMTS:CmtsMdIfIndex>
        <DOCSIS-REC:RecType>1</DOCSIS-REC:RecType>
        <DOCSIS-REC:RecCreationTime>2004-11-10T07:11:05Z</DOCSIS-REC:RecCreationTime>
        <DOCSIS-QOS:ServiceFlowChSet>01020304</DOCSIS-QOS:ServiceFlowChSet>
        <DOCSIS-QOS:ServiceAppId>10000</DOCSIS-QOS:ServiceAppId>
        <DOCSIS-QOS:ServiceDsMulticast>false</DOCSIS-QOS:ServiceDsMulticast>
        <DOCSIS-QOS:ServiceIdentifier>361</DOCSIS-QOS:ServiceIdentifier>
        <DOCSIS-QOS:ServiceGateId></DOCSIS-QOS:ServiceGateId>
        <DOCSIS-QOS:ServiceClassName>premium_up</DOCSIS-QOS:ServiceClassName>
        <DOCSIS-QOS:ServiceDirection>2</DOCSIS-QOS:ServiceDirection>
        <DOCSIS-QOS:ServiceTimeCreated>2210822</DOCSIS-QOS:ServiceTimeCreated>
        <DOCSIS-SERVICE-FLOW:ServiceTrafficPriority>2</DOCSIS-SERVICE-
FLOW:ServiceTrafficPriority>
```

```
        <DOCSIS-SERVICE-FLOW:ServiceMaxSustained>1000000</DOCSIS-SERVICE-
FLOW:ServiceMaxSustained>
        <DOCSIS-SERVICE-FLOW:ServiceMaxBurst>2000000</DOCSIS-SERVICE-
FLOW:ServiceMaxBurst>
        <DOCSIS-SERVICE-FLOW:ServiceMinReservedRate>0</DOCSIS-SERVICE-
FLOW:ServiceMinReservedRate>
        <DOCSIS-SERVICE-FLOW:ServiceIpTos></DOCSIS-SERVICE-FLOW:ServiceIpTos>
        <DOCSIS-SERVICE-FLOW:ServicePeakRate>3000000</DOCSIS-SERVICE-
FLOW:ServicePeakRate>
        <DOCSIS-SERVICE-FLOW:ServiceSchedule>2</DOCSIS-SERVICE-FLOW:ServiceSchedule>
        <DOCSIS-SERVICE-FLOW:ServiceNomPollInterval></DOCSIS-SERVICE-
FLOW:ServiceNomPollInterval>
        <DOCSIS-SERVICE-FLOW:ServiceTolPollJitter></DOCSIS-SERVICE-
FLOW:ServiceTolPollJitter>
        <DOCSIS-SERVICE-FLOW:ServiceUGSize></DOCSIS-SERVICE-FLOW:ServiceUGSize>
        <DOCSIS-SERVICE-FLOW:ServiceNomGrantInterval></DOCSIS-SERVICE-
FLOW:ServiceNomGrantInterval>
        <DOCSIS-SERVICE-FLOW:ServiceTolGrantJitter></DOCSIS-SERVICE-
FLOW:ServiceTolGrantJitter>
        <DOCSIS-SERVICE-FLOW:ServiceGrantsPerInterval></DOCSIS-SERVICE-
FLOW:ServiceGrantsPerInterval>
        <DOCSIS-SERVICE-FLOW:ServicePacketClassifier></DOCSIS-SERVICE-
FLOW:ServicePacketClassifier>
    </ipdr:IPDR>
    <ipdr:IPDRDoc.End count="1" endTime="2015-11-10T07:11:08Z"/>
</ipdr:IPDRDoc>
```

Appendix IV Spectrum Analysis Use Cases (Informative)

This appendix describes several use cases where the Signal Quality Monitoring features introduced in DOCSIS 3.0 can be utilized to manage the HFC plant.

To maintain the HFC network in optimal conditions constant monitoring of the physical characteristics is desired. This practice helps in the early detection of plant problems. These problems, if not properly corrected could cause degradation of services that are offered over the DOCSIS network. The RF impairments may often be the root cause of the problem affecting the quality of services offered over DOCSIS. These impairments result in excessive logging, and poor statistics indicating a lower quality of experience for customer of the services.

Ideally, rather than inferring the presence of RF impairments in the HFC from DOCSIS MAC statistics (for example), the use of Signaling Quality measurement equipment dedicated to monitor the HFC spectrum is desired. However, the cost of such equipment and its associated management and operation may not be justifiable. Instead, active network elements such as CMTSs have evolved their capabilities to report RF measurements using an SNMP management interface. The main advantage of this approach is the constant availability of information across the network. Such information can be correlated to determine e.g., a group of CMs with a common tap in the HFC path reporting the same measurements problem. The signal monitoring approach is similar to how specialized equipment is used to further isolate the problems based on the coarse measurements from a CMTS.

This appendix describes use cases for two main categories of the Enhanced Signaling Quality Monitoring features of DOCSIS 3.0:

- Normalization of RF Impairments Measurements
- Spectrum Amplitude Measurements for Upstream Interfaces

IV.1 Normalization of RF Impairments Measurements

IV.1.1 Problem Description

DOCSIS [RFC 4546] provides SNR (Signal-to-Noise) measurement. SNR among other measurements are available on a per CM basis and per interface.

SNR values reported may not be uniform amongst different CMTS vendors. Therefore, it might not be possible to compare and analyze information from different devices to determine the HFC plant conditions.

IV.1.2 Use Cases

Major contributors to impairments in the DOCSIS channels are linear distortion, non-linear distortion, impulse noise and ingress noise.

DOCSIS pre-equalization provides a mechanism to correct the linear distortion of each individual CM transmission. Ingress noise robustness has no specification requirements beyond the assumed RF plant conditions in [MULPIv4.0]. However, vendors have provided mechanisms to mitigate noise and ingress interference in plants that have more severe noise conditions than the ones assumed in the [MULPIv4.0] specification.

The available RF measurements in DOCSIS 3.0 are listed in Table 639 where the DOCSIS 3.0 added features are indicated in bold text and are the basis for the use cases of this section. In general, downstream RF measurements are performed by individual CMs while the upstream measurements are performed by the CMTS either at an interface or at a CM level. Based on CMTS and CM interactions, the CM provides an indirect measure of the distortion in the upstream channel through its pre-equalization coefficients.

Table 650 - RF Management Statistics Available in DOCSIS 3.0

CM (Downstream Measurements)	CMTS (Upstream Measurements)	Measurements Categories
SNR	SNR	Noise conditions
RxMER	RxMER	
	CNIR	

CM (Downstream Measurements)	CMTS (Upstream Measurements)	Measurements Categories
	Expected Received Power	Power level
Correctable/uncorrectable errors	Correctable/uncorrectable errors per CM	FEC performance statistics
	Correctable/uncorrectable errors per US interface	
Downstream micro-reflections	Upstream micro-reflections per CM	Linear distortion
CM post-equalization data	CM pre-equalization[1]	
Note: [1]CM may provide more accurate pre-equalization coefficient than what the CMTS is able to calculate.		

The following use cases refer to the noise measurement enhancements for DOCSIS 3.0.

IV.1.2.1 Use Case 1: Figure of Merit Estimation for Logical Upstream Channel

This Use Case defines a Figure of Merit for Logical Upstream Channel measurement that an operator can use to periodically collect information to characterize the performance of the HFC part of the Cable distribution network.

To overcome non-uniform SNR measurements, DOCSIS 3.0 defines two measurements: RxMER (Receive Modulation Error Rate) and CNIR (Carrier to Noise plus Interference Ratio). These provide better indication of the HFC plant impairments and the corrections achieved by the CMTS through compensation techniques. Combining RxMER and CNIR, a Figure of Merit of impairment compensation efficiency can be defined when noise or interference is present.

RxMER measures the average quantization error just prior to FEC, and CNIR measures the carrier to noise plus interference ratio prior to demodulation. A Figure of Merit of how efficiently interference and distortion is compensated in a logical channel can be defined as:

Figure of Merit (logical channel) = RxMER - CNIR

The variables from Section 6.6.1.2 to retrieve are:

- RxMER: docsIf3SignalQualityExtRxMER
- CNIR: docsIf3CmtsSignalQualityExtCNIR

The Figure of Merit is relevant when the device is capable of suppressing ingressors, thus increasing the RxMER value with respect to the channel CNIR.

To minimize the uncertainties in measuring the Figure of Merit due to distortion that is unique to individual upstream paths between a CM and CMTS, it is advisable to operate with pre-equalization on (see docsIfUpChannelPreEqEnable of [RFC 4546]).

IV.1.2.2 Use Case 2 Figure of Merit Estimation per CM

This Use Case defines a Figure of Merit per CM transmission. Similar to Use Case 1, the operator can periodically collect information to characterize the performance of CMs in terms of figure of Merit for the given CMTS the CM is attached to.

Unlike RxMER, the SNR parameter is unique for each CM. This allows you to define a Figure of Merit on a per CM basis. A Figure of Merit of how efficiently interference and distortion affecting a CM is compensated can be defined as:

Figure of Merit (CM) = SNR (CM) - CNIR (of the logical upstream channel)

The variables from Sections 7.2.2.2 and 6.6.1.2 to retrieve are:

- SNR: docsIf3CmtsCmUsStatusSignalNoise
- CNIR: docsIf3CmtsSignalQualityExtCNIR

This Figure of Merit indicates if a CM, through its pre-equalization mechanism, is efficiently compensating the linear distortion in its upstream path.

IV.1.2.3 Use Case 3 Absolute Noise and Interference Estimation

Traditionally CMTSs are expected to command the CMs' power transmission so that the CMTS received power is close to 0 dBmV across all CMs.

This Use Case defines how an operator may derive the absolute value of the noise plus interference (in dBmV) from the reported value (CNIR in dB) which is a relative measure.

For example, CNIR and ExpectedRxSignalPower can be used to estimate noise and interference levels (N+I) across the operator's network in dBmV as:

N + I = CNIR - ExpectedRxSignalPower (CMs of the logical upstream channel)

Operators may determine the difference between the target and the actual received power at the CMTS using the following equation:

CM Offset Power = CM Rx Power - ExpectedRxSignalPower

The variables from Sections 7.2.2.2 and 6.6.1.2 to retrieve are:

- CM Rx Power: docsIf3CmtsCmUsStatusRxPower
- ExpectedRxSignalPower: docsIf3CmtsSignalQualityExtExpectedRxSignalPower

IV.1.2.3.1 CM Estimated CNIR

Operators may estimate individual CM CNIR by combining the CNIR obtained for the logical channel and the CM offset power as follows:

CM Estimated CNIR = CM Offset Power + CNIR

CM Offset Power: The difference between the actual received CM power level and the expected commanded received signal power at the CMTS.

The variables from Sections 7.2.2.2 and 6.6.1.2 to retrieve are:

- CNIR: docsIf3CmtsSignalQualityExtCNIR
- CM Rx Power: docsIf3CmtsCmUsStatusRxPower
- Expected Commanded Received Signal Power: docsIf3CmtsSignalQualityExtExpectedRxSignalPower

IV.2 Upstream Spectrum Measurement Monitoring

IV.2.1 Problem Description

Placing spectrum analyzers to obtain granular spectrum monitoring to achieve extensive coverage of the number of nodes, the number of channels, increased frequency of samples, and with increased frequency resolution is cost prohibitive and cumbersome. Such limited coverage complicates agile troubleshooting of plant spectrum.

IV.2.2 Use Cases

DOCSIS 3.0 adds the spectrum monitoring feature where the management system requests CMTSs to perform spectrum measurement over an upstream channel.

IV.2.2.1 Use Case 1 Spectrum Analysis Measurement Setup

This Use Case describes the operator configuration procedure to start the measurements of spectrum amplitude values for a specific channel.

The operator only needs to select the logical upstream channel for which the upstream receiver will capture the spectrum amplitude. SNMP is used to trigger the test using a read-create RowStatus object set to 'CreateAndGo'.

The CMTS reports the following pre-configured parameters (refer to [OSSIv3.0] Annex J for object details):

- The *NumberOfBins* is the number of data points that compose the spectral data.

- The *FrequencySpan* is the width of the band across which the spectral amplitudes characterizing the channel are measured.
- The *ResolutionBW* is the equivalent noise bandwidth for each bin.
- The *TimeInterval* is the estimated average repetition period of measurements defining the average rate at which new spectra can be retrieved. An SNMP manager should not attempt to collect the data at a higher rate than the value specified.
- The *BinSpacing* is the frequency separation between adjacent bin centers.

IV.2.2.2 Use Case 2 Data Retrieval

This Use Case describes a typical procedure for the retrieval of spectrum amplitude data from the CMTS. The data can be retrieved via SNMP or streamed by the CMTS using the Spectrum Amplitude IPDR Service Definition defined in Section 8.

Section 8 illustrates the detailed steps for the IPDR connection establishment and data retrieval. The following process briefly defines the data retrieval process. Refer to Section 7.5.3.1, Streaming Telemetry IPDR/SP Protocol Stack for details on the IPDR Streaming Protocol.

- The collector opens a connection with the CMTS. If a reliable collection mechanism is not required, there is no need to have a backup collector.
- The CMTS is configured to generate data for a given interface.
- When the CMTS setup is complete, it starts the transfer of information to the collector.
- The operator can then use an application to plot the information collected as shown in Figure 115 and Figure 116.
- When the operator no longer wishes to continue retrieving information, the operator can remove the measurement point in the CMTS which suspends the data generation and export. The operator can then tear down the previously established IPDR/SP connection.

Figure 115 shows the sequence diagram for streaming of spectrum analysis measurement data. The operator selects the logical upstream channel of interest. The CMTS starts the data streaming to the collector. After the data is captured, the streaming may be terminated.

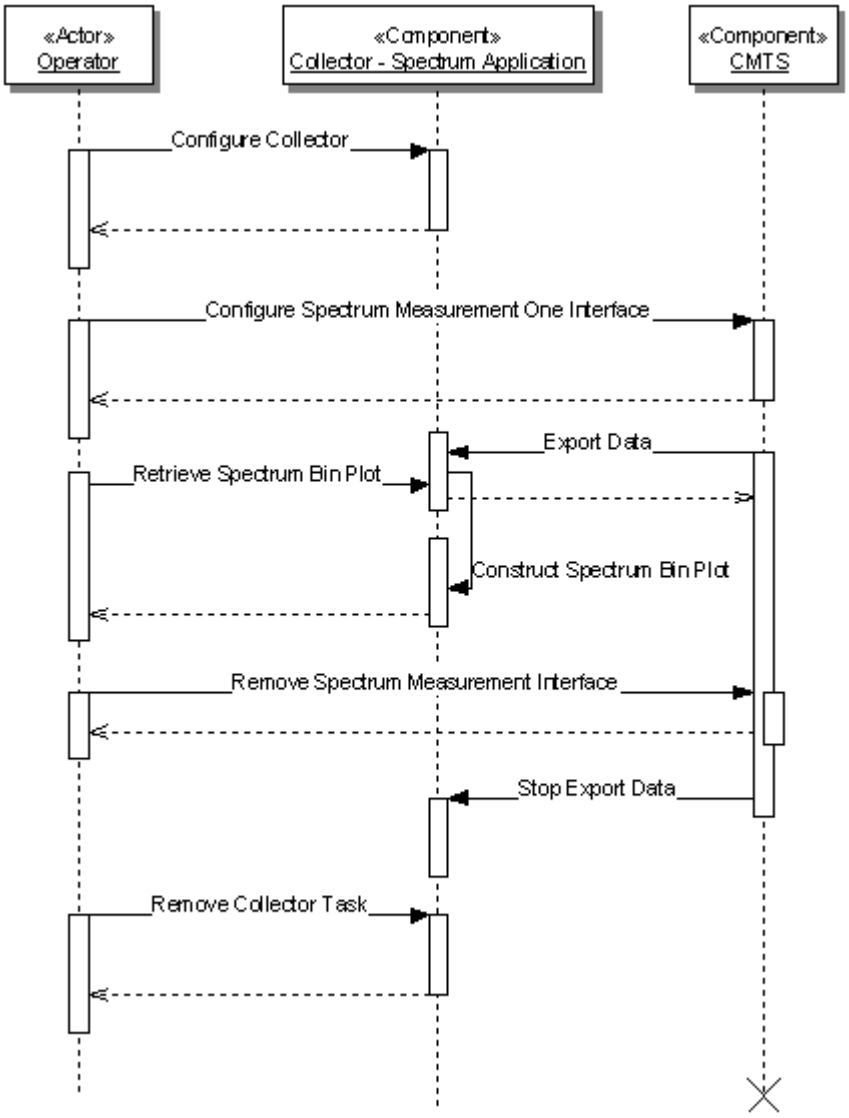

Figure 115 - Sequence Diagram for Streaming of Spectrum Analysis Measurement Data

IV.2.2.3 Use Case 3 Data Analysis

Table 640 shows a data point for a given time and plotted in Figure 116 and Figure 117 as the "current" data series. For this analysis, the following parameters are known from the configuration:

- Center Frequency of the channel is 25000000 Hz and is reported in the 129th bin (assuming 257 bins).
- Frequency Span is 3200000 Hz (Channel Width)
- Bin Spacing is 12500 Hz

From the collected data, the following parameters can be derived:

- Frequency of the lower bin is 23400000 Hz
- Frequency of the upper bin is 26600000 Hz

Figure 116 shows the plotted graph of two data series. The first series "Current" consist of the current spectral content characterized by the frequency bin amplitude values. The second data series is the "Maximum" amplitude

values per frequency bin recorded over time (max hold). Each time a new measurement point is collected the figure is updated. Figure 117 zooms around 24 MHz to show the presence of an interferer.

Table 651 - Spectrum Analysis Measurement Constructed Graph from Collected Data

First Bin Frequency (For Reference)	Bin Amplitude Values for 8 bins (Decimal)	Bin Amplitude Values for 8 bins (Hexadecimal)
23400000	-39.73 -20.60 -9.23 -4.77 -2.90 -0.08 -0.32 -0.07	F07A F7F4 FC64 FE23 FEDE FFF7 FFDF FFF9
23500000	-0.06 -0.03 -0.08 -0.16 -0.08 0.16 0.13 -0.09	FFFA FFFC FFF8 FFF0 FFF7 000F 000C FFF7
23600000	0.10 0.28 -0.24 -0.02 -0.38 -0.23 -0.01 -0.20	0009 001B FFE8 FFFE FFDA FFE9 FFFE FFEB
23700000	0.08 0.02 0.03 0.04 0.11 0.20 -0.03 0.13	0007 0001 0002 0004 000A 0014 FFFD 000C
23800000	-0.05 0.42 0.11 -0.05 -0.05 -0.36 0.12 -0.06	FFFB 0029 000A FFFB FFFA FFDC 000B FFFA
23900000	-0.07 0.03 -0.13 0.15 -0.17 -0.25 -0.01 -0.13	FFF8 0003 FFF3 000E FFEF FFE6 FFFE FFF3
24000000	-0.09 -0.47 -0.08 0.19 -0.03 0.09 0.13 0.27	FFF7 FFD0 FFF7 0013 FFFD 0009 000D 001A
24100000	0.23 -0.27 0.19 -0.08 0.17 0.11 0.25 0.06	0016 FFE4 0013 FFF7 0010 000A 0019 0005
24200000	0.26 0.00 0.03 -0.08 -0.33 -0.05 0.10 0.08	0019 0000 0003 FFF8 FFDE FFFB 0009 0007
24300000	-0.21 -0.11 0.07 -0.03 8.25 18.67 17.01 0.16	FFEA FFF5 0006 FFFC 0339 074A 06A4 0010
24400000	0.17 0.48 -0.15 0.34 0.40 -0.01 -0.12 0.02	0011 0030 FFF1 0022 0028 FFFE FFF3 0001
24500000	0.01 0.00 -0.08 0.30 -0.04 -0.04 -0.19 -0.01	0001 FFFF FFF7 001D FFFB FFFB FFED FFFF
24600000	0.13 -0.08 -0.07 0.02 0.12 -0.20 0.11 0.25	000D FFF7 FFF9 0002 000B FFEB 000B 0018
24700000	0.04 0.32 -0.11 0.03 0.16 0.06 -0.26 0.28	0004 001F FFF5 0003 000F 0005 FFE6 001B
24800000	-0.05 0.11 0.01 0.14 0.10 0.26 0.34 0.23	FFFB 000A 0000 000E 000A 0019 0022 0017
24900000	-0.18 -0.17 0.15 -0.11 0.08 -0.29 -0.20 0.32	FFED FFEE 000F FFF4 0008 FFE3 FFEC 0020
25000000	-0.10	FFF5
25012500	0.37 0.24 -0.43 -0.24 -0.09 0.23 -0.14 0.19	0025 0018 FFD5 FFE8 FFF7 0017 FFF1 0013
25112500	-0.02 -0.20 0.03 -0.01 -0.12 -0.07 0.24 0.22	FFFD FFEB 0003 FFFE FFF3 FFF8 0017 0015
25212500	-0.17 -0.20 -0.26 0.27 0.42 0.00 -0.08 -0.06	FFEE FFEC FFE6 001A 0029 FFFF FFF7 FFFA
25312500	-0.31 -0.12 0.13 0.02 0.03 0.10 -0.06 -0.30	FFE0 FFF3 000C 0001 0002 000A FFF9 FFE2
25412500	0.35 0.23 0.08 0.19 0.06 0.00 -0.15 0.16	0022 0016 0008 0013 0006 FFFF FFF0 000F
25512500	0.00 0.06 -0.19 0.32 -0.13 0.06 -0.03 -0.10	0000 0006 FFED 001F FFF2 0006 FFFD FFF5
25612500	0.00 0.26 0.09 -0.63 -0.23 0.09 0.38 0.30	0000 0019 0009 FFC1 FFE8 0008 0026 001D
25712500	0.24 -0.03 0.03 -0.01 0.30 0.09 0.05 -0.25	0018 FFFD 0003 FFFE 001D 0009 0004 FFE7
25812500	-0.11 0.29 0.39 -0.24 0.11 -0.01 -0.16 -0.36	FFF5 001C 0027 FFE7 000B FFFF FFF0 FFDC
25912500	-0.31 0.27 0.28 0.53 -0.03 0.08 0.00 0.40	FFE1 001B 001C 0034 FFFD 0008 0000 0027
26012500	0.10 -0.16 -0.13 -0.02 -0.05 -0.05 0.20 0.23	0009 FFF0 FFF2 FFFE FFFA FFFB 0014 0016
26112500	-0.01 -0.01 0.24 0.00 0.06 -0.36 -0.09 -0.02	FFFE FFFE 0018 0000 0006 FFDC FFF6 FFFE
26212500	0.00 0.10 0.15 0.21 0.36 -0.11 0.01 0.13	FFFF 000A 000E 0015 0023 FFF5 0001 000C
26312500	0.11 0.01 -0.07 0.15 0.36 -0.08 0.01 -0.02	000B 0001 FFF9 000E 0024 FFF7 0000 FFFE
26412500	0.35 -0.17 0.16 -0.03 0.03 0.05 0.18 -0.14	0022 FFEF 000F FFFC 0002 0004 0011 FFF2
26512500	0.13 -0.04 0.15 -2.62 -4.54 -10.43 -19.22 -39.43	000D FFFB 000F FEFA FE39 FBED F87E F098

Table Note: This first column corresponds to the frequency of the first spectrum amplitude bin value of each row and is for reference only (i.e., not part of the reported data array). The decimal representation of the reported data array is shown in the second column. The hexadecimal representation of the reported data array is shown in the third column. Each data point is delimited with a single space for readability.

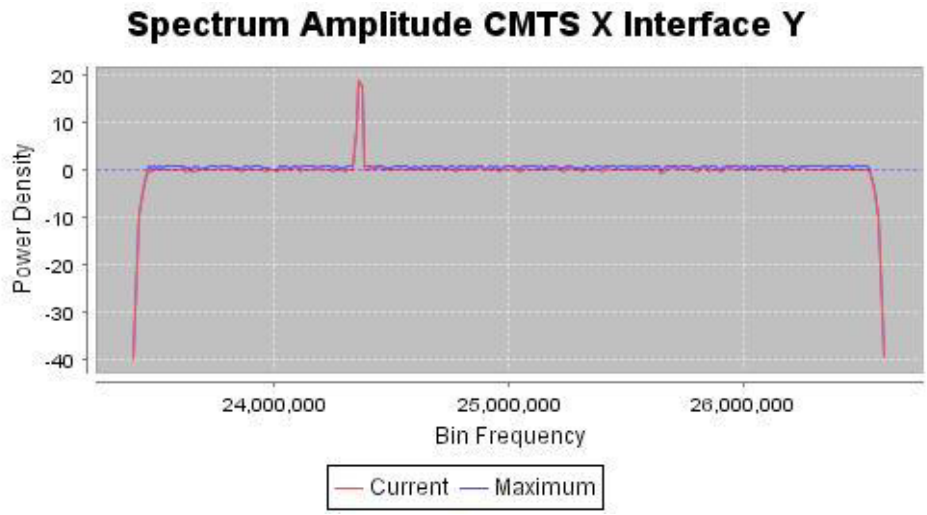

Figure 116 - Spectrum Amplitude Constructed Graph from Collected Data

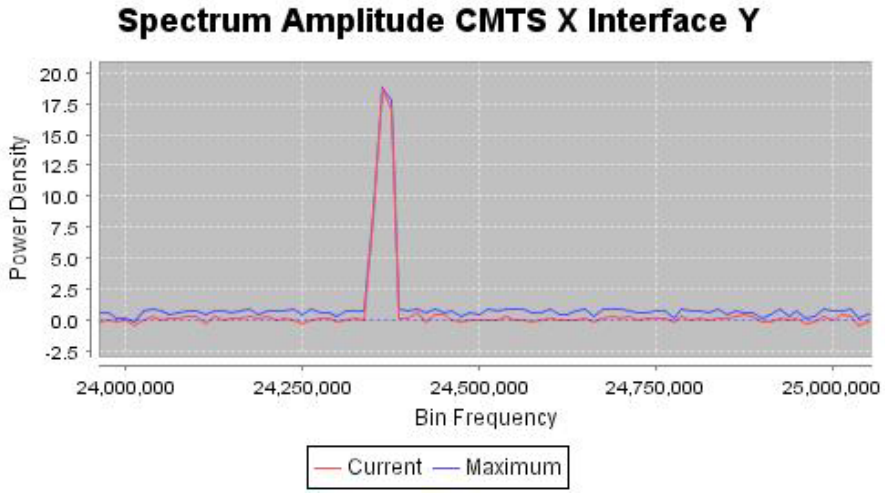

Figure 117 - Spectrum Amplitude Detail Graph from Collected Data

Appendix V Sequence Diagrams (Informative)

This appendix provides a set of detailed sequence diagrams for the use cases defined in Section 5.5. Sequence diagrams provide a detailed message flow for expanding Use Case definitions and define behavior between specific entities, thus illustrating behavior across different interfaces (e.g., OSSI). Like Use Cases, Sequence Diagrams are triggered by an action performed by an actor, in this case the operator from the back office perspective. Refer to [UML Guidelines] for additional details on Sequence Diagram syntax and usage.

V.1 Performance Management Sequence Diagrams

This section provides a set of example Performance Management Sequence Diagrams which map to the Use Cases defined in Section 5.5.3.

V.1.1 Proactive Network Maintenance Test Sequence Diagrams

V.1.1.1 Bulk Data Transfer Sequence Diagrams

The Sequence Diagrams in this section map to the Common Proactive Network Maintenance Use Case illustrated in Section 5.5.3.5.

V.1.1.1.1 Bulk Data File Transfer (Legacy SNMP/TFTP)

This Sequence Diagram maps to the Receive File Upload (which is an extension to the Receive Measurement Results) Use Case illustrated in Section 5.5.3.5, Common Proactive Network Maintenance. This sequence diagram illustrates the legacy scenario using SNMP to configure the bulk data server and TFTP to transfer the capture file using the Bulk File transfer mechanism. The PNM Active and Quiet Probe (AQP) test is used for illustrative purposes.

The sequence of steps, as illustrated in Figure 118 - Sequence Diagram for Receive File Upload (Legacy SNMP/TFTP), is as follows:

1. The MSO, or back office PNM Server, issues an SNMP SET operation to the CCAP via the CCAP's Northbound Interface (NBI). The SET operation is invoked on the BulkDataServerCtrl object for the server with Index=1 which has an IP Address of 10.0.0.1. The ServerIndex is an object key that identifies the file server where the test measurement results are to be sent. The file destination path is provisioned, as well as the upload control and PNM test selector. The provisioned upload control is "no automatic upload" indicating the CCAP will not automatically transfer the file once the test completes (the CCAP will store the results locally). The PNM test selector is set to the PNM AQP test type.
2. The PNM AQP test is configured via an SNMP SET to UsOfdmaActiveAndQuietProbe. Configuration of this test requires provisioning the US channel IfIndex, idle SID flag, timeout, number of symbols to capture, frequency domain samples flag and the requested filename.
3. The AQP Test is initiated by setting the Enable attribute to 'true'.
4. The CCAP initiates the PNM AQP Test.
5. The CCAP completes the PNM AQP Test.
6. The CCAP generates and locally stores the PNM AQP Test measurement results.
7. The PNM Server monitors the test status by querying the MeasStatus attribute. This step is repeated until a 'sampleReady' status is read.
8. The PNM Server receives a 'sampleReady' status from the CCAP, indicating there are measurement results available.
9. The PNM Server performs an SNMP WALK on the BulkDataFileStatus object searching for the filename provisioned in Step 2 (AQP_File_Results_2) along with a corresponding UploadStatus of 'availableForUpload'. This confirms the requested PNM test has measurement results ready to upload from the CCAP.

10. The PNM Server learns the file index from Step 9 using the SNMP WALK results.
11. The PNM Server issues an SNMP SET on the BulkDataFileCtrl object using the learned FileIndex. The FileControl attribute is set to 'tftpUpload'. This initiates a TFTP file transfer of the PNM measurement results.
12. The CCAP transfers the AQP measurement results via TFTP to the provisioned File Server using the destination path and configured filename.
13. The TFTP file upload process completes.
14. The PNM Server reads the UploadStatus again using the learned FileIndex from the BulkDataFileStatus object.
15. The PNM Server receives the UploadStatus of 'uploadComplete', indicating the TFTP file upload has been completed.
16. The PNM Server issues an SNMP SET of the FileControl attribute to 'deleteFile' using the learned FileIndex.
17. The CCAP deletes the locally stored PNM AQP measurement results file identified by FileIndex. This completes the sequence.

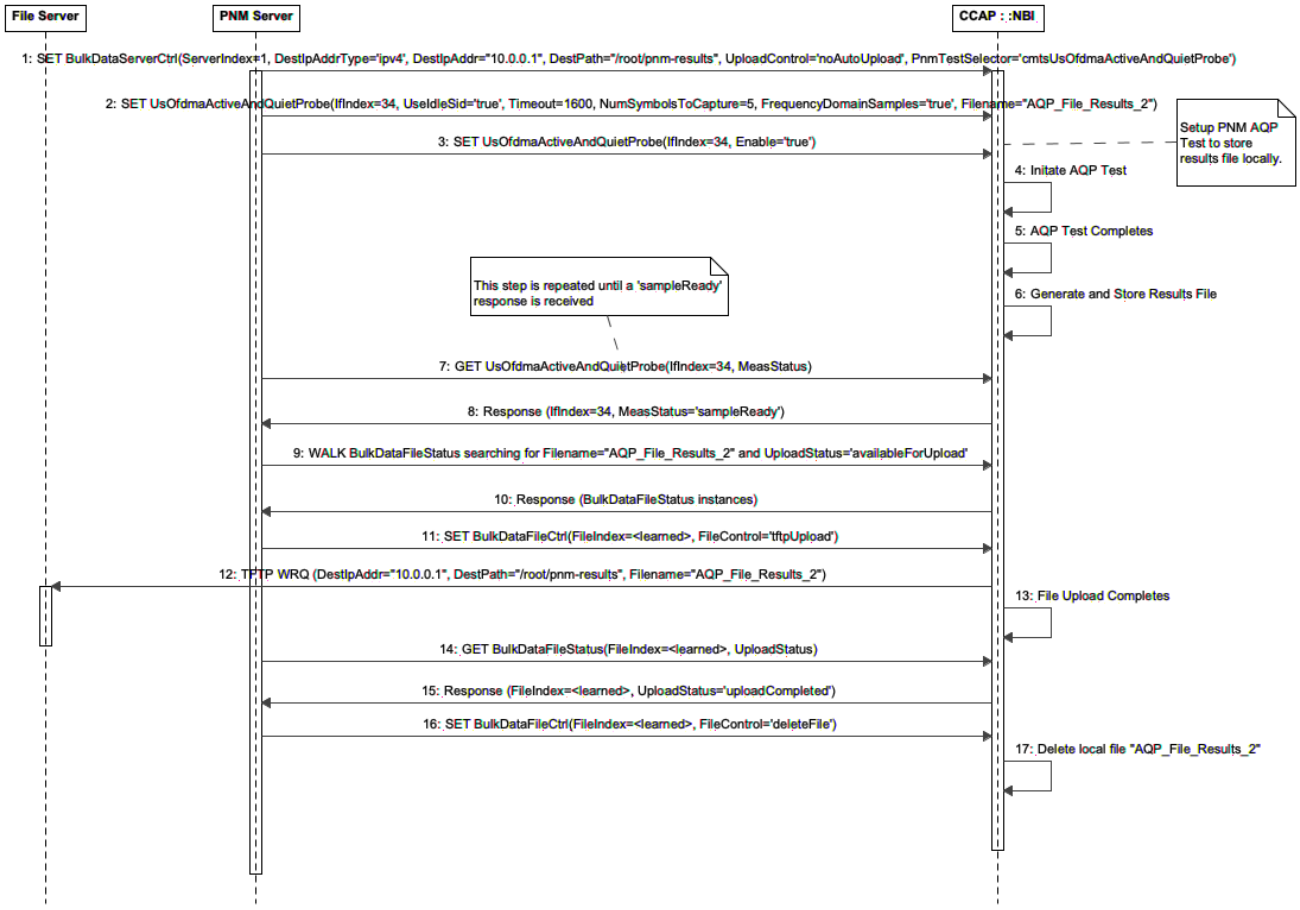

Figure 118 - Sequence Diagram for Receive File Upload (Legacy SNMP/TFTP)

V.1.1.1.2 Bulk Data Transfer

This Sequence Diagram maps to the Receive Measurement Results Use Case illustrated in Section 5.5.3.5, Common Proactive Network Maintenance. This sequence diagram illustrates multiple data transfer methods to transfer the

measurement results to back office collectors, as well as an option to store the measurements results locally on the CCAP. The PNM Active and Quiet Probe (AQP), US RxMER and UTSC tests are used for illustrative purposes. Three measurement result destinations will be configured: 1) streaming results via Streaming Telemetry, 2) TFTP file transfer, and 3) stored locally on the CCAP. Provisioning of each destination could be performed with SNMP, CLI, NETCONF, etc. Provisioning the Telemetry Client access is not in scope of this Sequence Diagram. It is assumed the Telemetry Client has already subscribed to the US RxMER measurement results via the CCAP's Telemetry Server.

The sequence of steps, as illustrated in Figure 119 - Sequence Diagram for Receive Measurement Results, is as follows:

1. The MSO, or back office PNM Server, issues a SET operation to the CCAP via the CCAP's Northbound Interface (NBI). The SET operation is invoked on the DataTransferCfg object for the server with Index=1 which has an IP Address of 10.0.0.1. The DestinationIndex is an object key that identifies the server where the test measurement results are to be sent. The destination base URI is provisioned, as well as the data transfer protocol and local storage flag. The provisioned protocol of 'gNMI' indicates the CCAP will stream the results using the Streaming Telemetry mechanism. The LocalStore flag is set to 'false' indicating the CCAP will not locally store the measurement results.
2. The PNM Server issues a SET operation on the DataTransferCfg object for the server with Index=2. No destination host IP address, destination base URI or transfer protocol is provisioned, but the LocalStore flag is set to 'true' indicating the CCAP will locally store the measurement results. The results will not be transferred to a server since none was provisioned.
3. The PNM Server issues a SET operation on the DataTransferCfg object for the server with Index=3 which has an IP Address of 10.0.10.1. The destination base URI and transfer protocol are provisioned, and the LocalStore flag is set to 'false' indicating the CCAP will not locally store the measurement results. The protocol of 'tftp' is configured, indicating the CCAP will transfer the measurement results using TFTP file transfer using the provisioned destination path specified by DestinationBaseUri.
4. The PNM Server initiates the US RxMER test using the defined RPC/Operation, using the DestinationIndex=1. Refer to Figure 121 - Sequence Diagram for Measure Upstream RxMER for additional details.
5. The PNM Server receives the TestId and operation response code from the CCAP, indicating the CCAP is executing the US RxMER test.
6. The PNM Server initiates the AQP test using the defined RPC/Operation, using the DestinationIndex=2.
7. The PNM Server receives the TestId and operation response code from the CCAP, indicating the CCAP is executing the AQP test.
8. The PNM Server initiates the UTSC test using the defined RPC/Operation, using the DestinationIndex=3 with a destination filename of 'pnm_utsc_file'.
9. The PNM Server receives the TestId and operation response code from the CCAP, indicating the CCAP is executing the UTSC test.
10. The CCAP completes the AQP test.
11. The CCAP stores the AQP test measurement results locally.
12. The CCAP notifies the PNM Server that the PNM AQP Test completed successfully.
13. The CCAP notifies the File Server that there is a PNM AQP Test measurement results file ready for upload. The CCAP provides the File Index and Filename in the notification to identify the file.
14. The CCAP completes the UTSC test.
15. The CCAP notifies the PNM Server that the PNM UTSC Test completed successfully.
16. The CCAP transfers the UTSC measurement results via TFTP.
17. The CCAP completes the US RxMER test.

18. The CCAP notifies the PNM Server that the PNM US RxMER Test completed successfully.
19. The CCAP publishes the US RxMER measurement results to the Telemetry Server. The results are part of the PNM YANG data model, under the PnmUsOfdmaRxMerMeas container. This completes the sequence.

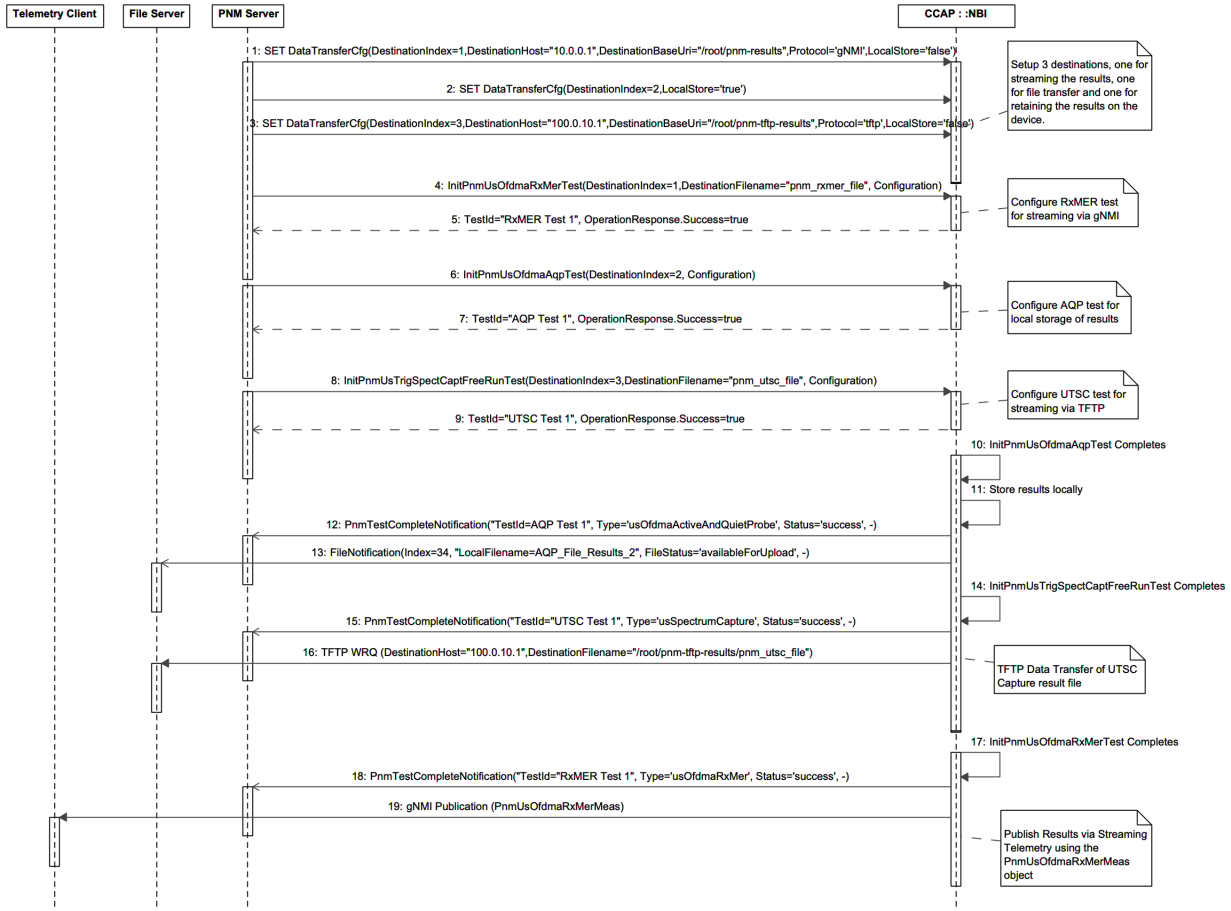

Figure 119 - Sequence Diagram for Receive Measurement Results

V.1.1.2 Upstream Proactive Network Maintenance Tests Sequence Diagrams

The Sequence Diagrams in this section map to the Upstream Proactive Network Maintenance Use Case illustrated in Section 5.5.3.4, Upstream Proactive Network Maintenance.

V.1.1.2.1 Measure Upstream Receive Modulation Error Ratio (Legacy SNMP/TFTP)

This Sequence Diagram maps to the Measure Upstream Receive Modulation Error Ratio Use Case illustrated in Section 5.5.3.4, Upstream Proactive Network Maintenance. This sequence diagram illustrates the legacy scenario using SNMP to configure the test and TFTP to transfer the capture file using the Bulk File transfer mechanism.

The sequence of steps, as illustrated in Figure 120, is as follows:

1. The MSO, or back office PNM Server, issues an SNMP SET operation to the CCAP via the CCAP's northbound interface. The SET operation is invoked on the docsPnmCmtsUsOfdmaRxMerTable object for the OFDMA upstream interface with IfIndex=34. The ifIndex is an object key that identifies the OFDMA channel where the test is to be performed. This step provisions the CM MAC Address attribute via an SNMP SET to docsPnmCmtsUsOfdmaRxMerCmMac.34. The CM MAC address specifies a CM to perform the active probe(s).

2. The RxMER number of averages is configured for the test via an SNMP SET to docsPnmCmtsUsOfdmaRxMerNumAvgs.34. The number of averages specifies the number of active probes to measure during the test.
3. The PNM test filename of "RxMER Test 1" is configured for the upstream RxMER capture test via an SNMP SET to docsPnmCmtsUsOfdmaRxMerFileName.34. This attribute is optional where a default filename is used if omitted. The filename is to be used when the CCAP writes bulk test results to the PNM Server file server.
4. The PNM Server retrieves the current test status by issuing an SNMP GET for docsPnmCmtsUsOfdmaRxMerMeasStatus.34.
5. The CCAP returns a value of "inactive" indicating there are no active tests on this interface.
6. The PNM upstream RxMER capture test is triggered, from the CCAP's northbound interface, via an SNMP SET to docsPnmCmtsUsOfdmaRxMerEnable.34. Note that the default value for docsPnmCmtsUsOfdmaRxMerPreEq of "false" is used.
7. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the CM indicated by the CM MAC.
8. The CM granted the opportunity transmits a probe on the OFDMA channel.
9. The CCAP captures probe symbols from the specified transmitting CM and calculates an average RxMER value. Steps 7 through 9 are repeated the number of times specified in the number of averages attribute.
10. The PNM Server retrieves the current test status by issuing an SNMP GET for docsPnmCmtsUsOfdmaRxMerMeasStatus.34.
11. The CCAP returns a value of "busy" indicating there is an active test on this interface.
12. The PNM Server retrieves the current test status by issuing an SNMP GET for docsPnmCmtsUsOfdmaRxMerMeasStatus.34.
13. The CCAP returns a value of "sampleReady" indicating there is a completed test on this interface with capture results ready for upload.
14. The CCAP transfers the results file to the PNM Server or back office file server using the CCAP Bulk Data File transfer mechanism defined in Section 6.6.1.4.4, Bulk File Transfer Information Model. These steps are not illustrated in Figure 120 since they are common to all PNM tests where measurement files are transferred using file transfer mechanisms.

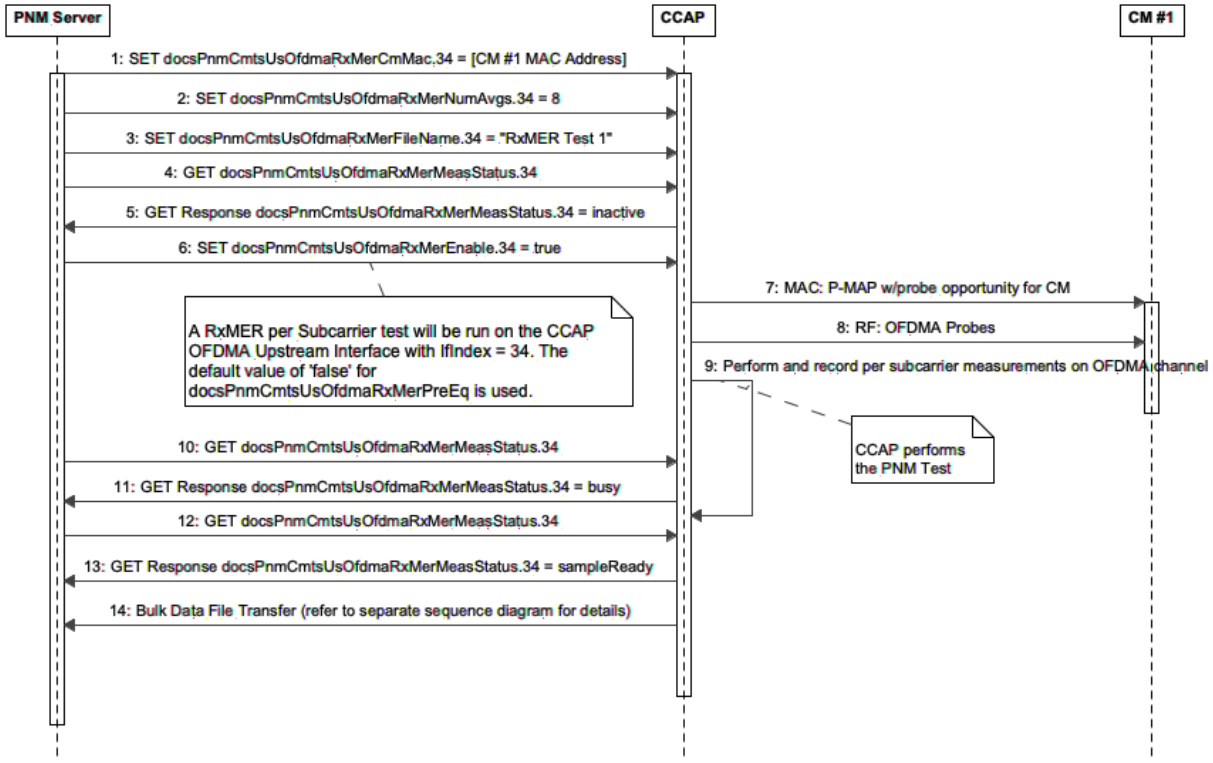

Figure 120 - Sequence Diagram for Measure Upstream RxMER per Subcarrier (Legacy SNMP/TFTP)

V.1.1.2.2 Measure Upstream Receive Modulation Error Ratio

This Sequence Diagram maps to the Measure Upstream Receive Modulation Error Ratio Use Case illustrated in Section 5.5.3.4, Upstream Proactive Network Maintenance. This sequence diagram illustrates the scenario using YANG-based models to configure and start the PNM test, configure the bulk data transfer destination and the Streaming Telemetry Client authorization. A Streaming Telemetry Client subscribes to and receives the corresponding PNM capture data according to the bulk data transfer configuration.

The sequence of steps, as illustrated in Figure 121, is as follows:

1. The MSO, or back office Network Support Services, configures the Telemetry Client with the US RxMER subscription data set. For the US RxMER test, this is the PNM results data set defined in Section 10.3.2.5 for PnmUsOfdmaRxMerResultGrp. Configuration of the Telemetry Client is outside the scope of this specification.
2. The MSO, or back office Network Support Services, configures the CCAP's Telemetry Server including authorizing which Telemetry Clients can connect and subscribe to data. This is further detailed in Appendix V.1.2, Streaming Telemetry Sequence Diagrams.
3. The MSO, or back office PNM Server, configures the desired bulk data destination for the PNM test results. This includes specifying the gNMI protocol as the bulk data transfer mechanism. The DestinationIndex uniquely identifies the destination created by the PNM Server. This is further detailed in Appendix V.1.1.1, Bulk Data Transfer Sequence Diagrams.
4. The Telemetry Client establishes a gNMI Connection with the CCAP's Telemetry Server and subscribes to the US RxMER results dataset. This is further detailed in Appendix V.1.2, Streaming Telemetry Sequence Diagrams.
5. The MSO, or back office PNM Server, issues a YANG RPC operation to the CCAP via the CCAP's northbound interface. The InitPnmUsOfdmaRxMerTest operation is defined in Section 10.3.2.4.1,

PnmUsOfdmaRxMerCfg. The Configuration input parameter contains the configuration elements for the PNM Test. The DestinationIndex is the index from Step 3 above.

6. The CCAP responds to the operation by returning a unique TestId="RxMER Test" and an operation response value of success=true. This indicates the CCAP will perform the PNM Test on the configured interface.
7. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the CM indicated by the CM MAC.
8. The CM granted the opportunity transmits a probe on the OFDMA channel.
9. The CCAP captures probe symbols from the specified transmitting CM and calculates an average RxMER value. Steps 7 through 9 are repeated the number of times specified in the number of averages attribute.
10. Using the TestId as the unique identifier for the test, the PNM Server retrieves the current test status via the PnmTestStatus object and Measurement Status attribute. Refer to Section 10.1.2, PNM Common Class Diagram for the definition of this object.
11. The CCAP returns a value of "busy" for MeasurementStatus indicating there is an active test on this interface.
12. Since the PNM Server had previously subscribed to receive PNM Notifications from the CCAP (an optional step), the CCAP notifies the PNM Server of the test completion status. The notification includes the test id, test type and test status attributes as specified in PnmTestCompleteNotification specified in Section 10.1.2.9.
13. Once the US RxMER capture completes, the CCAP streams the subscribed-to data to the Telemetry Client using the provisioned bulk data transfer mechanism from Step 3. This is further detailed in Appendix V.1.2, Streaming Telemetry Sequence Diagrams.

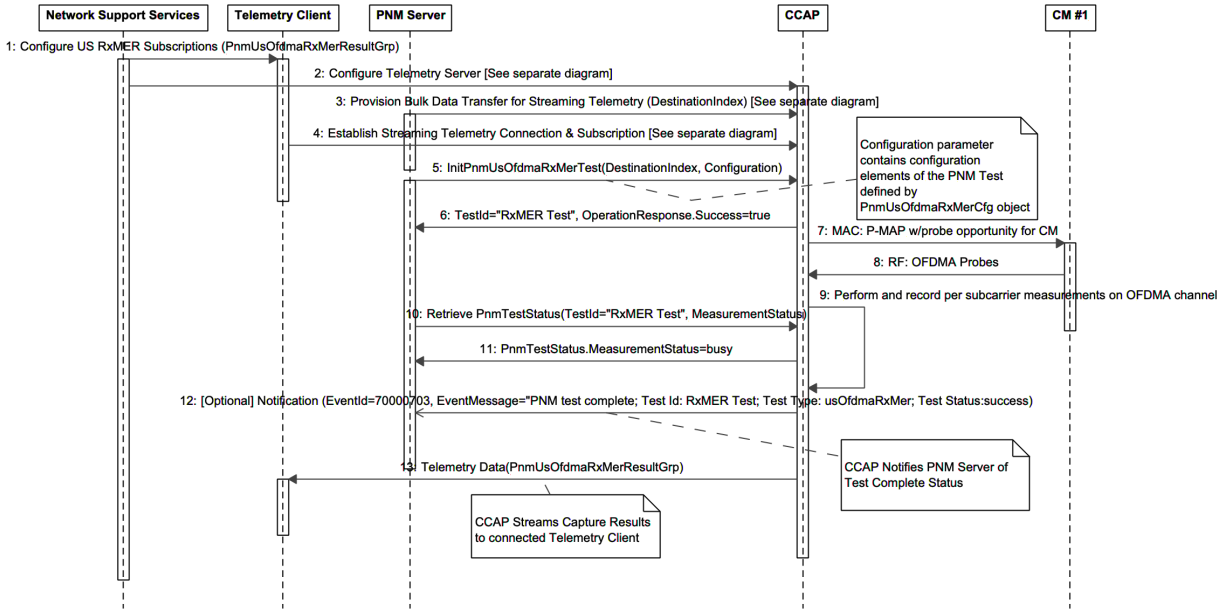

Figure 121 - Sequence Diagram for Measure Upstream RxMER

V.1.1.2.3 Measure Upstream Receive Modulation Error Ratio for Multiple Cable Modems

This sequence diagram illustrates the Upstream RxMER per Subcarrier test for multiple cable modems using the InitPnmMultipleCmUsOfdmaRxMerTest operation described in Section 10.3.2.6.1.2 to configure and start the PNM test, configure the bulk data transfer destination and the Streaming Telemetry Client authorization. A Streaming

Telemetry Client subscribes to and receives the corresponding PNM capture data according to the bulk data transfer configuration.

The sequence of steps, as illustrated in Figure 122, is as follows:

1. The PNM server in the operator's back office Network Support Services, configures the Telemetry Client with the PnmUsOfdmaRxMerResultGrp subscription data set defined in Section 10.3.1.3 *Upstream OFDMA RxMER Class Diagram*. Configuration of the Telemetry Client is outside the scope of this specification.
2. The PNM server configures the CCAP's Telemetry Server including authorizing which Telemetry Clients can connect and subscribe to data. This is further detailed in Appendix V.1.2, Streaming Telemetry Sequence Diagrams.
3. The PNM Server configures the desired bulk data destination for the PNM test results. This includes specifying the gNMI protocol as the bulk data transfer mechanism. The DestinationIndex uniquely identifies the destination created by the PNM Server. This is further detailed in Appendix V.1.1.1, Bulk Data Transfer Sequence Diagrams.
4. The Telemetry Client establishes a gNMI Connection with the CCAP's Telemetry Server and subscribes to the US RxMER results dataset. This is further detailed in Appendix V.1.2, Streaming Telemetry Sequence Diagrams.
5. The PNM Server issues a YANG RPC operation to the CCAP via the CCAP's northbound interface. The InitPnmMultipleCmUsOfdmaRxMerTest operation is defined in Section 10.3.2.6.1.2, InitPnmMultipleCmUsOfdmaRxMerTest Operation. The Configuration input parameter contains the configuration elements for the PNM Test. The DestinationIndex is the index from Step 3 above.
6. The CCAP responds to the operation by returning a unique TestId="RxMER Test_7" and an operation response value of success=true. This indicates the CCAP will perform the PNM Test on the configured interface.
7. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the first cable modem listed in the CmMacAddressList parameter passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object.
8. The cable modem granted the opportunity transmits a probe on the OFDMA channel.
9. The CCAP captures probe symbols from the specified transmitting cable modem and calculates an average upstream RxMER per subcarrier value. Steps 7 through 9 are repeated the number of times specified in the number of averages attribute. The PnmUsOfdmaRxMerMeas parameters are updated with the results of the upstream RxMER per subcarrier measurements. Updating the parameters triggers the ON_CHANGE gNMI subscription.
10. The MAC-NE returns the upstream Rx MER per subcarrier measurement data to the destination specified by the DestinationIndex configured in step 3, via gNMI streaming.

    The CCAP waits the configured ProbeOppInterval time, which was passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object in step 5. In this example, ProbeOppInterval is 0 seconds.
11. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the second cable modem listed in the CmMacAddressList parameter passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object.
12. The cable modem granted the opportunity transmits a probe on the OFDMA channel.
13. The CCAP captures probe symbols from the specified transmitting cable modem and calculates an average upstream RxMER per subcarrier value. Steps 11 through 13 are repeated the number of times specified in the number of averages attribute. The PnmUsOfdmaRxMerMeas parameters are updated with the results of the upstream RxMER per subcarrier measurements. Updating the parameters triggers the ON_CHANGE gNMI subscription.

14. The MAC-NE returns the upstream Rx MER per subcarrier measurement data to the destination specified by the DestinationIndex configured in step 3, via gNMI streaming.

    The CCAP waits the configured ProbeOppInterval time, which was passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object in step 5. In this example, ProbeOppInterval is 0 seconds.

15. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the third cable modem listed in the CmMacAddressList parameter passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object.
16. The cable modem granted the opportunity transmits a probe on the OFDMA channel.
17. The CCAP captures probe symbols from the specified transmitting cable modem and calculates an average upstream RxMER per subcarrier value. Steps 15 through 17 are repeated the number of times specified in the number of averages attribute. The PnmUsOfdmaRxMerMeas parameters are updated with the results of the upstream RxMER per subcarrier measurements. Updating the parameters triggers the ON_CHANGE gNMI subscription.
18. The MAC-NE returns the upstream Rx MER per subcarrier measurement data to the destination specified by the DestinationIndex configured in step 3, via gNMI streaming.

    The CCAP waits the configured CycleGap time, which was passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object in step 5. In this example, CycleGap is 360 minutes.

19. The CCAP starts the second cycle of upstream RxMER per subcarrier testing for the configured set of cable modems by sending a P-MAP with a probe opportunity on the OFDMA channel for the first cable modem listed in the CmMacAddressList parameter passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object.
20. The cable modem granted the opportunity transmits a probe on the OFDMA channel.
21. The CCAP captures probe symbols from the specified transmitting cable modem and calculates an average upstream RxMER per subcarrier value. Steps 19 through 21 are repeated the number of times specified in the number of averages attribute. The PnmUsOfdmaRxMerMeas parameters are updated with the results of the upstream RxMER per subcarrier measurements. Updating the parameters triggers the ON_CHANGE gNMI subscription.
22. The MAC-NE returns the upstream Rx MER per subcarrier measurement data to the destination specified by the DestinationIndex configured in step 3, via gNMI streaming.

    The CCAP waits the configured 0 second ProbeOppInterval time.

23. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the second cable modem listed in the CmMacAddressList parameter passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object.
24. The cable modem granted the opportunity transmits a probe on the OFDMA channel.
25. The CCAP captures probe symbols from the specified transmitting cable modem and calculates an average upstream RxMER per subcarrier value. Steps 23 through 25 are repeated the number of times specified in the number of averages attribute. The PnmUsOfdmaRxMerMeas parameters are updated with the results of the upstream RxMER per subcarrier measurements. Updating the parameters triggers the ON_CHANGE gNMI subscription.
26. The MAC-NE returns the upstream Rx MER per subcarrier measurement data to the destination specified by the DestinationIndex configured in step 3, via gNMI streaming. The CCAP waits the configured 0 second ProbeOppInterval time

27. The CCAP sends a P-MAP with a probe opportunity on the OFDMA channel for the third cable modem listed in the CmMacAddressList parameter passed in the PnmMultipleCmUsOfdmaRxMerCfg configuration object.
28. The cable modem granted the opportunity transmits a probe on the OFDMA channel.
29. The CCAP captures probe symbols from the specified transmitting cable modem and calculates an average upstream RxMER per subcarrier value. Steps 27 through 29 are repeated the number of times specified in the number of averages attribute. The PnmUsOfdmaRxMerMeas parameters are updated with the results of the upstream RxMER per subcarrier measurements. Updating the parameters triggers the ON_CHANGE gNMI subscription.
30. The MAC-NE returns the upstream Rx MER per subcarrier measurement data to the destination specified by the DestinationIndex configured in step 3, via gNMI streaming.
31. The PNM Server issues YANG RPC operation PnmStopTest to terminate the PNM Multiple CM Upstream OFDMA Rx MER test. Because the value of parameter CycleDuration passed in the PnmMultipleCmUsOfdmaRxMerCfg in step 5 is 0, the CCAP will continue running the PNM Multiple CM Upstream OFDMA Rx MER test until it is explicitly stopped.
32. The CCAP responds to the PnmStopTest operation with the response success='true' indicating the CCAP will perform the Stop Test operation on the interface.
33. The Telemetry Client cancels the subscription established in step 4.

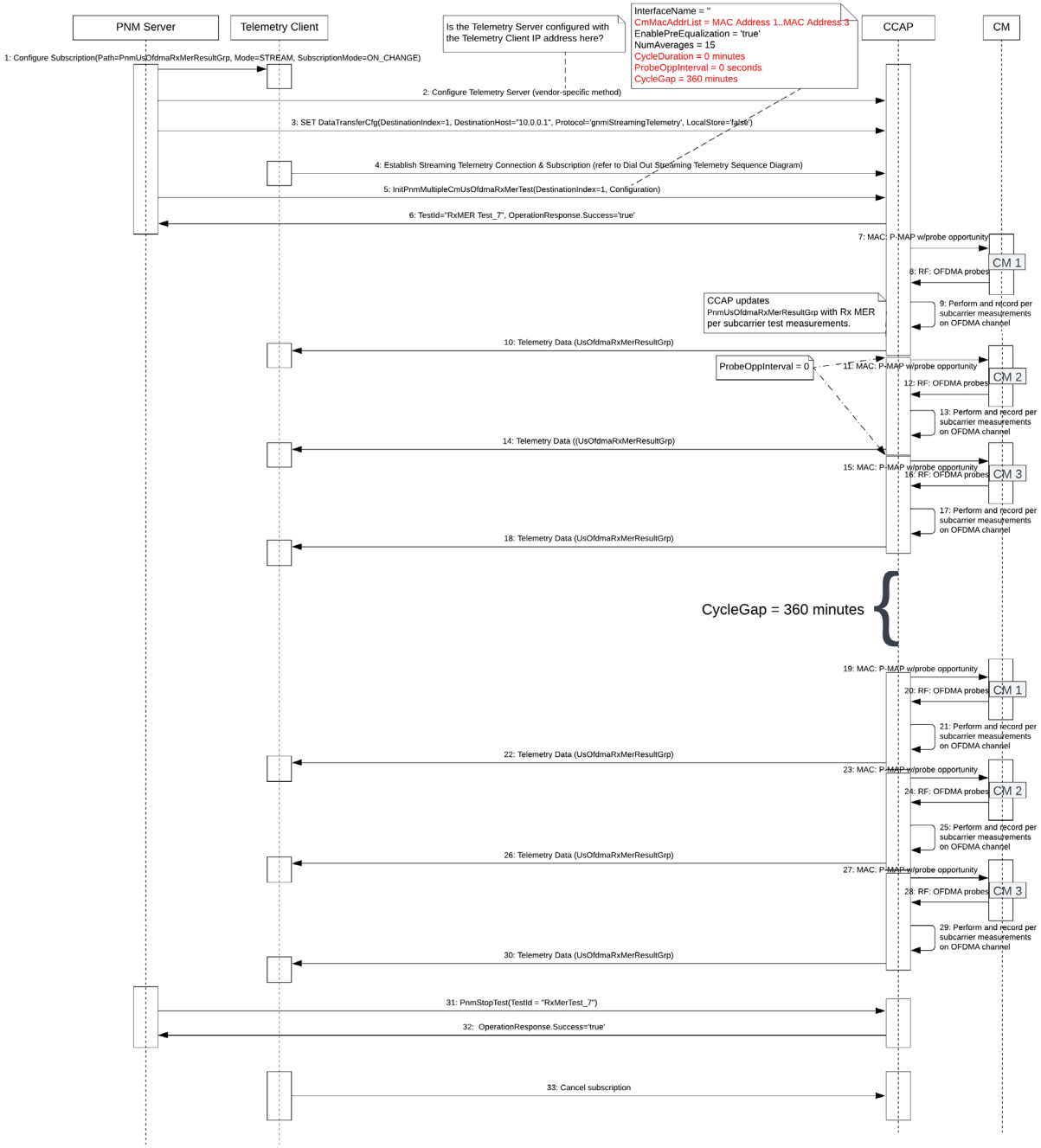

Figure 122 - Sequence Diagram for Multiple Cable Modem Measure Upstream RxMER

V.1.2 Streaming Telemetry Sequence Diagrams

The Sequence Diagrams in this section map to the Streaming Telemetry Use Cases illustrated in Section 5.5.3.6.

V.1.2.1 Dial Out Sequence Diagram

This Sequence Diagram provides example sequences for the following Streaming Telemetry Use Cases illustrated in Section 5.5.3.6:

- Configure Telemetry Server
- Receive Streaming Telemetry Alarms and Events
- Subscribe to Telemetry Data
- Receive Telemetry Stream
- Cancel Streaming Telemetry Data

Provisioning the Telemetry Client is not in scope of this Sequence Diagram. This Use Case illustrates the dial-out case where the CCAP initiates the gRPC connection via a gRPC Tunnel.

The sequence of steps, as illustrated in Figure 123 - Dial Out Streaming Telemetry Sequence Diagram, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the Telemetry Client with the CCAP's Telemetry Server connection details. In addition, the specific Subscriptions are provisioned such that the Telemetry Client can send Subscribe Request messages for the desired Telemetry Data sets. Provisioning of the Telemetry Client is not in scope of this specification.
2. The back office application can retrieve the set of supported Streaming Telemetry capabilities from the CCAP. This is an optional step.
3. If the back office application queries the CCAP's Streaming Telemetry capabilities, they are returned to the back office application. In this example, the CCAP supports the gNMI Streaming Telemetry feature and supports up to five connected Telemetry Clients.
4. The back office application issues a SET operation on the StreamingTelemetryServerCfg object to configure the Telemetry Client access mode. In this example, the CCAP is provisioned with a Telemetry Client access mode of 'explicitlyAuthorizedOnly' indicating only authorized Telemetry Clients can connect. In addition, the CCAP's Telemetry Server is provisioned to use port 8080.
5. The back office application issues a SET operation on the TelemetryAuthClientListCfg object for the Telemetry Client with IP Address of 10.0.0.1, using port 43 for the connection. In this dial out example, the maximum retries is set to 3, the initial backoff timer is set to 150 seconds and the maximum backoff timer is set to 1500 seconds. This step completes the Telemetry Server configuration.
6. When the CCAP is ready to connect to a Telemetry Client, it negotiates an HTTPS connection with that Telemetry Client.
7. The Telemetry Client provides a response to the HTTPS connection request to establish the connection.
8. Once the TLS authentication is complete and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the authentication is complete and the HTTPS connection is established. In this example, this represents the event with Event Id=89020100. Refer to Annex D for the event definition.
9. The CCAP initiates the gRPC Channels using the appropriate gRPC protocol messages. Refer to [gRPC] for additional details. In addition, the CCAP establishes a gRPC Tunnel. Refer to [gRPC-TUNNEL] for additional details.
10. The Telemetry Client responds to the gRPC Channel request and establishes the Connection as well as the gRPC Tunnel.
11. Once the gRPC Channel establishment is complete and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gRPC Channel is established. In this example, this represents the event with Event Id=89020000. Refer to Annex D for the event definition.
12. The Telemetry Client can request the gNMI capabilities from the CCAP's Telemetry Server. This is an optional step in the gNMI protocol. Refer to [gNMI] for additional details.
13. If the Telemetry Client requests the CCAP's gNMI capabilities, the CCAP responds accordingly.

14. The Telemetry Client issues a gNMI SubscribeRequest message containing the list of desired subscriptions. All subscriptions are on the same gRPC Channel. Refer to [gNMI] for additional details.
15. The CCAP responds accordingly to the gNMI SubscribeResponse.
16. Once the gNMI subscription establishment is complete and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gNMI subscriptions have been established. In this example, this represents the event with Event Id=89020006. Refer to Annex D for the event definition.
17. The CCAP streams the subscribed Telemetry Data to the Telemetry Client using gNMI.
18. There are multiple options for the Telemetry Client to cancel a subscription. Option 1 is where the Telemetry Client cancels the subscriptions sent in the earlier SubscribeRequest RPC message. In this case, all subscriptions which were established as part of the SubscribeRequest RPC will be terminated. This allows the Telemetry Client to cancel individual SubscribeRequest calls which contain a SubscriptionList. The Telemetry Client cannot modify an existing SubscriptionRequest. Refer to section 3.5.1.1 of [gNMI] for details.
19. Under Option 1 and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gNMI subscriptions have been cancelled by the Telemetry Client. In this example, this represents the event with Event Id=89020009. Refer to Annex D for the event definition.
20. Option 2 is where the Telemetry Client terminates the gRPC Channel. In this case, all SubscribeRequest RPCs which were sent on this gRPC Channel are terminated. This means all subscriptions on this gRPC Channel are terminated.
21. Under Option 2 and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gRPC Channel has been terminated by the Telemetry Client. In this example, this represents the event with Event Id=89020010. Refer to Annex D for the event definition.

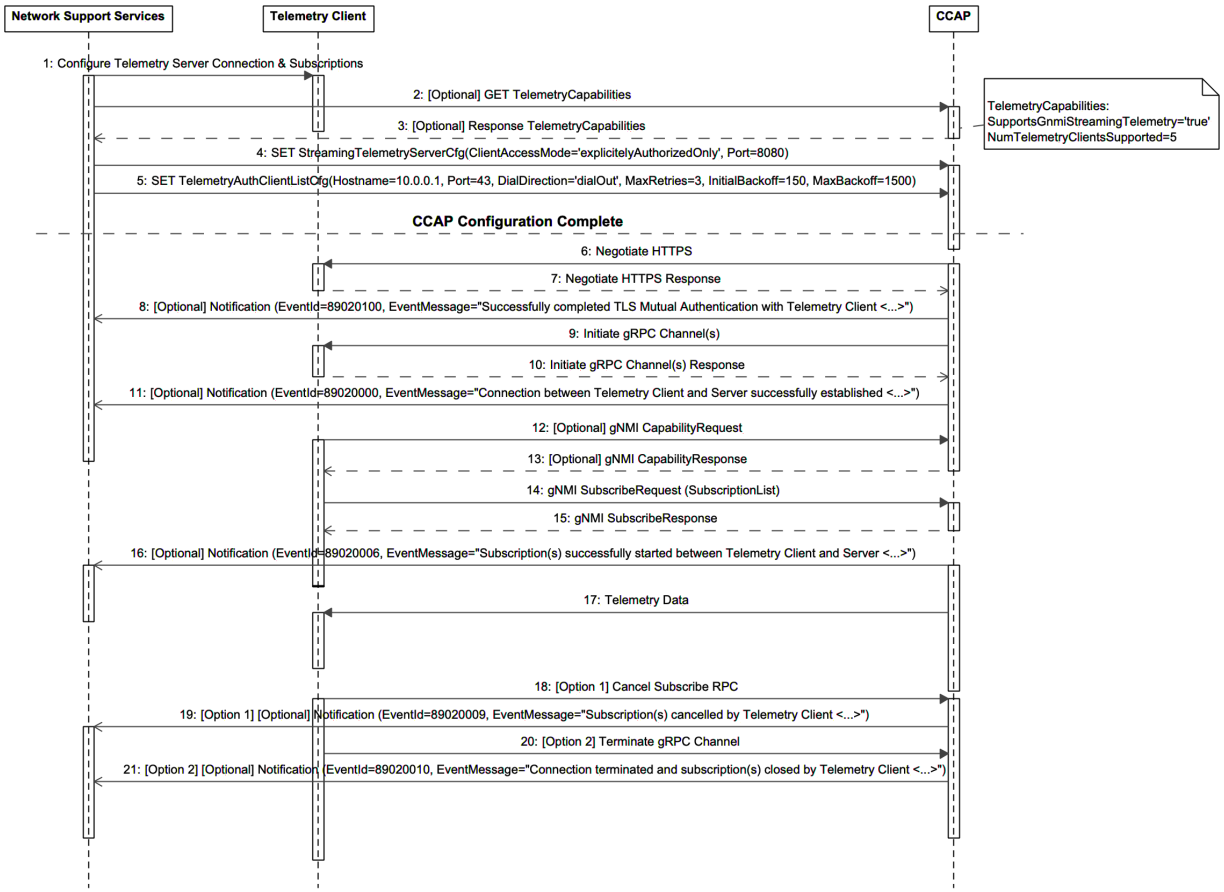

Figure 123 - Dial Out Streaming Telemetry Sequence Diagram

V.1.2.2 Dial In Sequence Diagram

This Sequence Diagram provides example sequences for the following Streaming Telemetry Use Cases illustrated in Section 5.5.3.6:

- Configure Telemetry Server
- Receive Streaming Telemetry Alarms and Events
- Subscribe to Telemetry Data
- Receive Telemetry Stream
- Cancel Streaming Telemetry Data

Provisioning the Telemetry Client is not in scope of this Sequence Diagram. This Use Case illustrates the dial-in case where the Telemetry Client initiates the gRPC connection.

The sequence of steps, as illustrated in Figure 124, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the Telemetry Client with the CCAP's Telemetry Server connection details. In addition, the specific Subscriptions are provisioned such that the Telemetry Client can send Subscribe Request messages for the desired Telemetry Data sets. Provisioning of the Telemetry Client is not in scope of this specification.
2. The back office application can retrieve the set of supported Streaming Telemetry capabilities from the CCAP. This is an optional step.

3. If the back office application queries the CCAP's Streaming Telemetry capabilities, they are returned to the back office application. In this example, the CCAP supports the gNMI Streaming Telemetry feature and supports up to five connected Telemetry Clients.
4. The back office application issues a SET operation on the StreamingTelemetryServerCfg object to configure the Telemetry Client access mode. In this example, the CCAP is provisioned with a Telemetry Client access mode of 'explicitlyAuthorizedOnly' indicating only authorized Telemetry Clients can connect. In addition, the CCAP's Telemetry Server is provisioned to use port 8080.
5. The back office application issues a SET operation on the TelemetryAuthClientListCfg object for the Telemetry Client with IP Address of 10.0.0.1, using port 43 for the connection. In this dial in example, the maximum retries is set to 3, the initial backoff timer is set to 150 seconds and the maximum backoff timer is set to 1500 seconds. This step completes the Telemetry Server configuration
6. When the Telemetry Client is ready to connect to the CCAP, it negotiates a new HTTPS connection.
7. The CCAP provides a response to the HTTPS connection request to establish the connection.
8. Once the TLS authentication is complete and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the authentication is complete and the HTTPS connection is established. In this example, this represents the event with Event Id=89020100. Refer to Annex D for the event definition.
9. The Telemetry Client initiates the gRPC Channels using the appropriate gRPC protocol messages. Refer to [gRPC] for additional details.
10. The CCAP responds to the gRPC Channel request and establishes the gRPC Connection.
11. Once the gRPC Connection establishment is complete and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gRPC Connection is established. In this example, this represents the event with Event Id=89020000. Refer to Annex D for the event definition.
12. The Telemetry Client can request the gNMI capabilities from the CCAP's Telemetry Server. This is an optional step in the gNMI protocol. Refer to [gNMI] for additional details.
13. If the Telemetry Client requests the CCAP's gNMI capabilities, the CCAP responds accordingly.
14. The Telemetry Client issues a gNMI SubscribeRequest message containing the list of desired subscriptions. All subscriptions are on the same gRPC Channel. Refer to [gNMI] for additional details.
15. The CCAP responds accordingly to the gNMI SubscribeResponse.
16. Once the gNMI subscription establishment is complete and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gNMI subscriptions have been established. In this example, this represents the event with Event Id=89020006. Refer to Annex D for the event definition.
17. The CCAP streams the subscribed Telemetry Data to the Telemetry Client using gNMI.
18. There are multiple options for the Telemetry Client to cancel a subscription. Option 1 is where the Telemetry Client cancels the subscriptions sent in the earlier SubscribeRequest RPC message. In this case, all subscriptions which were established as part of the SubscribeRequest RPC will be terminated. This allows the Telemetry Client to cancel individual SubscribeRequest calls which contain a SubscriptionList. The Telemetry Client cannot modify an existing SubscriptionRequest. Refer to section 3.5.1.1 of [gNMI] for details.
19. Under Option 1 and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gNMI subscriptions have been cancelled by the Telemetry Client. In this example, this represents the event with Event Id=89020009. Refer to Annex D for the event definition.
20. Option 2 is where the Telemetry Client terminates the gRPC Channel. In this case, all SubscribeRequest RPCs which were sent on this gRPC Channel are terminated. This means all subscriptions on this gRPC Channel are terminated.

21. Under Option 2 and if provisioned to send Telemetry events, the CCAP sends a notification to the back office application indicating the gRPC Channel has been terminated by the Telemetry Client. In this example, this represents the event with Event Id=89020010. Refer to Annex D for the event definition.

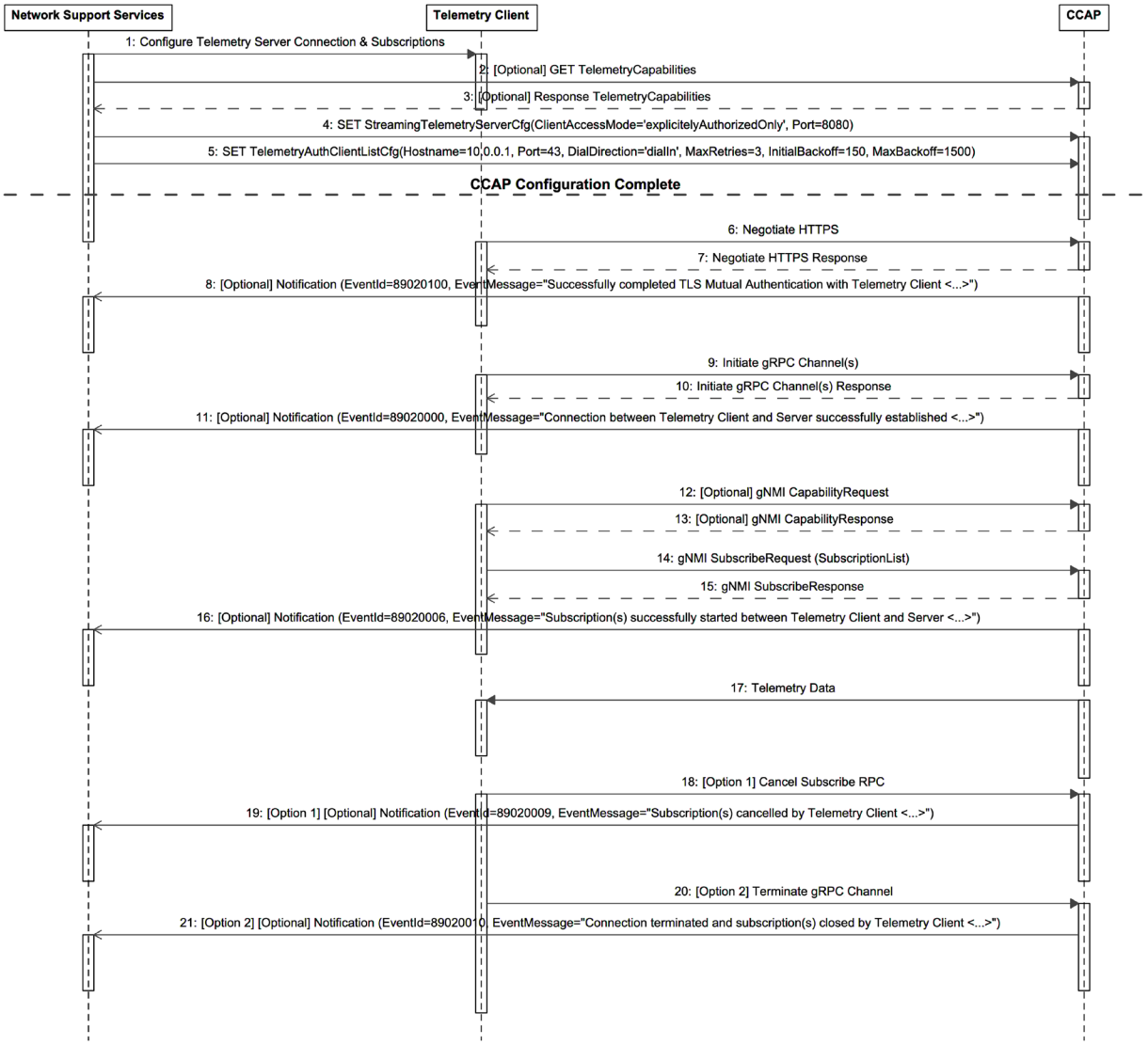

Figure 124 - Dial In Streaming Telemetry Sequence Diagram

V.1.2.3 Streaming CCAP Downstream Utilization Statistics Sequence Diagrams

V.1.2.3.1 IPDR/SP Streaming of CCAP Downstream Utilization Statistics

Refer to Figure 82 - Basic Network Model (IPDR/BSR).

V.1.2.3.2 gNMI On-change Streaming of CCAP Downstream Utilization Statistics

The CCAP Downstream Utilization Statistics Sequence Diagram provides example message flows for gNMI Streaming Telemetry where the streaming trigger is based on an on-change update (e.g., data population) of the CCAP Downstream Utilization Statistics counter values.

The sequence of steps, as illustrated in Figure 125, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the Telemetry Client with the CCAP's Telemetry Server connection details. In addition, the specific Subscription Lists and subscription mode are provisioned such that the Telemetry Client can send Subscribe Request messages for the desired Downstream Utilization Telemetry Data sets. Provisioning of the Telemetry Client is not in scope of this specification.
2. The back office application configures the CCAP Telemetry Server. Refer to the Dial-out Streaming Telemetry Sequence diagram for additional details.
3. The back office application issues a SET operation to the CCAP. The SET operation is invoked on the DataTransferCfg object for the remote server as specified by a DestinationIndex. The DestinationIndex is an object key that identifies the remote server where the Telemetry data are to be sent. The destination port is provisioned, as well as the data transfer protocol and local storage flag. The provisioned protocol of 'gnmiStreamingTelemetry' indicates the target will stream the results using the gNMI Streaming Telemetry mechanism. The LocalStore flag is set to 'false' indicating the target will not locally store the Telemetry data.
4. The back office application provisions the Channel Utilization Interval [RFC 4546] to 15 minutes (900 seconds) which enables the CCAP to begin data sampling.
5. The Telemetry Client establishes a Streaming Telemetry Connection with the CCAP as described in the Dial-out Streaming Telemetry Sequence diagram.
6. The Telemetry Client sends the gNMI SubscribeRequest message with the Mode=STREAM, and SubscriptionMode=ON_CHANGE. The SubscribeRequest message contains the SubscriptionList which contains multiple Subscription messages. Each Subscription message contains a Path message which includes a PathElem. The PathElem encodes the data tree path, as a series of repeated strings, from the set of Downstream Utilization Statistics paths Lists shown in the section above. This encoding also includes elements of the gNMI path such as keys.
7. When the 15 minute channel utilization timer expires, the CCAP populates the Downstream Utilization Statistics counters with the new calculated values.
8. The ON_CHANGE counter update triggers the gNMI stream from the CCAP for the completed Utilization interval for the Downstream Utilization Telemetry Data set.
9. The CMTS resets the 15 minute utilization timer and the process repeats every 15 minutes in the active gNMI Connection.
10. The back office application disables the Downstream Utilization Statistics streaming session. Provisioning of the Telemetry Client is not in scope of this specification.
11. The Telemetry Client terminates the connection with the CCAP by either cancelling the subscription or terminating the gRPC Channel as described in the Dial-out Streaming Telemetry Sequence diagram.

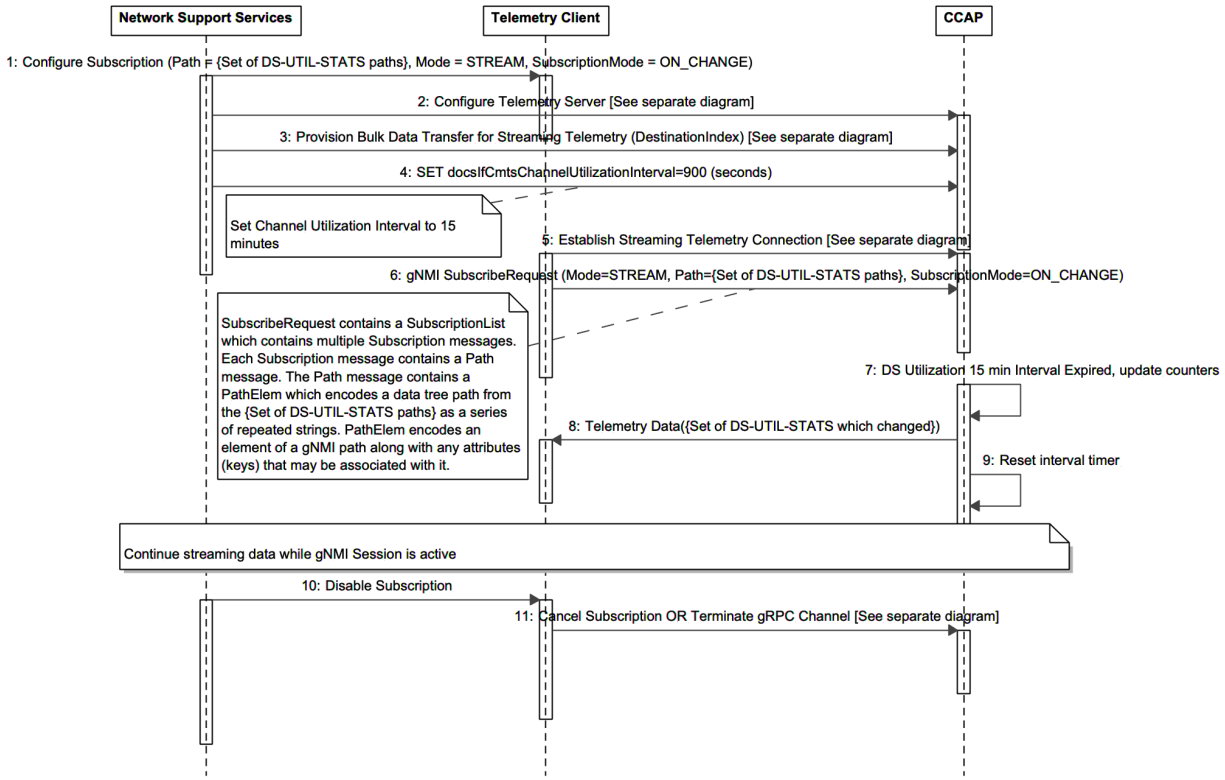

Figure 125 - gNMI On-change Streaming DS Utilization Statistics Sequence Diagram

V.1.2.3.3 gNMI Sample Streaming of CCAP Downstream Utilization Statistics

The CCAP Downstream Utilization Statistics Sequence Diagram provides example message flows for gNMI Streaming Telemetry where the streaming trigger is based on an sample interval, as defined [RFC 4546], of the CCAP Downstream Utilization Statistics counter values.

The sequence of steps, as illustrated in Figure 126, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the Telemetry Client with the CCAP's Telemetry Server connection details. In addition, the specific Subscription Lists and subscription mode are provisioned such that the Telemetry Client can send Subscribe Request messages for the desired Downstream Utilization Telemetry Data sets. Provisioning of the Telemetry Client is not in scope of this specification.
2. The back office application configures the CCAP Telemetry Server. Refer to the Dial-out Streaming Telemetry Sequence diagram for additional details.
3. The back office application issues a SET operation to the CCAP. The SET operation is invoked on the DataTransferCfg object for the remote server as specified by a DestinationIndex. The DestinationIndex is an object key that identifies the remote server where the Telemetry data are to be sent. The destination port is provisioned, as well as the data transfer protocol and local storage flag. The provisioned protocol of 'gnmiStreamingTelemetry' indicates the target will stream the results using the gNMI Streaming Telemetry mechanism. The LocalStore flag is set to 'false' indicating the target will not locally store the Telemetry data.
4. The back office application provisions the Channel Utilization Interval [RFC 4546] to 15 minutes (900 seconds) which enables the CCAP to begin data sampling.
5. The Telemetry Client establishes a Streaming Telemetry Connection with the CCAP as described in the Dial-out Streaming Telemetry Sequence diagram.

6. The Telemetry Client sends the gNMI SubscribeRequest message with the Mode=STREAM, and SubscriptionMode=SAMPLE which a SampleInterval=900 seconds to match the channel utilization interval provisioned in Step 5. The SubscribeRequest message contains the SubscriptionList which contains multiple Subscription messages. Each Subscription message contains a Path message which includes a PathElem. The PathElem encodes the data tree path, as a series of repeated strings, from the set of Downstream Utilization Statistics paths Lists shown in the section above. This encoding also includes elements of the gNMI path such as keys.
7. The first 15 minute channel utilization interval 't' timer expires, the CCAP populates the Downstream Utilization Statistics counters with the new calculated values for this interval.
8. The SampleInterval timer expiration triggers the gNMI stream from the CCAP for the completed Utilization interval for the Downstream Utilization Telemetry Data set calculated for interval 't'.
9. The next 15 minute channel utilization interval 't+1' timer expires, the CCAP populates the Downstream Utilization Statistics counters with the new calculated values for this interval.
10. The SampleInterval timer expiration triggers the gNMI stream from the CCAP for the completed Utilization interval for the Downstream Utilization Telemetry Data set calculated for interval 't+1'. Interval calculations and streaming continues while the channel utilization reporting is enabled and the corresponding gNMI Connection remains active.
11. The back office application disables the Downstream Utilization Statistics reporting by clearing the interval timer value.
12. The back office application disables the Downstream Utilization Statistics streaming session. Provisioning of the Telemetry Client is not in scope of this specification.
13. The Telemetry Client terminates the connection with the CCAP by either cancelling the subscription or terminating the gRPC Channel as described in the Dial-out Streaming Telemetry Sequence diagram.

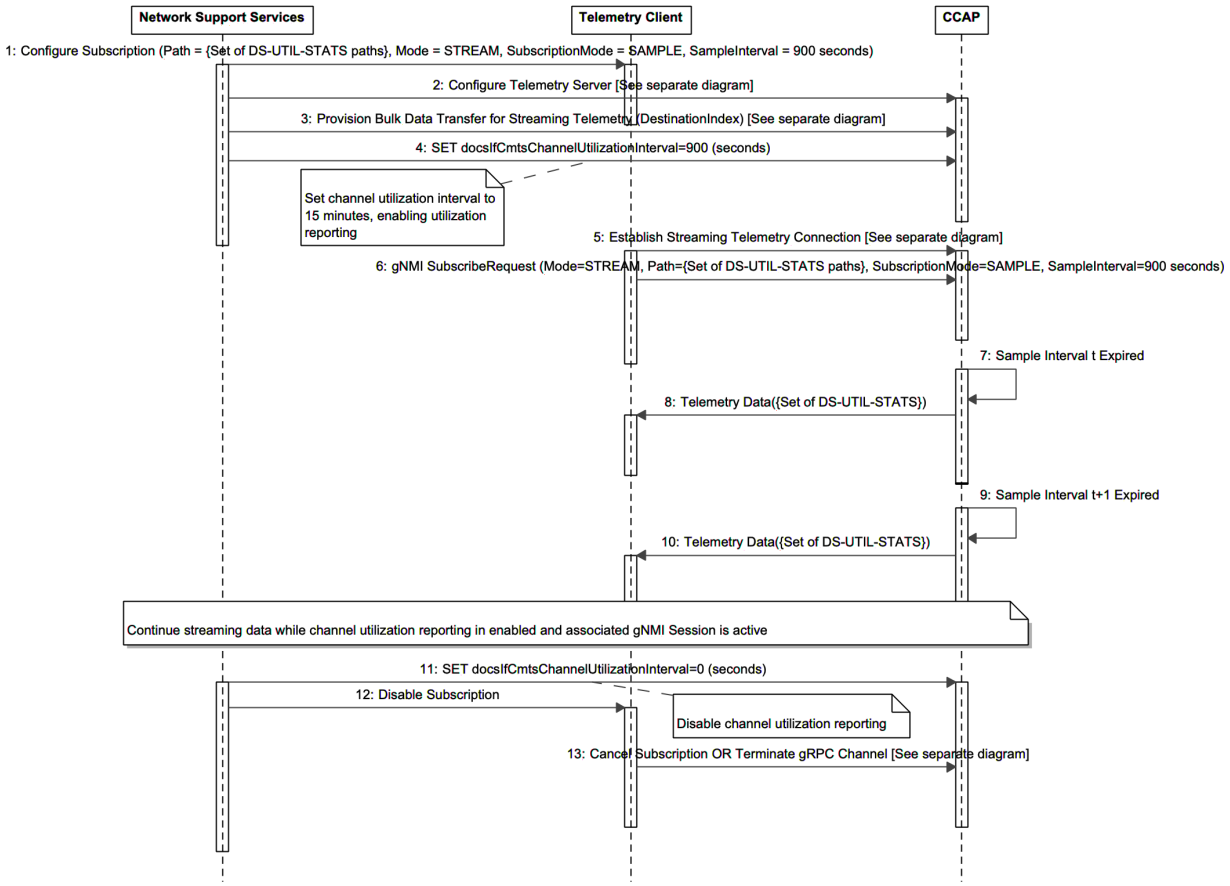

Figure 126 - gNMI Sample Streaming DS Utilization Statistics Sequence Diagram

V.1.2.4 Streaming CCAP Subscriber Usage Statistics

V.1.2.4.1 IPDR/SP Streaming of CCAP SAMIS-TYPE-1 and SAMIS-TYPE-2

Refer to Figure 84 - IPDR/SP Streaming Telemetry Time Interval Session Sequence Diagram.

Refer to Figure 86 - IPDR/SP Streaming Telemetry Ad-hoc Session Sequence Diagram

V.1.2.4.2 gNMI Streaming of CCAP Subscriber Usage Statistics

The CCAP Subscriber Usage Statistics Sequence Diagram provides example message flows for gNMI Streaming Telemetry.

The sequence of steps, as illustrated in Figure 127, are as follows:

1. The MSO, or back office application within the Network Support Services layer, configures the Telemetry Client with the CCAP's Telemetry Server connection details. In addition, the specific Subscription Lists are provisioned such that the Telemetry Client can send Subscribe Request messages for the desired Subscriber Usage (Type 1 or Type 2) Telemetry Data sets. Provisioning of the Telemetry Client is not in scope of this specification.
2. The back office application configures the CCAP Telemetry Server. Refer to the Dial-out Streaming Telemetry Sequence diagram for additional details.
3. The back office application issues a SET operation to the CCAP. The SET operation is invoked on the DataTransferCfg object for the remote server specified by a DestinationIndex. The DestinationIndex is an

object key that identifies the remote server where the Telemetry data are to be sent. The destination port is provisioned, as well as the data transfer protocol and local storage flag. The provisioned protocol of 'gnmiStreamingTelemetry' indicates the target will stream the results using the gNMI Streaming Telemetry mechanism. The LocalStore flag is set to 'false' indicating the target will not locally store the Telemetry data.

4. The Telemetry Client establishes a Streaming Telemetry Connection with the CCAP as described in the Dial-out Streaming Telemetry Sequence diagram.
5. The Telemetry Client sends the gNMI SubscribeRequest message with the Mode=STREAM, and SubscriptionMode=SAMPLE with a sample interval of 15 minutes. The SubscribeRequest message contains the SubscriptionList which contains multiple Subscription messages. Each Subscription message contains a Path message which includes a PathElem. The PathElem encodes the data tree path, as a series of repeated strings, from the set of Type 1 or Type 2 Subscriber Usage Statistics paths Lists shown in the section above. This encoding also includes elements of the gNMI path such as keys.
6. When the 15 minute collection interval ‘t’ timer expires, the CCAP populates the Type 1 or Type 2 Subscriber Usage Statistics counters.
7. The sample interval expiration triggers the gNMI stream from the CCAP for the completed collection interval ‘t’ for the Subscriber Usage Statistics Telemetry Data set.
8. When the 15 minute collection interval ‘t+1’ timer expires, the CCAP populates the Subscriber Usage Statistics counters.
9. The sample interval expiration triggers the gNMI stream from the CCAP for the completed collection interval ‘t+1’ for the Subscriber Usage Statistics Telemetry Data set. Steps 8-9 repeats every 15 minutes in the active gNMI Connection.
10. The back office application disables the Subscriber Usage Statistics streaming session. Provisioning of the Telemetry Client is not in scope of this specification.
11. The Telemetry Client terminates the connection with the CCAP by either cancelling the subscription or terminating the gRPC Channel as described in the Dial-out Streaming Telemetry Sequence diagram.

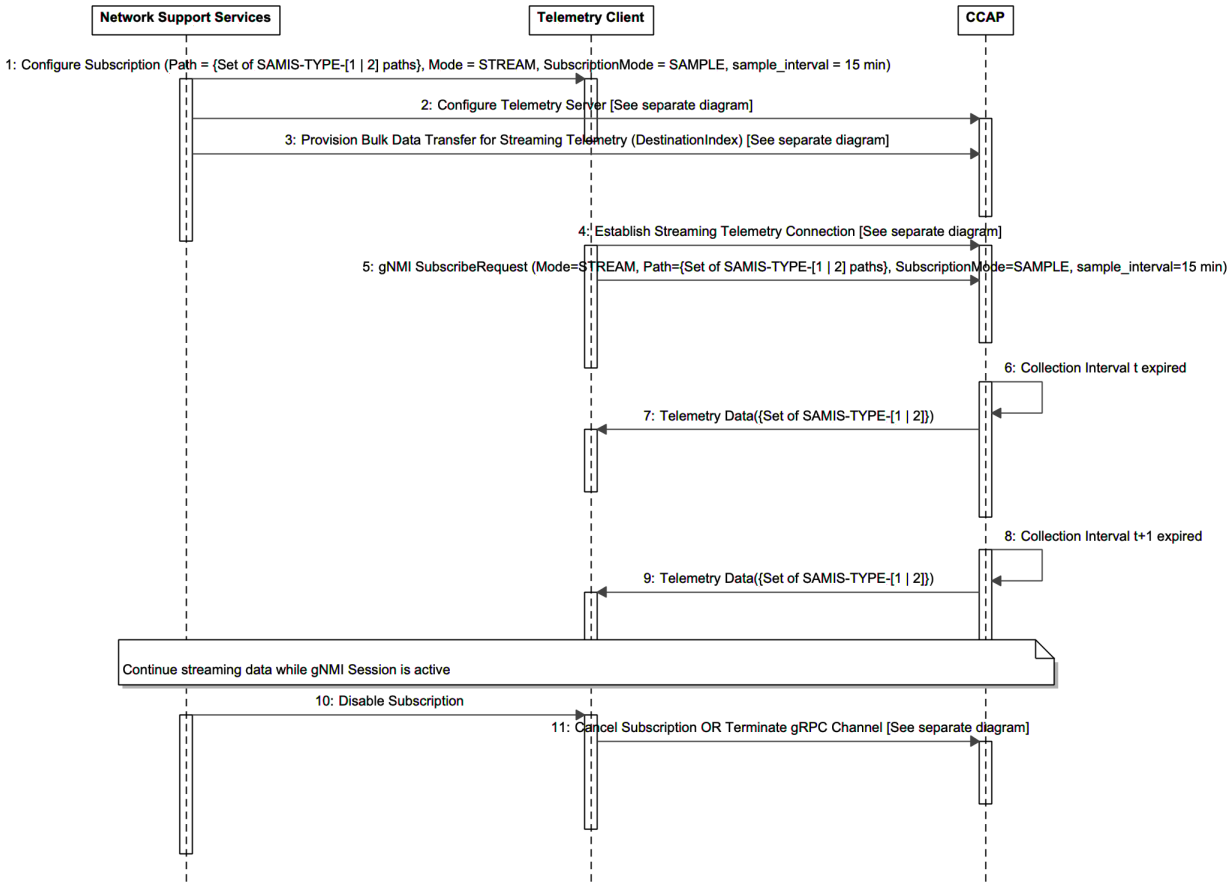

Figure 127 - gNMI Streaming Subscriber Usage Statistics Sequence Diagram

Appendix VI Acknowledgements (Informative)

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

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Kevin Luehrs	CableLabs, OAM Technology Consulting
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Joe Solomon	Comcast
Larry Wolcott	Comcast
Dwain Frieh	Commscope
Mark Lynch	Commscope
Dan Torbet	Commscope
Brian Bresnahan	Cisco
Dan Hegglin	Cisco
Pawel Sowinski	Cisco, Falcon V Systems
Andrew Sundelin	Dial in the Sun, LLC
Tom Staniec	GainSpeed
Hesham ElBakoury	Huawei
Satish Mudugere	MaxLinear
Brian Hedstrom	OAM Technology Consulting
Mukul Joshi	ST Micro
Niem Dang	Time Warner Cable

Appendix VII Revision History (Informative)

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I02-200311.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-19.2054-2	9/26/2019	DOCSIS 4.0 I01 CCAP Configuration YANG module	Hedstrom
CCAP-OSSIv4.0-N-19.2056-1	10/31/2019	Initial Full Duplex DOCSIS MIB Module DOCS-FDX-MIB	Hedstrom
CCAP-OSSIv4.0-N-19.2061-1	11/27/2019	DOCSIS 4.0 CCAP YANG Module update to remove extension points	Hedstrom
CCAP-OSSIv4.0-N-20.2071-5	2/20/2020	DOCSIS 4.0 CCAP OSSI I02 Compilation	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I03-210127.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-20.2086-1	3/19/2020	DOCSIS 4.0 YANG module update for DOCSIS 4.0 OSSI I02 specification release	Hedstrom
CCAP-OSSIv4.0-N-20.2140-3	12/17/2020	DOCSIS 4.0 CCAP OSSI I03 compilation	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I04-210521.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-21.2143-1	2/4/2021	DOCSIS 4.0 YANG module update for DOCSIS 4.0 OSSI I03 release	Thompson
CCAP-OSSIv4.0-N-21.2162-4	5/13/2021	DOCSIS 4.0 CCAP OSSI I04 compilation	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I05-210927.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-21.2168-1	6/10/2021	DOCSIS 4.0 CCAP OSSI configuration YANG module update for I04 release	Thompson
CCAP-OSSIv4.0-N-21.2191-2	9/16/2021	DOCSIS 4.0 CCAP OSSI I05 compilation	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I06-220302.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-21.2199-1	10/21/2021	DOCSIS 4.0 YANG module update for DOCSIS 4.0 OSSI I05 specification release	Thompson
CCAP-OSSIv4.0-N-22.2226-2	2/3/2022	DOCSIS 4.0 CCAP OSSI I06 compilation	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I07-220629.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-22.2238-1	3/24/2022	YANG module update for CCAP OSSIv4.0 I06	Thompson
CCAP-OSSIv4.0-N-22.2259-1	6/2/2022	DOCSIS 4.0 CCAP OSSI I07 compilation	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I08-221111.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-22.2284-2	10/13/2022	CCAP OSSIv4.0 I08 compilation EC candidate	Burroughs
CCAP-OSSIv4.0-N-22.2290-1	11/10/2022	Remove section 10.3.8 US FEC Summary Stats from CCAP OSSIv4.0 I08 candidate	Burroughs

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I09-230516.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-22.2294-1	1/5/2023	Monolithic configuration YANG module update for DOCSIS 4.0 CCAP OSSI I07 release	Jewitt
CCAP-OSSIv4.0-N-23.2300-2	4/6/2023	Monolithic configuration YANG module update for DOCSIS 4.0 CCAP OSSI I08 release	Erichsen
CCAP-OSSIv4.0-N-23.2302-2	4/13/2023	Compilation for CCAP OSSI v4.0 I09	Erichsen

The following Engineering Changes were incorporated into CM-SP-CCAP-OSSIv4.0-I10-231012.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-23.2317-1	6/15/2023	YANG module update for CCAP OSSIv4.0 I09	Erichsen
CCAP-OSSIv4.0-N-23.2323-3	9/7/2023	Compilation for CCAP OSSI v4.0 I10 Release	Erichsen

The following Engineering Change was incorporated into CM-SP-CCAP-OSSIv4.0-I11-240605.

ECN Identifier	Accepted Date	Title of EC	Author
CCAP-OSSIv4.0-N-24.2364-1	4/25/2024	CCAP OSSI v4.0 compilation candidate for I11 release	Erichsen

The following Engineering Change was incorporated into CM-SP-CCAP-OSSIv4.0-I12-250703.

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CCAP-OSSIv4.0-N-25.2408-1	4/24/2025	First quarter CCAPv4.0 OSSI I12 candidate	Jones

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