Verizon
OpenOMCI Specification

Version 2.2

Apr 14, 2022

EXECUTIVE SUMMARY

The Optical Network Terminal (ONT) Management and Control Interface (OMCI) has been the preferred method of Passive Optical Network (PON) management since the earliest deployed PON systems. In 2010, the ITU-T replaced the B-PON and G-PON specific OMCI specifications (G.983.2 and G.984.4, respectively) with a unified ITU-T Recommendation G.988, which is applicable to the existing PON systems and is designed to be extensible in principle to the new PON systems.

The ITU-T Recommendation G.988 specifies the managed entities of a protocol-independent management information base (MIB) that models the exchange of information between OLT and ONT in a PON-based access network. It also addresses the ONT management and control channel (OMCC) setup, protocol and message formats. Still G.988 by itself is not sufficient for successful interoperability between OLT and ONT vendors. Traditionally applied in a single vendor environment, G.988 defines a number of options that are left for vendor preference and allows substantial vendor freedom in specifying proprietary managed entities, attributes and methods within what has been known as "vendor-specific" code point space. It also leaves out the specification of high-scale sequencing of action in provisioning of complex services. These traits effectively encourage single-vendor non-interoperable environments.

In the G-PON context, some fundamental OMCI interoperability work was performed by the FSAN's OMCI interoperability study group (OISG, has been defunct for several years). This work resulted in an OMCI Implementers' Guide, presently incorporated into G.988 as informative Appendices I and II. In addition, FSAN and the Broadband Forum (BBF) have established the G-PON interoperability testing program (based on TR-255, G-PON Interoperability Test plan) that is centered on a subset of L2 services, as specified in BBF's TR-156. Within that service scope the TR-255 testing has allowed to demonstrate interoperability between selected vendors, achieved through modification and adaptation of the existing systems by means of vendor-specific MIB and code extensions.

In the commercial NG-PON2 deployment, Verizon has abandoned the traditional approach to interoperability as an added feature achievable among the limited set of selected vendors. Instead Verizon has positioned OLT and ONT interoperability as a fundamental mandatory requirement from the very first day of system deployment, which reduces cost by opening the door for the third party ONT vendors to bid on network contracts with Verizon, as well as facilitate smaller volume ONTs to be manufactured by one vendor. As a basis for the third party entry, Verizon has developed the OpenOMCI specification that provides

the formal framework for interoperability between NG-PON2 OLT and ONT in Verizon network. In a parallel effort aimed at encompassing all aspects of interoperability, Verizon has spearheaded the development of the NG-PON2 TC layer interoperability test plan, and has lead the development of the Inter-Channel-Termination protocol (ICTP) specification that governs the interactions between the OLT channel terminations (CTs) within a single NG-PON2 system.

The Verizon OpenOMCI specification is dealing specifically with the ONU Management and Control Interface (OMCI) aspects of the interaction between an OLT and an ONT in the Verizon network.

Verizon OpenOMCI specification Version 1.0 was published in June 2017. As a result of its submission to ITU-T, the core TWDM managed entities have been incorporated into ITU-T Rec G.988, for the first time providing the foundation for accommodating multi-channel PON systems represented by NG-PON2 within the OMCI framework. The need remains to fully address the features and requirements of the NG-PON2 specifications, G.989.2 (Physical medium dependent layer) and G.989.3 (Transmission convergence layer), and to ensure OMCI support of NG-PON2 services.

Verizon OpenOMCI specification Version 2.0:

- is based on the current version of the ITU-T Recommendation G.988, that is, the base version (11/2017) with Amendments 1 (11/2018) and 2 (08/2019), including the best practice Appendices I and II, otherwise known as the OMCI Implementers' Guide;
- makes necessary extensions to support NG-PON2 multi-wavelength channel architecture and the new features introduced by the NG-PON2 PMD and TC layer specifications, G.989.2 and G.989.3;
- defines the managed entities (MEs), the ME properties (i.e., attributes, attribute values, actions, notifications) and, where necessary, ME relationship diagrams and message sequences related to NG-PON2 OMCI to ensure OMCI interoperability between different vendor's ONTs and OLTs;
- incorporates support of all ONT types of interest to Verizon, including the NG-PON2 ONT in SFP+ module package;
- addresses the OMCC channel establishment and the ONT's OMCI MIB management and provisioning for support of Verizon-specific services;
- disallows the use of vendor-proprietary OMCI objects, thus eliminating the need for vendor-specific OMCI extensions;

- allows the use of the OMCI managed entities (MEs) and other objects in the respective vendor-specific code point spaces, provided such MEs and objects are exhaustively specified, including all pertinent semantics, methods, relationship diagrams, and message sequences;
- is designed to be future proof in order to reduce the changes on the Verizon OpenOMCI specifications as new ONT models, services, and features are added.

Verizon OpenOMCI specification Version 2.1:

- adds support for multicast image transfer (clauses 5.5.14.4 and C.4).

Verizon OpenOMCI specification Version 2.2 additionally provides:

- Power shedding defaults (clause 6.3);
- Per-call RTCP statistics (clause 7.5.3);
- Refinement of SFU traffic management architecture (clause 3.4.2.2);
- Traceroute support (clause 8.2);
- MAC swap loop function (clauses 4.1.2, 7.1.9, and 7.5.4);
- New Extended remote debug ME (clauses 5.5.17 and 7.1.10);
- ONU-G alarms (clause 6.4);
- IP multicast video service (clause 4.7 with its subclauses);
- Clarification of TWDM system profile ME (clause 7.1.2);
- Clarification of IP host PMHD part 2 ME (clause 7.5.1);
- Clarification of ONU operational PMHD ME (clause 7.5.2).

The Verizon OpenOMCI specification addresses the Verizon interoperability needs for the NG-PON2 deployment and is laying the foundation for the on-going industry-wide best-practice standardization. However, for the Verizon vendors, the compliance with Verizon OpenOMCI is an unconditional requirement which is not contingent upon level of its formal standardization.

REVISION HISTORY

Version	*Date*	*ITU-T Recommendation base*
1.0	20170630	G.988 (10/2012) G.988 (2012) Amd. 1 (05/2014) G.988 (2012) Amd. 2 (06/2016)
2.0	20200330	G.988 (11/2017) G.988 (2017) Amd. 1 (11/2018) G.988 (2017) Amd. 2 (08/2019)
2.1	20210331	G.988 (2017) Amd. 3 (03/2020)
2.2	20220331	G.988 (2017) Amd 4 (09/2021)

Note: The ITU-T has changed the style of the amendment support. From this point on, rather than presenting the instructions to the editor, the official text of an amendment includes the base text of the Recommendation with all the modifications and changes. Therefore, the official text of the most recent G.988 amendment effectively incorporates the base text of ITU-T Recommendation as well as all its prior amendments.

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Table of Contents

1. Introduction

This section covers the scope, purpose, and overall organization of the present document.

1.1 Scope

The Verizon OpenOMCI specification is an integral part of a typical Verizon Network Element Requirements (NER) document dealing specifically with the ONU Management and Control Interface (OMCI) aspects of the interaction between an OLT and an ONT in the Verizon network. It addresses the OMCC channel establishment and the ONT's OMCI MIB management and provisioning for support of Verizon-specific services.

The Verizon OpenOMCI specification is intended to define the managed entities (MEs), the ME properties (i.e., attributes, attribute values, actions, notifications) and, where necessary, ME relationship diagrams and message sequences related to NG-PON2 OMCI to ensure OMCI interoperability between different vendor's ONTs and OLTs. The Verizon OpenOMCI imposes requirements and constraints on both ONT and OLT implementations.

The updates of the Verizon OpenOMCI specification are aligned with the current ITU-T Recommendation base, as specified in the Revision History table of this document, providing necessary additions, extensions, disambiguations, and clarifications.

For the NGPON2 equipment deployed in the Verizon network, the compliance with the Verizon OpenOMCI specification is required.

While this document does address the configuration and status monitoring of the PON devices with dual management domains, the details of a non-OMCI management path in such devices are out of scope.

1.2 Purpose

The Verizon OpenOMCI specification is intended for open publication, thus allowing multiple third party ONT vendors to develop compliant and interoperable products that can be deployed in Verizon network which would lead to reducing the cost and operational expenses for Verizon.

1.3 Document organization

This document is structured as follows.

Section 2 discusses the general principles of OpenOMCI interoperability.

Section 3 is concerned with the aspects of general ONT architecture, ONT activation and OMCC channel setup in the context of the TC layer parameters, and overall traffic management structure.

Section 4 addresses the OMCI provisioning of individual service types.

Section 5 discusses the guiding principles of G.988 adaptation to OpenOMCI and provides necessary clarifications, disambiguation, and additional value constraints.

Section 6 lists the modifications to the existing G.988 MEs.

Section 7 contains the specification of the new MEs introduced by the OpenOMCI specification.

Section 8 contains a list of all MEs, including those already standardized, modified, and newly proposed, categorizing their applicability to the Verizon OpenOMCI specification.

The detailed Verizon OpenOMCI MIB description spreadsheet accompanies the specification.

2. General principles of OMCI interoperability

2.1 Development of Verizon OpenOMCI specification

The Verizon OpenOMCI specification has been developed by Verizon in cooperation with an ad hoc group of participating vendors with the immediate goal to address the interoperability needs of the NG-PON2 deployment and PON interoperability in general. The Verizon OpenOMCI specification is intellectual property of Verizon.

The stable version of the Verizon OpenOMCI specification is publicly available on Verizon website and can be copied and distributed by interested parties provided the source is unambiguously attributed and no modification is made to the text.

2.2 Relationship with G.988

The Verizon OpenOMCI specification is based on ITU-T Recommendation G.988 along with all pertinent amendments, as indicated in the Introduction to this document. With respect to the standard MEs, attributes, actions, and notifications, the Verizon OpenOMCI specification may provide clarification and disambiguation.

For all specified MEs, the specification defines the creation method (automatic creation by the ONT, or controlled creation by the OLT instruction) specified in G.988.

For all specified attributes, actions, and notifications the ONT and OLT support the semantics details as specified in G.988, unless otherwise noted in the Verizon OpenOMCI specification.

The specification defines support all OMCI message types according to G.988.

The specification supports both the baseline OMCI message format and the extended OMCI message format.

While the Verizon OpenOMCI specification allows the use of the OMCI managed entities (MEs) in the vendor-specific ME class space as long as the structure and functionality of such ME is disclosed, the use of the vendor-proprietary MEs is prohibited as such MEs preclude OLT/ONT interoperability.

2.3 Future-proofing of Verizon OpenOMCI specification

Verizon OpenOMCI specification is intended to be future proof. This includes the following principles.

- An update to the Verizon OpenOMCI Specification shall not require an update to already deployed ONTs and OLTs supporting the existing services.
- The specification shall be able to absorb new services and features without forcing an upgrade to already deployed ONTs.
- Any upgrade to the OLT OMCI implementation to provide support for future versions of Verizon OpenOMCI Specification shall be backward-compatible with the deployed ONT base.
- An OLT shall support ONTs on the same PON that have implemented different versions of the Verizon OpenOMCI specification.

2.4 Version control and capability discovery

The Verizon OpenOMCI specification provides means for version control, should future standardization and/or service definition changes require an update to the Verizon OpenOMCI specification. The specification version is represented by a pair of integer values (R, V), where R is the major release, and V is the version within release. A higher version number within a release shall be backward compatible with all lower version numbers within the same release.

Upon ONT activation, the OLT and ONT negotiate and positively agree on the support of the Verizon OpenOMCI specification and a specific ONT type feature set, using the Verizon OpenOMCI ME, the support of which is mandatory if the equipment is being deployed in Verizon network.

Along with its target (R, V) pair, the OLT implementation and the ONT implementation are required to interoperate with an ONT or OLT counterpart supporting a lower version within the same major release R, as well as all published versions within the major release one step lower than R.

2.5 Standardization of the Verizon OpenOMCI

The Verizon OpenOMCI specification addresses the Verizon interoperability needs for the NG-PON2 deployment and is laying the foundation for industry-wide best-practice standardization.

The present document provides tentative OMCI object ID designations in the vendor-specific number space. A companion mapping table provides the correspondence of the tentative object ID designations in the vendor-specific number space and the permanent object ID designations in the standard number space.

2.6 The Verizon OpenOMCI specification compliance

For the NGPON2 equipment deployed in the Verizon network, the compliance with Verizon OpenOMCI specification is a requirement.

The Verizon OpenOMCI specification compliance requirements do not apply to the B-PON and G-PON deployments.

3. ONT bring-up and general configuration

3.1 OMCC establishment in the context of TC layer configuration

The TC layer configuration in a TWDM PON system includes the items specified in Table 12-5/G.989.3. These items are assigned to four parameter groups:

Group A:

- System profile parameters;
- Channel profile parameters;
- Burst profile parameters.

Group B:

- MSK & derived shared keys.

Group C:

- ONU-ID;
- Default Alloc-ID;
- Default XGEM Port-ID;
- Equalization delay.

Group D:

- Non-default Alloc-IDs;
- Protection PON-ID.

An ONU maintains its Channel Partition Index (CPI) as a read/write-accessible attribute of the OMCI MIB which, unlike other TC layer configuration parameters, survives ONU reactivation, warm and cold reboot, power cycle, and/or power loss.

An activating ONU (whether newly installed, undergoing reboot, or previously active entering a new activation cycle) starts in the state O1.1 (Off-Sync substate of the Initial state) with no TC layer configuration, by scanning the downstream tuning range in search of a valid downstream wavelength channel.

Except when newly installed, the activating ONU may optimize the downstream wavelength channel search by prioritizing the downstream wavelength channel used during the previous activation cycle, if reactivation has been caused by a PLOAM or OMCI command, or by deprioritizing that channel, if reactivation was associated with the timed-out LODS condition.

Once the downstream channel synchronization is acquired, the activating ONT transitions into state O1.2 (Profile Learning substate of the Initial state). It then autonomously learns the TC layer configuration parameters of Group A.

The activating ONU makes a decision that the downstream wavelength channel is "OK to work" and transitions to state O2-3 (Serial number state), if (1) its OMCI MIB has been initialized and populated; (2) the ONU's CPI value is either set to default, or matches the CPI value reported by the Channel_Profile PLOAM message for this TWDM channel; (3) the ONU's own upstream optical link type and upstream line rate are supported according to corresponding bitmap parameters reported by the Channel_Profile PLOAM message for this TWDM channel. If condition (1) above is not met, the ONU blocks the decision pending initialization and population of the OMCI MIB. If conditions (1) is met, but either condition (2) or condition (3) is violated, the ONU abandons the downstream wavelength channel and searches for an alternative downstream wavelength channel, returning to state O1.1.

The ONT authentication in the Verizon network is based on the Serial Number. Consequently, the ONT uses the default Registration ID, $(0x00)_{36}$, for the MSK and dependent key derivation. The ONT computes the derived shared keys as soon as the context-binding component of the profile (PON-TAG) is learned.

The activating ONT obtains the TC layer configuration parameters of Group C from the OLT CT while in O2-3 and O4 states. The OLT CT communicates these parameters over the PLOAM channel after it is able to confirm the acquisition of both downstream and upstream wavelength channels by the ONT, regardless of availability of the service profile for the ONT.

The OLT CT communicates the ONU-ID explicitly in the Assign_ONU-ID PLOAM message. The ONU uses the assigned ONU-ID value to set the default Alloc-ID and the default XGEM Port-ID. The default XGEM Port-ID is used exclusively for the OMCC traffic. The default Alloc-ID is used exclusively for the upstream transport of the OMCC and PLOAM traffic.

The OLT CT communicates the Equalization delay to the ONU in state O4 (Ranging state) explicitly in the directed Ranging_Time PLOAM message. The assignment of ONT's Equalization delay completes the OMCC channel setup from the ONT perspective. It also triggers ONU transition into state O5.1 (Associated substate of the Operating state).

If an ONT has activated with a discovering OLT CT that does not have the service profile for that ONU, it is the responsibility of the discovering OLT CT to initiate the ICTP exchange with the other OLT CTs of the NG-PON2 system and to hand over the ONU to the appropriate serving OLT CT.

The ONT obtains the TC layer configuration parameters of Group D from the serving OLT CT while in O5 state. The serving OLT CT communicates these

parameters over the PLOAM channel only after and if the service profile for the ONT has been established.

The OLT CT should not attempt to associate the default Alloc-ID with any T-CONT ME. However, if the OLT CT does make such an attempt, the ONT shall accept it and follow the requirements of clause B.1/G.988.

3.2 ONT's OMCI capability discovery

The ONT supports the Verizon OpenOMCI ME in the vendor-specific ME class range. From the perspective of the present specification, this is a mandatory ME, the only instance of which is instantiated and populated autonomously by the ONT. The ONT declares the supported version of the OpenOMCI specification in the Supported Specification Version attribute, which refers to the version of the Verizon OpenOMCI specification, and its compliance with the Verizon OMCI MIB requirements for a specific ONT type in PON device type attribute, which represents a bitmap of distinct ONT types specified by Verizon.

The OLT CT discovers the OMCI capabilities of the ONT indirectly by reading the Specification Version and PON device type attributes of the Verizon OpenOMCI ME. The OLT then indicates the adherence to the OpenOMCI specification by writing the Specification Version in Use attribute of the Verizon OpenOMCI ME. Once OLT and ONT thus complete the negotiation, the ONT may fully utilize the features of the agreed version of the OpenOMCI specification, including the rejection of OLT's attempts to access the ME and attributes beyond those specified by the agreed version of the specification for the agreed ONT type.

If the OLT does not access the Verizon OpenOMCI ME, or if it sets the value of the Specification Version in Use attribute to zero, the ONT should presume that Verizon OpenOMCI is not supported and employ the common G.988 set of the OMCI MEs, attributes, and features.

The ONT expects the OLT to re-negotiate the Verizon OpenOMCI support upon activation at the start of each power cycle and also after each MIB reset. This convention allows to gracefully handle not only a continuous operation on the PON, but also ONT transfer to a different PON. See sequence diagram of Figure 3-1.

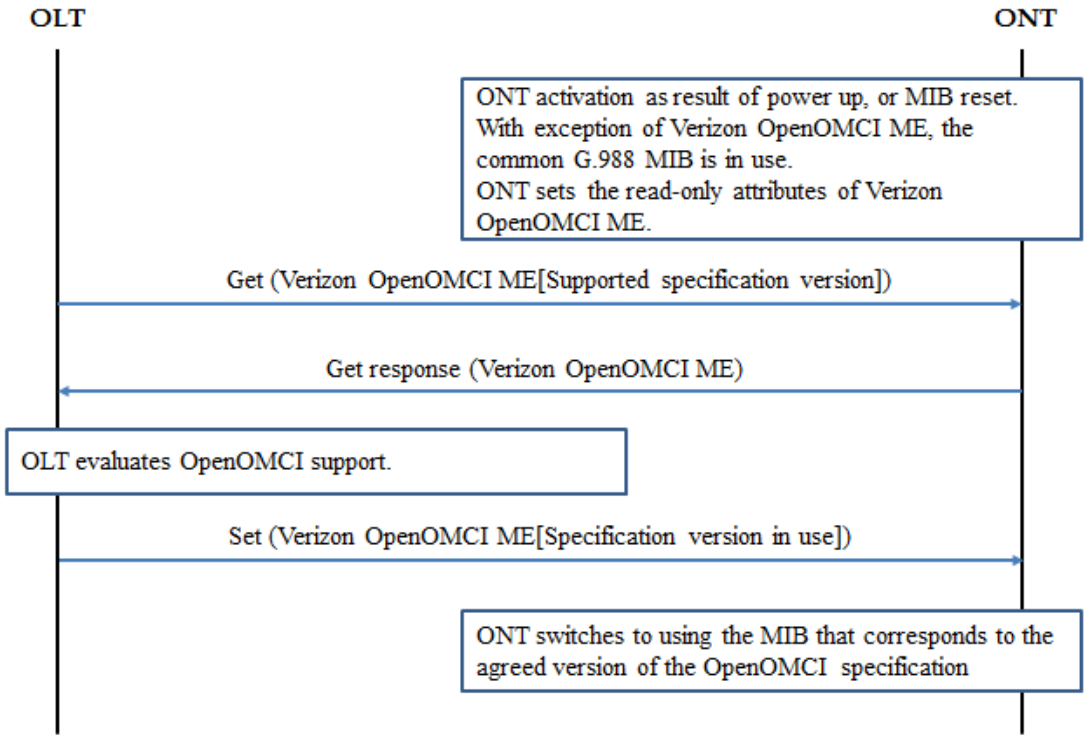


Figure 3-1 – OpenOMCI version negotiation

The OLT CT performs ONT MIB upload (note that Verizon OpenOMCI ME is included into the MIB upload), ONT MIB audit, and ONT MIB synchronization according to the best practices described in Appendix I/G.988.

3.3 Core ONT equipment capabilities

Upon initial power up or other event requiring OMCI MIB initialization, the ONT autonomously creates the instances of the following MEs, according to its core equipment configuration, for all device types and supported interfaces/services.

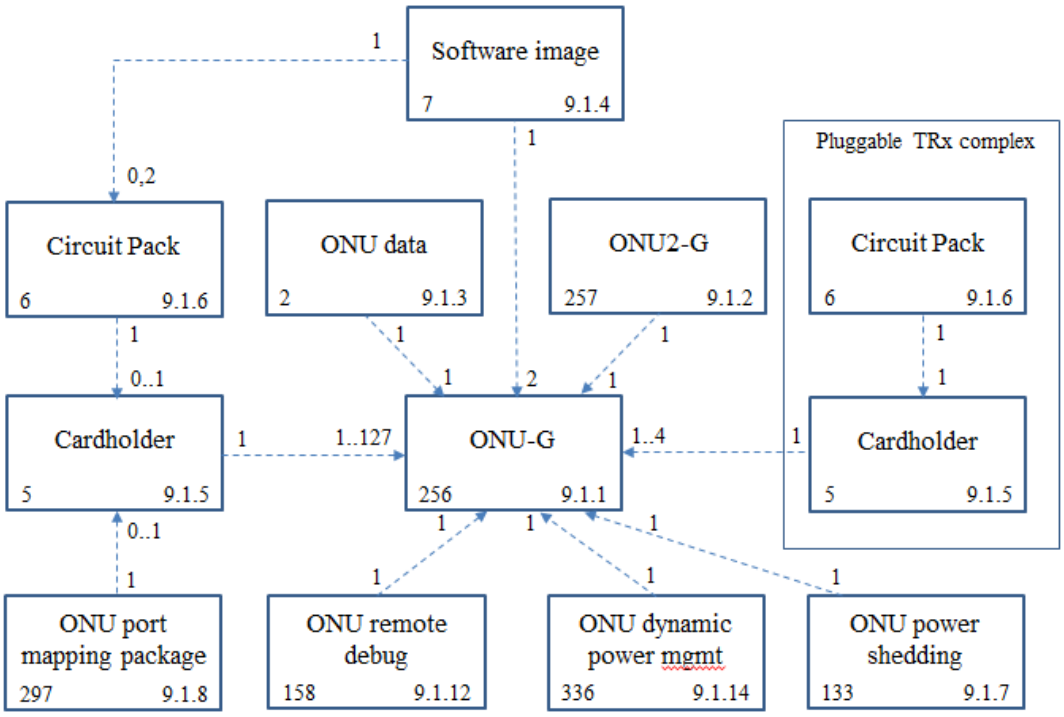


Figure 3-2 – ONT core model

The ONT follows the slot-port model of the equipment management, representing its hardware capabilities with a set of virtual Cardholders (5) ME. The virtual cardholders have the ME IDs of the form 0x01**. A Cardholder (5) ME is used to model a pluggable XFP transceiver. To support XFP inventory retrieval, such a Cardholder is implicitly associated with an instance of Flexible Configuration and Status Portal ME.

The ONT may utilize the ONU port mapping package (297) ME or additional virtual cardholders to represent its hardware capabilities. All ONTs of interest are integrated ONTs, with virtual cardholders per port type. The numbering of the ports within a slot should be consistent with the labeling of the physical ports on the face plate of the ONT device (the lowest number ME ID corresponding to the lowest number label, etc.). Ports numbers should start with 1.

To model an independently-managed software module, the ONT creates an instance of Cardholder (5) ME with an associated Circuit pack (6) and a pair of Software image (7) MEs. The ONT is not expected to instantiate Software image (7) ME for vendor-specific usage.

3.4 Traffic management

3.4.1 Default traffic management configuration

The ONT generally supports the traffic management functionality as specified in OMCI Implementer's Guide, ITU-T Recommendation G.988, clauses II.3.2 and II.3.3.

The ONT supports flexible traffic management configuration, indicating so by setting the QoS configuration flexibility attribute of the ONU2-G (257) ME to TRUE. As a default, the ONT creates a flat (non-hierarchical) QoS configuration.

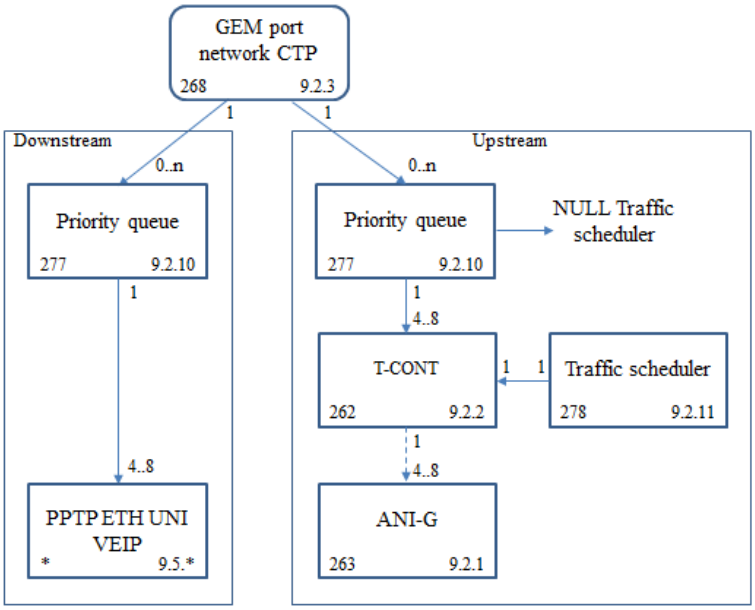


Figure 3-3 – Default traffic management configuration

In the upstream direction, the ONT instantiates an ANI-G (263) ME for each access network port in each instance of a cardholder (5) ME that has a populated circuit pack (that is, an installed pluggable optics module).Note that in most cases there will be a single ANI-G per cardholder, in which case the ANI-G's ME ID is expected to be of the form 0xSS00, where 0xSS is the cardholder (5) ME's Slot ID. Four, six or eight T-CONT (262) MEs are associated with ANI-G via the Slot ID, and 4 to 8 priority queue (277) MEs are associated with each T-CONT

ME with the scheduling policy being strict priority by default (subject to change by the OLT at its discretion).

In the downstream direction, for each locally created instance of a PPTP-type ME or a Virtual Ethernet Interface Point (VEIP) (329) ME, the ONT instantiates 4 to 8 priority queues associated with that PPTP ME via a particular slot and port. The scheduling policy for these queues is fixed to strict priority (and cannot be changed by the OLT).

The default traffic management configuration is subject to modification by the OLT at its discretion. However, as clause II.3.3.2/G.988 implies, the OLT may re-arrange or simplify the traffic management configuration, using less than ONT's full capabilities, but cannot make it more complex

With regard to a mandatory Alloc-ID attribute of a T-CONT (262) ME, it should be noted that the Alloc-ID assignment performed in the TC layer does not populate this attribute, but rather indicates that the ONT must respond to the grants provided to that Alloc-ID. The Alloc-ID attribute shall be populated explicitly via the OMCI message.

3.4.2 Preferred traffic management configuration per ONT type

As special case of general traffic management, this section illustrates the preferred configurations for principal ONT types.

3.4.2.1 IBONT

For the IBONT type, Figure 3-4 presents the upstream traffic management architecture, followed by the OMCI relationship diagrams for the data path and the management path.

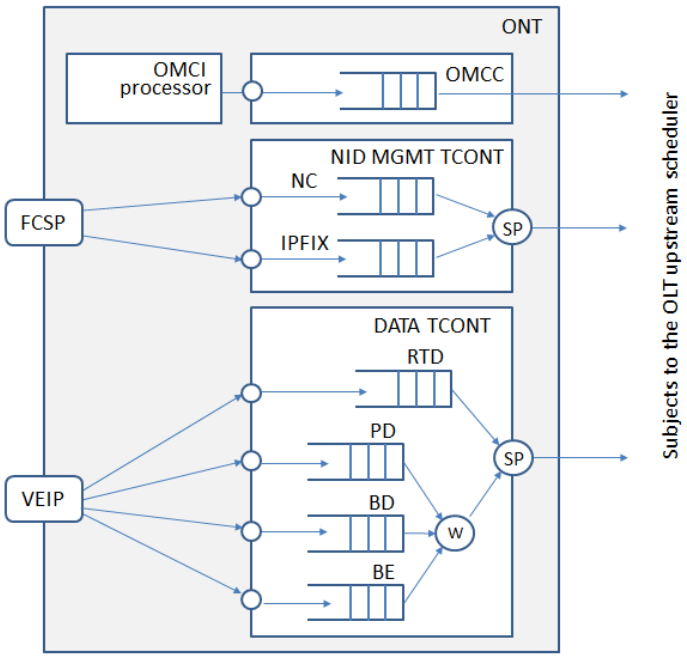


Figure 3-4 – IBONT traffic management

For the Data T-CONT, the number N of classes of services needs to be scalable beyond N = 4. The parameters of the traffic descriptor are derived from the traffic parameters of the provisioned Ethernet Virtual Circuits (EVCs). The weights of the weighted scheduler are provided by the OSS and set independently of the specific traffic parameters. For the NID management T-CONT, the parameters of the traffic descriptor are common across different IBONTs. The IBONT OAM traffic is carried over the NID management T-CONT and is classified based on the VLAN association: NETCONF management traffic is single-tagged with VID = 4094, IPFIX traffic is single-tagged with VID = 4093.

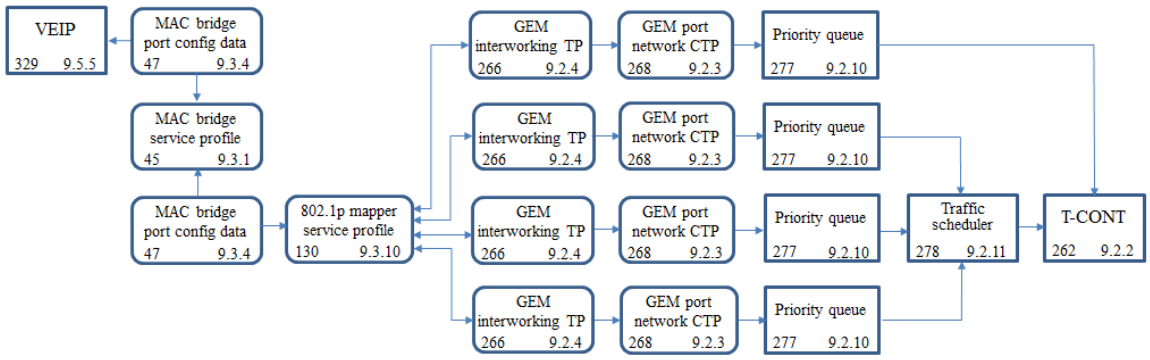


Figure 3-5 – IBONT data path ME relationship diagram

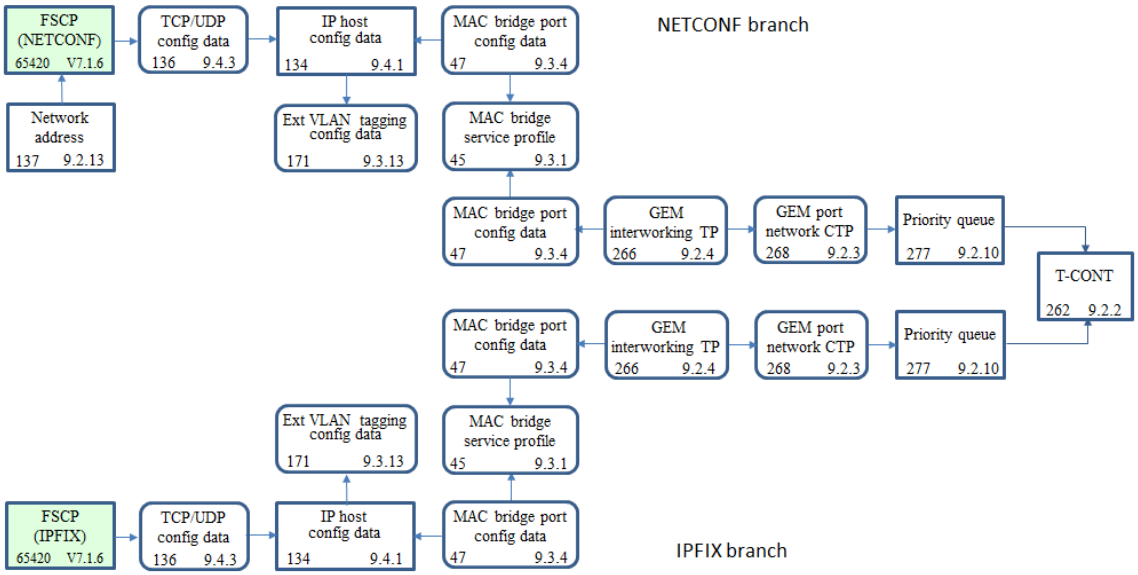


Figure 3-6 – IBONT management path relationship diagram

3.4.2.2 SFU and BHR ONTs

For the SFU or BHR ONT types, Figure 3-7 presents the upstream traffic management architecture. Note that the requirement for POTS port isolation via separate queues within VoIP T-CONT has been deprecated.

The DSCP value of the voice traffic is specified outside of the OMCI management domain and is handled transparently. As far as the IEEE 802.1p priority code point (PCP) values are concerned, the bearer traffic is assigned the PCP value 5 while the signaling traffic is assigned the PCP value 6.

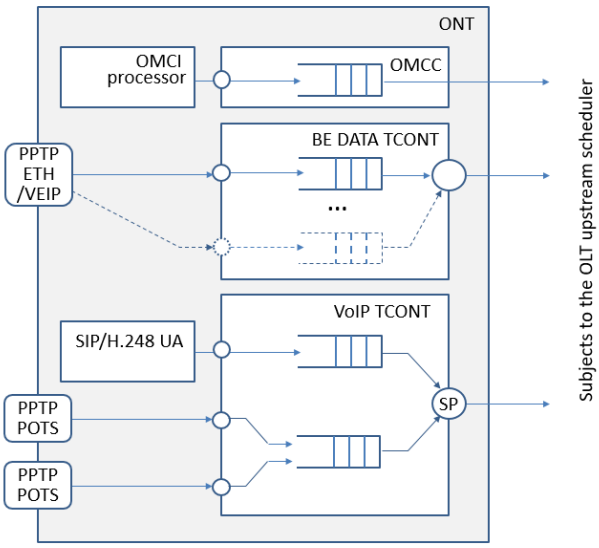


Figure 3-7 – SFU/BHR traffic management

Note that the OLT's DBA implementation should follow the reference model of Clause 7.1 of ITU-T Recommendation G.989.3. The T-CONT descriptor parameters (fixed, assured, maximum, or alternatively, additional bandwidth, and the eligibility indicator) derived based on the individual EVC parameters are supplied to the OLT by the OSS.

3.5 TWDM system configuration

The ONT uses several MEs introduced by Verizon OpenOMCI to model a multi-wavelength TWDM PON system (see Figure 3-8). Such OpenOMCI-specific MEs are represented by the shaded blocks.

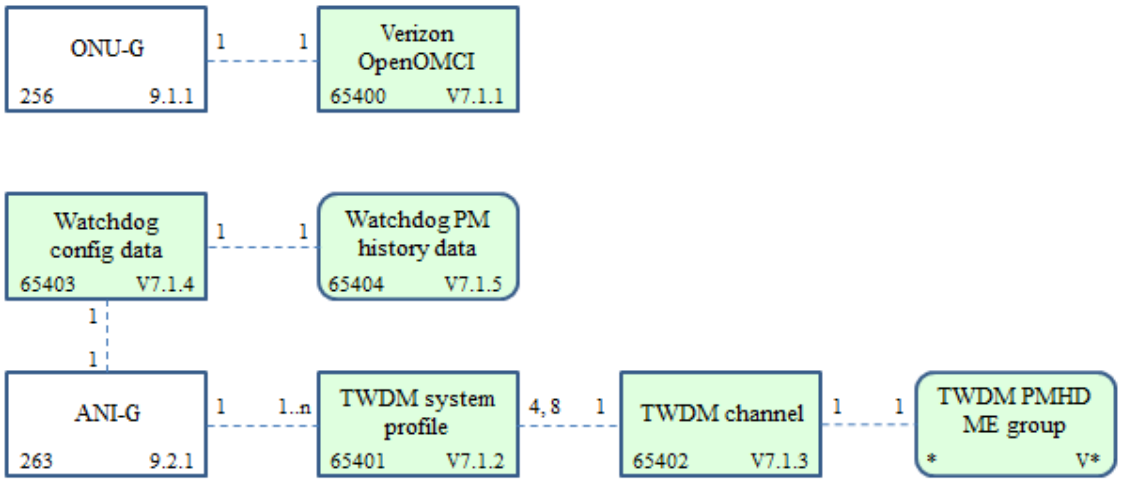


Figure 3-8 – Modeling a TWDM PON system with self-monitoring capabilities

There is a single instance of TWDM system profile ME per access network slot. In most cases the correspondence between the TWDM system profile ME and the ANI-G ME is 1:1. However, there are use cases, in particular, TWDM channel bonding and Type C protection, that can make use of multiple ANI-G per access network slot, a configuration which is technically allowed, but not corroborated by G.988. Depending on its capabilities, the ONT instantiates four or eight TWDM channel MEs. These MEs get populated as the ONT discovers active TWDM channels through tuning range scanning.

The ONT also instantiates the Watchdog ME, associated with an instance of ANI-G, to model the ONT's self-monitoring capabilities.

3.6 PON devices with dual management domains

Among the PON device types defined in this specification, two types, NG-PON2 IBONT and NG-PON2 BHR, are dual-managed devices where the ONU part is managed via the OMCI, while the UNI equipment is managed by other means, such as TR-069 (in case of NG-PON2 BHR) or NETCONF/YANG (in case of NG-PON2 IBONT).

The dual-managed devices follow the two management domain architecture, as specified in Section II.2/G.988, with the VEIP (329) ME providing the demarcation point between the OMCI and non-OMCI management domains. The VEIP ME is explicitly linked to the TCP/UDP config data (136) and IP host config data (134) ME, which provide the non-OMCI management domain's IP connectivity, and implicitly associated with an instance of the OpenOMCI-specific Flexible configuration and status portal (65420) ME, with an instance of the standard TR-069 management server (340) ME, which provide the IP address and access credentials for the non-OMCI management station and, if necessary,

the means to exchange the configuration and status information associated with the non-OMCI management domain between the OLT and the ONT.

The preferred traffic management configurations for the dual-managed PON device types can be found in section 3.4.2. As far as the L2 connectivity and VLAN tag management is concerned, the NID portion of the NG-PON2 IBONT is expected to perform traffic classification and all necessary VLAN tag manipulations, presenting fully tagged Ethernet frames at the VEIP demarcation point. The router portion of the NG-PON2 BHR is viewed as an untrusted device and is expected to present untagged Ethernet frames at the VEIP.

3.7 Multicast image transfer

Per Verizon OpenOMCI v2.1, this section introduces the method of ONT software image download using a light-weight Multicast Image Transfer (MCIT) protocol that increases the time-efficiency of the download process with respect to the conventional unicast method detailed in G.988 Section I.3.

An ONT supporting this method instantiates and reports an instance of the Flexible Configuration and Status Portal ME associated with Multicast Image Transfer. A supporting OLT may select this method in order to transfer the desired image simultaneously to all applicable subtending ONTs rather than sending individual copies of the image to each ONT. The method transfers Ethernet frames containing image blocks over a multicast XGEM port (Direction ANI-to-UNI). Control and status as described in Figure I.3.2.1-2 of ITU-T Rec. G.988 are replaced by interactions with the Multicast Image Transfer instance of the FCSP ME.

The light-weight nature of this method allows integration into an OLT's existing ONT image deployment mechanism without the need to manage additional external servers, IP addresses, or other configuration items. The method is externally transparent while substantially improving the overall software download times.

A detailed description of the MCIT method may be found in Appendix C.4 of this specification.

4. Service provisioning

4.1 Layer 2 connectivity

4.1.1 Layer 2 service models

The ONT supports the Layer 2 OMCI common model (L2-OCM) for unicast provisioning, as specified in clause II.1.2/G.988, with all the pertaining MEs and message sequences.

The ONT supports one instance of single-UNI L2-OCM provisioning model for each user-facing Ethernet interface.

In the upstream direction, the ONT supports four instances of T-CONT ME in addition to the upstream OMCC traffic entity. The number of supported T-CONTs does not scale with the number of ONT's UNI interfaces.

By default, the ONT supports four priority queues corresponding to four classes of traffic, with an option to extend the number of supported priority queues up to eight.

The ONT OMCI implementation supports flexible configuration of the Priority queue (277), Traffic Scheduler (278), and T-CONT (262) MEs.

The Traffic Scheduler (278) ME supports both strict priority and weighted round robin scheduling policies selectable by the OLT CT.

For the IPTV service, the ONT supports the L2-OCM with multicast provision model, as specified in clause II.1.3/G.988, with all the pertaining MEs and message sequences. Multicast related MEs include Multicast GEM interworking termination point (281), Multicast operations profile (309), Multicast subscriber config info (310), and Multicast subscriber monitor (311).

4.1.2 MAC swap loop function

Verizon OpenOMCI v2.2 provides support for a single instance of the MAC swap loop function per ONT (a feature missing from ITU-T G.988 OMCI specification), either on per-UNI or per-VLAN basis. At most one UNI or at most one VLAN can be subject to MAC swap loop at any given time. Any Ethernet UNI or any VLAN can be selected for the MAC swap loop function.

Since MAC swap loop is not an executable test but rather a behavioral mode, the implementation mechanism uses a newly defined ME rather than OMCI Test message.

It is expected that the OLT will prevent operation of the MAC swap loop function and the standard PPTP Eth UNI Ethernet loopback configuration simultaneously. An ONT that instantiates the MAC swap loop configuration ME shall reject an attempt to set the loopback configuration attribute of the PPTP Ethernet UNI ME as unsupported.

Two new MEs are introduced: MAC swap loop configuration (65425), Clause 7.1.9, and MAC swap loop monitor (65428), Clause 7.5.4.

4.2 Layer 3 connectivity

The only services that requiring an IP stack are those associated with setting the direct management path in a dual-managed ONT, such as IP-provisioned VoIP and TR-069 support. The ONT does not require an IP stack for performing its core functions.

The ONT supports all MEs specified in clause 9.4/G.988.

The IP host config data (134) ME is instantiated autonomously by the ONT. The other MEs of that group: IP host performance monitoring history data (135), TCP/UDP config data (136), TCP/UDP performance monitoring history data (342), IPv6 host config data (347) -- are instantiated by the OLT CT.

The OLT CT populates the ONU identifier attribute of the IP host config date ME (134) with the unique *client identifier* parameter. The ONT uses this parameter to form a DHCP discovery message to the DHCP server. The ONT uses the content of the DHCP offer response from the DHCP server to populate the remaining attributes of IP host config data (134) ME.

The ONT uses the IP host performance monitoring history data (135) ME to collect DHCP statistics and to report threshold crossing alerts (TCAs).

4.3 Voice services

4.3.1 SIP-based VoIP service

This section specifies the OMCI-specific aspects of SIP-based VoIP services configuration, provisioning, and monitoring. The complete specification of the Verizon VoIP architecture, mandatory requirements and optional capabilities, along with other Verizon-specific information required for interconnecting with

the Verizon SIP-based packet telephony network is provided in the current version of Verizon SIP-Based Packet Telephony Network UNI Specification document (Verizon SIP UNI specification).

Verizon uses the non-OMCI based control of VoIP service; this is referred as "IP path" in clause 6.4/G.988. The relationship diagram of VoIP provisioning is shown in Figure 4-1.

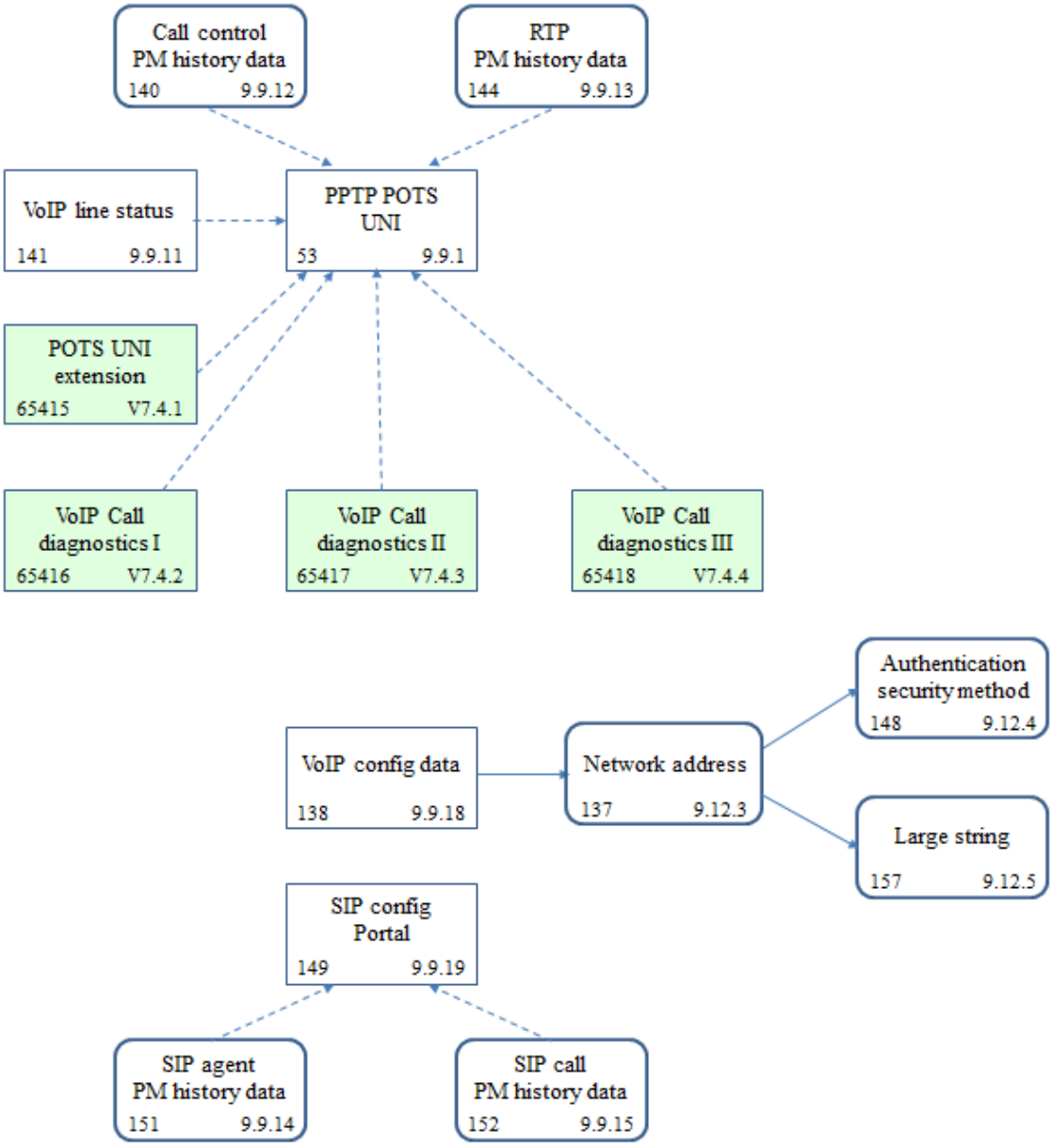


Figure 4-1 – VoIP provisioning MEs

The ONT supports the VoIP config data (138) ME instantiating it autonomously, as long as VoIP services are supported, and declaring SIP signaling protocol and Configuration file retrieval VoIP configuration method.

To allow the ONT to retrieve its SIP configuration, the OLT CT provides the profile server address, as defined by the Verizon SIP UNI specification, and configuration credentials by instantiating the Network address (137) and Authentication security method (148) MEs, populating them with appropriate parameters, and writing the pointer to the instance of the Network address (137) ME into the VoIP configuration address pointer attribute of the VoIP config data (138) ME.

The ONU obtains the local domain name and host name via DHCP.

Once the profile server address and associated credentials are established, the ONT leverages the SIP SUBSCRIBE/NOTIFY mechanism to obtain the SIP user agent configuration, according to Method B of Verizon SIP UNI specification. The OLT CT uses a Set operation on the Retrieve profile attribute of the VoIP config data (138) ME to provide an indication to the ONU to initiate or reinitiate the process of obtaining the SIP configuration information and configuring its SIP user agent(s), starting with the acquisition of the new profile server address.

The ONT uses the notification capabilities of the VoIP config data (138) ME, IP host performance monitoring history data (135), and the OpenOMCI-specific SIP UNI Application server alarm status ME to report SIP service related alarms, in accordance with section 7.1.2/ Verizon SIP UNI specification.

The SIP configuration parameters retrieved from the configuration server in the form of an XML profile document are not presented in the OMCI MIB. However, the ONT makes the profile document itself available in an unstructured form via the Configuration text table attribute of the SIP config portal (149) ME. (See II.4.6.2/G.988.)

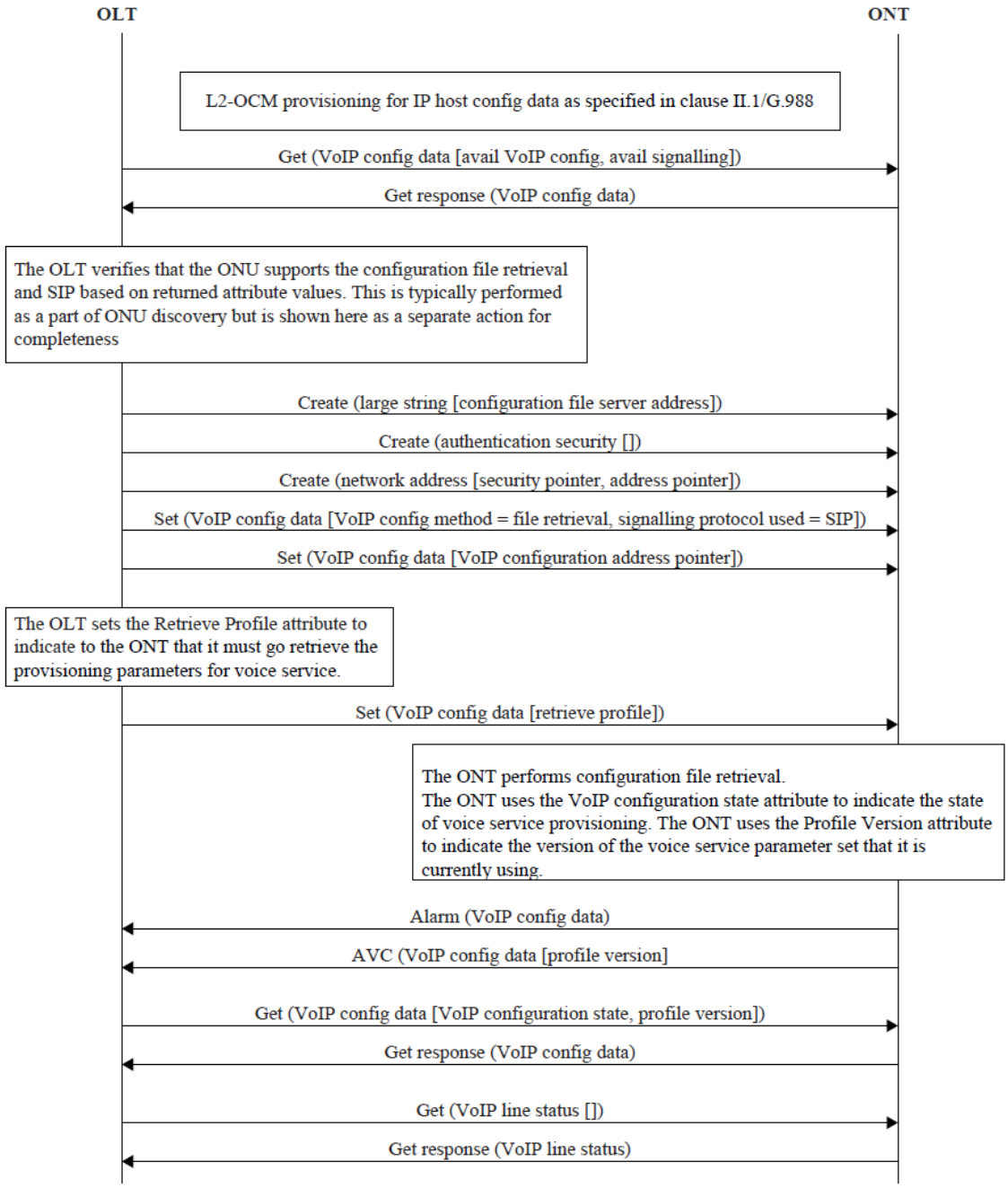


Figure 4-2 – OMCI message sequence for VoIP provisioning

4.3.2 H.248-based voice

The support of H.248-based voice follows the specification in ITU-T G.988.

4.3.3 POTS holdover

POTS holdover refers to the loop voltage being held up under certain adverse conditions associated with the loss of connectivity on the PON fiber, preventing false positive activation of premises intrusion alarm circuits. There are two distinct mechanisms to support POTS holdover: the POTS holdover timer of PPTP POTS UNI (53) ME and the Controlled POTS holdover timer of POTS UNI extension (65415) ME.

The former controls the POTS voltage holdover in case of loss of TC layer connectivity. The timer is started once the connectivity is lost (that is, when the "ONU is not ranged on the PON"), and reset to the preconfigured original value when the connectivity is restored. When the timer expires, the POTS voltage is dropped. As the PON connectivity is by definition lost, the ONT is not able to report remaining holdover time.

The latter guarantees POTS voltage holdover for the specified duration of time regardless of PON connectivity. The timer is started once its initial value is set by the OLT and runs until expiration. While the timer is running, any condition that normally causes the ONT to drop the POTS loop voltage is ignored. Expiration of the timer restores the normal operation. As the TC layer connectivity can be maintained and the OMCC channel can be up while the timer is running, the ONT can be able to report the remaining holdover time.

4.4 Ethernet service OAM

An ONT supporting IEEE 802.1ag Ethernet Connectivity Fault Management (CFM) supports the following OMCI ME:

Dot1ag maintenance domain (299). Dot1ag maintenance association (300), Dot1ag default MD level (301), Dot1ag MEP (302), Dot1ag MEP status (303), Dot1ag MEP CCM database (304), Dot1ag CFM stack (305), Dot1ag chassis-maintenance info (306).

The ONT automatically creates an instance of Dot1ag chassis-maintenance info (306) ME. The ONT creates an instance of Dot1ag CFM stack (305) ME and an instance of Dot1ag default MD level (301) for each supported MAC bridge. The ONT creates an instance of Dot1ag MEP CCM database (304) ME and an instance of Dot1ag MEP status (303) ME with each Dot1ag MEP (302) ME instantiated by the OLT CT.

The ONT uses the notification capabilities of the Dot1ag MEP (302) ME to report CFM alarms and failure conditions.

The ONT supports the loopback test & test results and link trace test & test result messages per G.988 sections A.{2|3}.21 and A.{2|3}.39.

Note that the Ethernet service OAM support on the IBONT type PON device is a function of the NID.

4.5 Switched Ethernet service NID support

This section applies to Integrated Business ONT (IBONT) only.

IBONT is an ONT type providing Network Interface Device (NID) functionality in Verizon E-Line architecture which supports Switched Ethernet Services (SES) and Converged Packet Access (CPA). IBONT is a dual-managed device which supports OMCI provisioning of the basic traffic management functionality and the non-OMCI (NETCONF/YANG) management path for NID management and control.

4.6 RF video overlay service

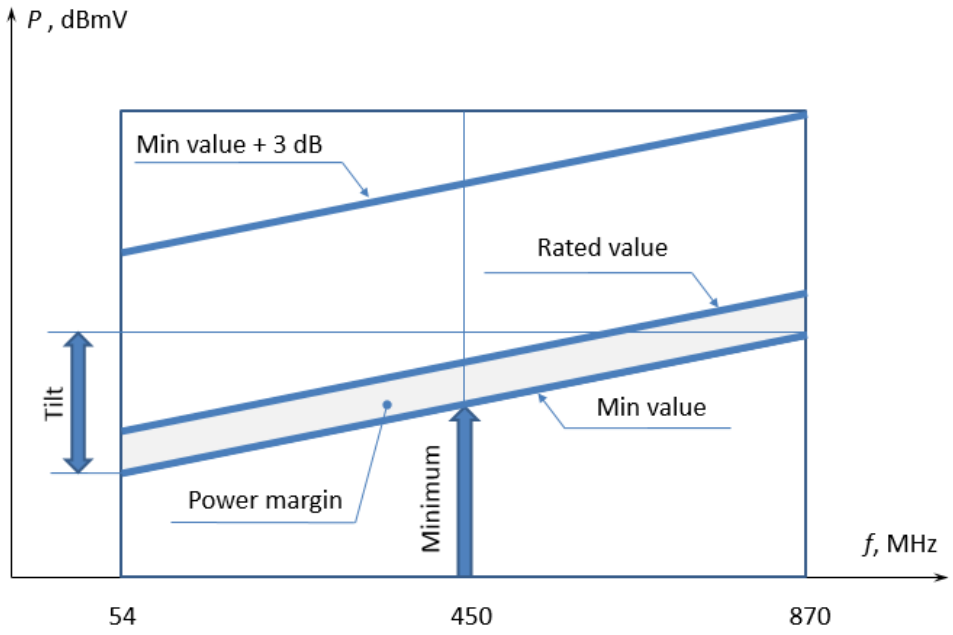
Subject to operator requirements, an ONT may have to support RF video services via the wavelength overlay in the 1550—1560 nm band. A single downstream-only optical carrier is modulated by an RF signal with the frequency range from 54 to 870 MHz which allows to accommodate up to 136 digital 256-QAM channels, each having the data capacity of 38.8107 Mbit/s.

The configuration and monitoring of the RF video services is performed using the standard-based Physical path termination point video UNI (82) and Physical path termination point video ANI (90) MEs. This section provides additional clarifications describing the use of these MEs.

4.6.1 Physical path termination point video UNI (82) ME

The ONT is not required to provide power over the coaxial cable. Therefore, the value of the Power control attribute shall be set and maintained at the default 0.

The RF output alarms are raised with respect to the ONT's RF power level value. That value is subject to the minimum requirement (specified as +12 dBmV per channel at 450 MHz at the ONT's coax connector) and the tilt (specified as 2dB positive between 54 MHz and 870 MHz).



The ONT monitors the composite RF power over the frequency range and raises an alarm whenever the inferred per channel power falls out of range for any channel. The ONT raises the Video-OOR-Low alarm, if the output power falls below the minimum value boundary. The ONT raises the Video-OOR-High alarm, if the output power exceeds the minimum value shifted up by 3 dB. The ONT's own rated power level may exceed the specified minimum. To accommodate this case, an additional alarm in the vendor-specific space is specified to indicate that while the output power is within the required boundaries, the equipment is not functioning correctly.

4.6.2 Physical path termination point video ANI (90) ME

As the ONT is required to support the RF frequency range from 54 MHz to 870 MHz, it should report the Frequency range high and Frequency range low attributes consistent with this requirement. That is, the low end of the lower range is 50 MHz, and the upper end of the higher range is 870 MHz.

The ONT is required to support measurement of both total optical power level at the fiber interface within the 1550—1560 nm band, and broadband RF power level at the video service interface. Therefore, the Signal capability attribute should default to 7, and should not allow any change.

As only digital 256-QAM channels are supported, the Signal level min, Signal level max, and Pilot frequency attributes are not used and should default to 0.

The ONT is required to support the Broadband RF AGC, but not the Optical AGC. The AGC mode attribute should default to 1, and should not allow change.

Alarming with respect to the optical power level is required. Therefore, the Video lower optical threshold and Video upper optical threshold with the corresponding alarms should be supported.

4.7 IP Multicast video service

Subject to operator requirements, an ONT may have to support IP-based multicast services. The primary OpenOMCI v2.2 applications include Electronic Programming Guide (EPG), and Set Top Box (STB) firmware management. The full IPTV support, including multicast streaming of IPTV content channels, may be required at a later date.

For these applications the general approach is that multicast content is transmitted downstream on the PON via a single ANI-to-UNI multicast XGEM port carrying traffic associated with one or more single-tagged multicast VLANs.

The ONT is expected to merge authorized multicast content into the associated UNI side data service. The multicast operations profile ME is utilized to indicate the VLAN tag manipulation required to perform this merge operation. It is a mandatory requirement that the unauthorized multicast traffic coming on the multicast XGEM port must be dropped by the ONT. To meet this requirement, the ONT is expected to perform the snooping operation on the upstream IGMP flow, so that it tracks requested and authorized multicast addresses filtered by the multicast operations profile configuration.

The text and figure below from [G.988 8.2.2 Layer 2 functions] illustrate the applicable OMCI MEs and relationships necessary to support multicast video applications. The relationship diagram of the IP-based multicast services modifies Fig.8.2.2-10/G.988 with exclusion of the optional Extended VLAN tagging operation configuration data ME.

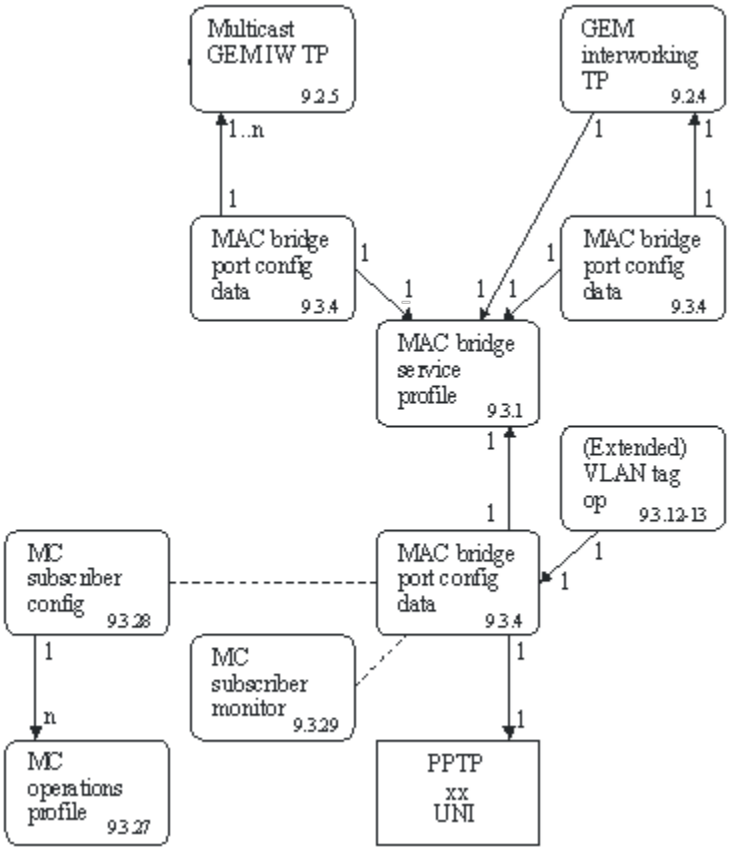


Figure 12 (4-4) — Relationship diagram for video multicast service (modified Fig.8.2.2-10/G.988).

Multicast-specific MEs are described in the sections below to enhance interoperability.

4.7.1 Multicast GEM IW TP (281)

The Multicast GEM interworking TP provides a reference to the ANI-to-UNI GEM port network CTP ME (268) used for multicast control. All multicast content is carried over a unique multicast XGEM port, but can be tagged to one or more multicast VLANs.

In the OpenOMCI applications the IPv4 multicast address table and IPv6 multicast address table are not used as these functions are covered in a more flexible form in the Multicast operations profile and Multicast subscriber configuration info MEs.

4.7.2 Multicast operations profile (309)

The Multicast Operations profile provides the ability to configure relevant IGMP protocol aspects, VLAN tagging behavior and multicast address ACLs. An instance of this ME will be created for each multicast VLAN applicable to the ONT. Refer directly to [G.988 9.3.27 "Multicast operations profile"] for attributes that are not clarified here. Within the scope of Verizon OpenOMCI, all attributes of that ME, as listed in ITU-T G.988 (2017) Amd 4(2021), are considered mandatory.

- **IGMP version:** the selection of a non-deprecated, non-reserved code point depends on operator requirements, and the ONT shall follow the setting made by the OLT.
- **IGMP function:** for a single UNI ONT, the OLT selects code point 0, transparent IGMP snooping.
- **Upstream IGMP TCI / Upstream IGMP tag control:** the OLT shall configure these 2 attributes such that upstream IGMP traffic will be tagged equivalent to the subscriber service. This would typically be code point 1 for untagged subscriber traffic or code point 2 or 3 for tagged subscriber traffic.
- **Upstream IGMP rate:** The default value used by the OLT is 8 message per second. Conceptually, the rate regulator for *N* messages per second is implemented as a token bucket of the maximum capacity *N*, initially completely filled, to which a token is added every 1/*N* seconds.
- **Dynamic access control list table:** This table will be used for installing the allowed multicast addresses for the subscriber's multicast video service. As of Verizon OpenOMCI v2.2, only row part format 0 is used. The use of row part format 1 and row part format 2 along with a non-zero source IP address are for future study. The OLT and ONT implementations should not preclude the use of row part formats 1 and 2 in the future.
- **Downstream IGMP and multicast TCI:** this attribute controls the downstream tagging of both the IGMP/MDL control and multicast content. The OLT shall set the first byte of this attribute to 0x01 to ensure striping of a VLAN tag on both the control and content flows.

Referring to ITU-T G.988 (2017) Amd 4(2021), note that a comment titled "Discussion of table size" has been incorrectly formatted as an attribute of the Multicast operations profile ME. In fact, in the attribute list, Static access control list table follows immediately the Dynamic access control table.

4.7.3 Multicast subscriber config info (310)

The Multicast subscriber config info ME establishes the relationship between the multicast video service and the data service. In the context of OpenOMCI the following guidelines will be established:

- The Multicast subscriber config info ME will be associated with the MAC bridge port config data instance referencing the PPTP Ethernet UNI.
- In the case where a single multicast VLAN is in use the Multicast operations profile pointer will be used and the Multicast service package table will not be populated by the OLT.
- In the case where multiple multicast VLANs are applicable for the subscriber, the Multicast service package table will be used rather than the Multicast operations profile pointer for the ONT to determine appropriate settings, VLAN tagging behavior and ACL behavior for the associated multicast VLAN.

4.7.4 Multicast subscriber monitor (311)

It is expected that the ONT support the Multicast subscriber monitor to allow access to current status related to the multicast video service.

4.7.5 Extended VLAN tagging operation configuration (171)

In the context of OpenOMCI the optional Extended VLAN tagging operation configuration instance associated with the Multicast GEM interworking TP will not be utilized.

5. Standard G.988 ME adaptation to OpenOMCI

5.1 High level guidelines

In addition to having short-term ONU/OLT OMCI interoperability, Verizon OpenOMCI needs to be flexible enough to support future features without redefining the Verizon OpenOMCI specification. To support this, Verizon OpenOMCI needs to be as encompassing as possible to minimize the need for future revisions. This goal of flexibility will also guide the optional behavior (if any) for MEs and attributes.

The following list summarizes the high level guidelines used to refine G.988 for use in the Verizon OpenOMCI specification. As these are guidelines, there can be exceptions in order to improve interoperability.

1. Interoperability is limited to the OMCI protocol level, “look and feel”, scale, performance, “form/fit/function” are not part of OMCI interoperability.
2. All G.988 optional attributes will become mandatory or O1 (See below), with few exceptions.
3. All AVCs are supported.
4. All alarms are supported.
5. All actions are supported.
6. All notifications are supported.
7. All TCAs are supported.
8. ARC and ARC interval are supported.
9. All set/get tables are supported.
10. All get current data actions are mandatory.
11. No attributes appearing as deprecated in G.988 are to be used.
12. If an ME has an "extended" counterpart, the extended version will be used.
13. If a performance monitoring history data type ME has a 64-bit version, that version is used.
14. Unless otherwise noted, all equipment IDs will be CLEI code formatted.
15. Some attributes use 0 to indicate “internal ONU policy” or other indication that the feature is defined by the ONU vendor. These attributes cannot have the value of 0.
16. Some attributes are marked as “G.984 only” or “G.987 only” in G.988. These attributes are not used.
17. In the case where a feature described by a mandatory attribute is not supported by the ONU, the attribute still needs to be supported.

5.2 Mandatory and optional attributes

5.2.1 Discussion on Mandatory and optional attributes

This section is used for discussion and illustrative purposes and does not impose any requirements or constraints on implementing Verizon OpenOMCI.

ITU-T Recommendation G.988 uses qualification "mandatory" in several different ways. Although MEs are marked as mandatory or optional, certain fundamental MEs (ONU-G) are obviously mandatory. But some MEs are feature based, such as VoIP. If an ONU does not support VoIP, does it need to support those VoIP MEs with mandatory attributes? It is not clear from the recommendations.

A similar analogy can be made for attributes.

1. Some mandatory attributes are required for basic operation of the feature, such as Serial number on ONU-G.
2. Some mandatory attributes refer to features that are dependent on implementation, such as Battery Backup in ONU-G: "This Boolean attribute controls whether the ONU performs backup battery monitoring (assuming it is capable of doing so)". What does it mean to have a mandatory attribute to manage a feature that is optional? G.988 does not provide clear direction.
3. Some optional attributes are hardware-feature based, such as power shedding override (circuit pack). If the ONU does not support this feature, then there is no need to support the ME.
4. Some optional attributes are software-feature based, such as lower transmit power threshold (ANI-G). The measuring of the transmit power is supported by hardware, but the software chooses not to implement it.
5. Some optional attributes are based on service provisioning, such as RMEP 2 database table (Dot1ag MEP CCM database). The number of remote MEP databases depends on the number of remote MEPs.

5.2.2 Use of Mandatory and Optional in Verizon OpenOMCI

To clarify these rules, the Verizon OpenOMCI specification uses the following:

1. The specification identifies several ONU types, based on features (such as SFU, IBONT, etc.).
2. For each ONU type, the specification will identify which MEs must be supported.
3. For each attribute, the specification will assign one of the following categories

a. M – mandatory. Must be implemented as an ME, even if the ME refers to a feature not supported in that particular make/model of the ONU. When the attribute is accessed, the rules outlined in G.988 apply. Most G.988 Optional MEs are marked as Mandatory in the Verizon OpenOMCI specification

b. O1 – optional based on the provisioned service or the scale supported by the ONU. All G.988 scale based optional attributes are O1 in the Verizon OpenOMCI specification

c. O2 – optional based on vendor's discretion (very few of these)

Unless otherwise specified, the format and values allowed for attributes in the Verizon OpenOMCI generally follow G.988. The Verizon OpenOMCI defines any restrictions in attribute values, or constrains optional format values for attributes.

If needed, description for the rationale of restrictions, constraints or other notes are listed in Section 5.5.

5.3 MIB description

The detailed description of Verizon OpenOMCI MIB Verizon can be found in the spreadsheet that accompanies the present document. It represents a tabulated list of the MEs, attributes, alarms, AVCs, etc., defined for the Verizon Open OMCI specification, mandatory MEs, mandatory attributes and restricted ranges for attributes.

A summary of the MEs supported by the Verizon OpenOMCI specification can be found in Annex B

5.4 Attribute formats, values and optional syntax

Unless otherwise specified, the format and values allowed for attributes in the Verizon Open OMCI generally follow G.988. The Verizon OpenOMCI defines any restrictions in attribute values, or constrains optional format values for attributes.

If needed, description for the rationale of restrictions, constraints or other notes are listed in Section 5.

Several attributes on G.988 have optional semantic use, or unspecified formats, or listed as to be specified by the vendor. The Verizon OpenOMCI specification defines and constrains these attributes to ensure interoperability. The definition and constraints are listed in the accompanying spreadsheet.

5.5 Detailed and operational requirements

The following sections provide information on the use or definition of the MEs/attributes, as needed.

5.5.1 Modeling of interfaces

All interfaces will be modeled using the cardholder and circuit pack MEs.

Non-pluggable interfaces will be modeled as virtual cardholders, using cardholder and circuit pack MEs.

5.5.2 9.1.2-Attr-12, Current connectivity mode

This value is deprecated in Verizon OpenOMCI. ONT's use of this value is not specified and G988 implies that even if set, it does not have an effect on the ONT.

5.5.3 "Software Image"/9.1.4-Attr-00, Managed entity ID

Per G.988, software image ME must support fundamental usage, which consists of two images of the ONU software; this is indicated by the last byte having a value of 0x0 or 0x1. However, there may be ONUs that require more than one software image (SIP user agent, FPGA images, etc.).

The Verizon OpenOMCI specification supports the use of multiple software images. If needed, the ONU will use the fundamental MEID for different virtual slots.

This is not a requirement on the ONT that it must use multiple software images. However, the OLT must support the management of these files via the fundamental method with virtual slots.

5.5.4 "Port Mapping", 9.1.8

The Port Mapping ME is optional, and needed only when an ONU has pluggable cards with different port types.

5.5.5 "ONU Remote Debug", 9.1.12-Attr-01, Command format

This attribute offers two options for the debug command, ASCII text or free format.

Since the OLT simply passes the command/response messages without interpretation, and the OLT is agnostic to the format, either format can be supported based on ONU vendor requirements.

This is an example where the Verizon Open OMCI is NOT specifying a command format; the reason is that this ME is needed for vendor debug but is not impacted by interoperability requirements.

5.5.6 “ANI-G”, 9.2.1 Managed Entity ID

In the particular case where a plug in card can support multiple ANIs, each ANI is modeled as multiple virtual cards with one port, rather than one card with multiple ports.

The reason is that there is no direct way to tie TCONTs to ports on cards, but there is a way to tie TCONTS to cards.

5.5.7 “GEM port network CTP”, 9.2.3-Attr-01, Port-ID

This attribute must follow the guidelines for this attribute in G.988, note 1.

5.5.8 “FEC performance monitoring history data”. 9.2.9-Attr-07, FEC Seconds

G.988 refers to “FEC anomaly”. Verizon Open OMCI interprets this as “uncorrectable code words”.

5.5.9 “Priority Queue”, 9.2.10-Attr-02

This attribute must follow the guidelines listed for this attribute in G.988, note 2.

5.5.10 “Ethernet performance monitoring history data 3”9.5.4

Per G.988 suggestion in note 2, Ethernet frame extended PM 64-bit is used instead.

5.5.11 ME Sequencing

For voice and data services, the OLT controls the sequence of ME creation. The ONU should be able to accept ME creation in any sequence without long term degraded operation or long term impact on existing services.

However for qualification purposes, the OLT should create MEs as follows

1. For data services, the OLT should follow the ME sequences outlined in G.988, Annex II.1
2. For voice services, the OLT should follow the ME sequences outlined in G.988,AnnexII.4, with the constraints that SIP uses IP for service provisioning
3. In general, the OLT should follow the practice in G.988 Annex II.1.2.1.5 of “It is recommended to follow the depicted ordering of steps and the ordering of messages within those steps to ensure that no ME pointer attribute is populated prior to the creation of its target ME “

5.5.12 Admin down until last piece is put into place

For all service creations, service should be disabled until all MEs have been instantiated and populated. This can be accomplished in several ways, including

1. Either endpoint (UNI side or ANI side) must be put in an admin-down state (if supported) and then brought back up once all the provisioning is completed
2. If the service end-points don't have and admin down state, then the OLT must create the service end-point as the last ME.

5.5.13 Intentionally blank

This section has been found redundant and is deprecated in Verizon OpenOMCI specification V.2.00 and higher.

5.5.14 Use of Flexible Configuration and Status Portal

An ONT creates an instance of the FCSP ME in support of each pluggable transceiver. An ONT in a pluggable transceiver module (PTM) form factor creates an instance of FCSP ME to represent itself.

The FCSP portal is used to report the data in the pluggable module's memory map containing identification, diagnostic, and control information (for SFP+, see SFF-8472, Figure 4-1; for XFP, see SFF INF-8077i, Figure 28). This information is reported through the Status Message attribute. The Status Message Available attribute reflects the availability of the data based on the ONT's ability to read the data from the PTM.

Three examples are shown below.

5.5.14.1 FCSP ME supporting an ANI-side XFP PTM

An XFP PTM is used to provide an ANI for the ONT. There is a need to report the module ID and other status information from Upper and Lower memory map sections of the pluggable modules that support SFF INF-8077i. This is done using the Flexible Configuration and Status Portal. An instance of FCSP ME for each PTM is created by the ONT.

Attribute Name	Use
Managed Entity ID	65420
Service Instance:	
Service Type ID	0x0000

Protocol	0xFF
Service Instance	based on instance
Configuration Method	0x0003
Network address pointer	0 (NA)
Administrative State	0x00
Operational State	0x00, when PTM is plugged in and operating normally; 0x01, when PTM is removed; 0x02, when PTM is plugged in but with a hardware error
Cause for last abnormal halt	0xFFFF
Configuration Portal Update Available	0 (static)
Configuration Portal Table	Don't care (NA)
Configuration Portal Result	0 (static)
Status Message Available	0 (default)
Status Message	Tag Class 0x0000 items: o Tag item identifier 0x0001 : SFF INF-8077i MSA serial ID data -- Serial address A0H upper memory table 01H, bytes 128-255. o Tag item identifier 0x0002: SFF INF-8077i Digital diagnostic – Serial address A0H lower memory table, bytes 0-118. o Tag item identifier 0x0003: SFF INF-8077i User EEPROM data – Serial address A0H upper memory map table 02H, bytes 128-255. o Tag item identifier 0x0007: PTM Supplier name, ASCII format. o Tag item identifier 0x0008: PTM Supplier part number, ASCII format. o Tag item identifier 0x0009: PTM OEM name, ASCII format. **Note: The contents should match SFF INF-8077i Table 01H bytes 163-148.** o Tag item identifier 0x000A: PTM OEM part number, ASCII format. **Note: The contents should match SFF INF-8077i Table 01H bytes 183-168.** o Tag item identifier 0x000B: Informational Text, ASCII format. For use by the ONT to provide opaque printable text that could be displayed by the North-bound interface.
Status Message Result	0 (default)
Associated ME Class	263 (ANI)

Associated ME Class Instances	Appropriate MEID
AVC Name	
Operational Status	Normal use
Configuration Portal Results	NA
Status Message Available	Normal use
Alarm Name	
Receive Configuration Timeout	NA
Status Acknowledgement timeout	NA
Service requires attention – medium	NA
Service requires attention - high	NA

5.5.14.2 FCSP ME supporting a UNI-side SFP+ PTM

An SFP+ PTM, which supports SFF-8472, can be used to provide a UNI in some ONT types. An instance of FCSP ME for each PTM is created by the ONT.

Attribute Name	Use
Managed Entity ID	65420
Service Instance:	
Service Type ID	0x0000
Protocol	0xFF
Service Instance	Based on instance
Configuration Method	0x0003
Network address pointer	0 (NA)
Administrative State	0x00
Operational State	0x00, when PTM is plugged in and operating normally; 0x01, when PTM is removed; 0x02, when PTM is plugged in but with a hardware error
Cause for last abnormal halt	0xFFFF
Configuration Portal Update Available	0 (static)

Configuration Portal Table	Don't care (NA)
Configuration Portal Result	0 (static)
Status Message Available	0 (default)
Status Message	Tag Class 0x0000 items: o Tag item identifier 0x0004: SFF-8472 MSA serial ID data – Serial address A0H, bytes 0-95. o Tag item identifier 0x0005: SFF-8472 Digital diagnostic – Serial address A2H, bytes 0-119. o Tag item identifier 0x0006: SFF-8472 Vendor specific data – Serial address A0H, bytes 96-127. o Tag item identifier 0x0007: PTM Supplier name, ASCII format o Tag item identifier 0x0008: PTM Supplier part number, ASCII format. o Tag item identifier 0x0009: PTM OEM name, ASCII format. o Tag item identifier 0x000A: PTM OEM part number, ASCII format. o Tag item identifier 0x000B: Informational Text, ASCII format. For use by the ONT to provide opaque printable text that could be displayed by the North-bound interface.
Status Message Result	0 (default)
Associated ME Class	11 (PPTP Ethernet UNI)
Associated ME Class Instances	Appropriate MEID
AVC Name	
Operational Status	Normal use
Configuration Portal Results	NA
Status Message Available	Normal use
Alarm Name	
Receive Configuration Timeout	NA
Status Acknowledgement timeout	NA
Service requires attention – medium	NA
Service requires attention - high	NA

5.5.14.3 FCSP ME supporting a pluggable ONT

This example applies when the ONT itself is implemented in a form factor of a pluggable optical module. An SFP+ ONT supports SFF-8472 diagnostic monitoring interface. Such an ONT is powered up through the host interface and

necessarily is operational only when it is plugged into a host. An instance of FCSP ME representing an SFP+ ONT is created by the ONT itself.

Attribute Name	Use
Managed Entity ID	65420
Service Instance:	
Service Type ID	0x0000
Protocol	0xFF
Service Instance	0x00
Configuration Method	0x0003
Network address pointer	0 (NA)
Administrative State	0x00
Operational State	0x00, when SFP+ ONT is plugged in and operating normally; 0x02, when SFP+ ONT is plugged in, but with a hardware error
Cause for last abnormal halt	0xFFFF
Configuration Portal Update Available	0 (static)
Configuration Portal Table	Don't care (NA)
Configuration Portal Result	0 (static)
Status Message Available	0 (default)
Status Message	Tag Class 0x0000 items: o Tag item identifier 0x0004: SFF-8472 MSA serial ID data – Serial address A0H, bytes 0-95. o Tag item identifier 0x0005: SFF-8472 Digital diagnostic – Serial address A2H, bytes 0-119. o Tag item identifier 0x0006: SFF-8472 Vendor specific data – Serial address A0H, bytes 96-127. o Tag item identifier 0x0007: PTM Supplier name, ASCII format o Tag item identifier 0x0008: PTM Supplier part number, ASCII format. o Tag item identifier 0x0009: PTM OEM name, ASCII format. o Tag item identifier 0x000A: PTM OEM part number, ASCII format. o Tag item identifier 0x000B: Informational Text, ASCII format. For use by the ONT to provide opaque printable text that could be displayed by the North-bound interface.

Status Message Result	0 (default)
Associated ME Class	263 (ANI)
Associated ME Class Instances	Appropriate MEID
AVC Name	
Operational Status	Normal use
Configuration Portal Results	NA
Status Message Available	Normal use
Alarm Name	
Receive Configuration Timeout	NA
Status Acknowledgement timeout	NA
Service requires attention – medium	NA
Service requires attention - high	NA

5.5.14.4 FCSP ME supporting Multicast Image Transfer

See section C.4.

5.5.15 Definition of Column C “Value” in OMCI MIB Spreadsheet

Column C describes the range of values that are allowed for each attribute. The meaning of each description listed below

Description	Meaning
Per 988	Values as specified in the Source column (G.988 or an amendment)
0, 1, A, etc.	Restricted to the value
1..4, etc	Restricted to the range of values
!0, !1, !A, etc	Not that value
NA	Not applicable; used for deprecated attributes
>8, > 0xB2	Value greater than that listed
0x…	Hexadecimal representation
CLEI, ASCII String	ASCII string containing CLEI code
2 char	Two characters

0x**[00,01)	For Software Image MEID, restricts the last 2 bits to be 00 or 01 (must have main and backup versions)
0xSSBB	0xSSBB as per 988
Per 988 <text>	Per 988 with supplemental text
XML	XML format
Per VOS	Per Verizon Open OMCI Specification (present document)

1

2

5.5.16 Clarification on the use of “Extended VLAN tagging operation configuration data” ME

The G.988 definition of the Extended VLAN tagging operation configuration data ME had been a subject of known ambiguity that was partially addressed G.988 (2017) Amd. 2 (08/2019). In the use of this ME, the implementers shall comply with the following guidelines:

(1) In case of IBONT providing Ethernet Virtual Circuit (EVC) service, where a large number of EVCs may be supported, the VLAN manipulation is a function of NID and is provisioned over the non-OMCI (NETCONF/YANG) management path.

(2) For all Verizon ONT types and services, the Association type attribute is expected to be set to Physical path termination point Ethernet UNI (2).

(3) When Downstream mode 0 is configured, in the special case of matching the untagged upstream traffic which results in adding the VLAN tag and p-bit in the upstream direction, the inverse operation in the downstream direction should match on the VLAN tag only, as the p-bit becomes not applicable upon tag removal.

(4) In addition, an implementation is advised to employ one-to-one mappings over one-to-many mappings.

5.5.17 Extended remote debug operation

The Extended Remote Debug ME is used for information exchange with an ONU for the purpose of debugging an ONU from an OLT. This may be appropriate due to the lack of other debug access (primarily due to security concerns of the operator) or because the ONU is located remotely. It is not the purpose of remote debug access to offer management abilities that should be done using conventional OMCI or other vendor-specific MEs. An OLT access node that supports 3rd party ONU may use the Extended Remote Debug ME to troubleshoot 3rd party ONUs (the command table and command reply table will be opaque to the OLT) as shown in Figure 5-1.

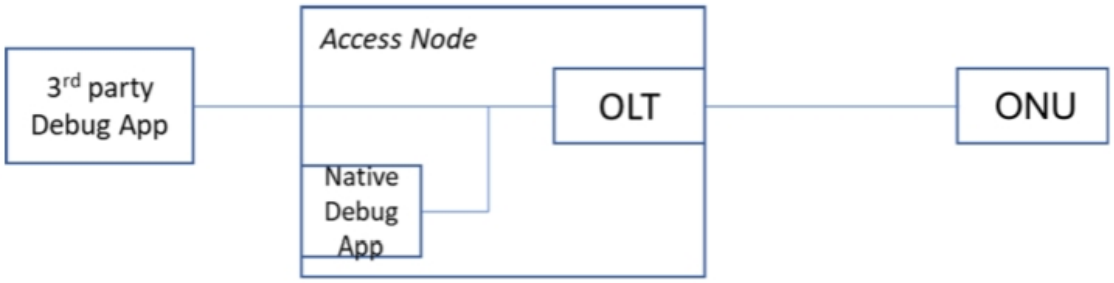
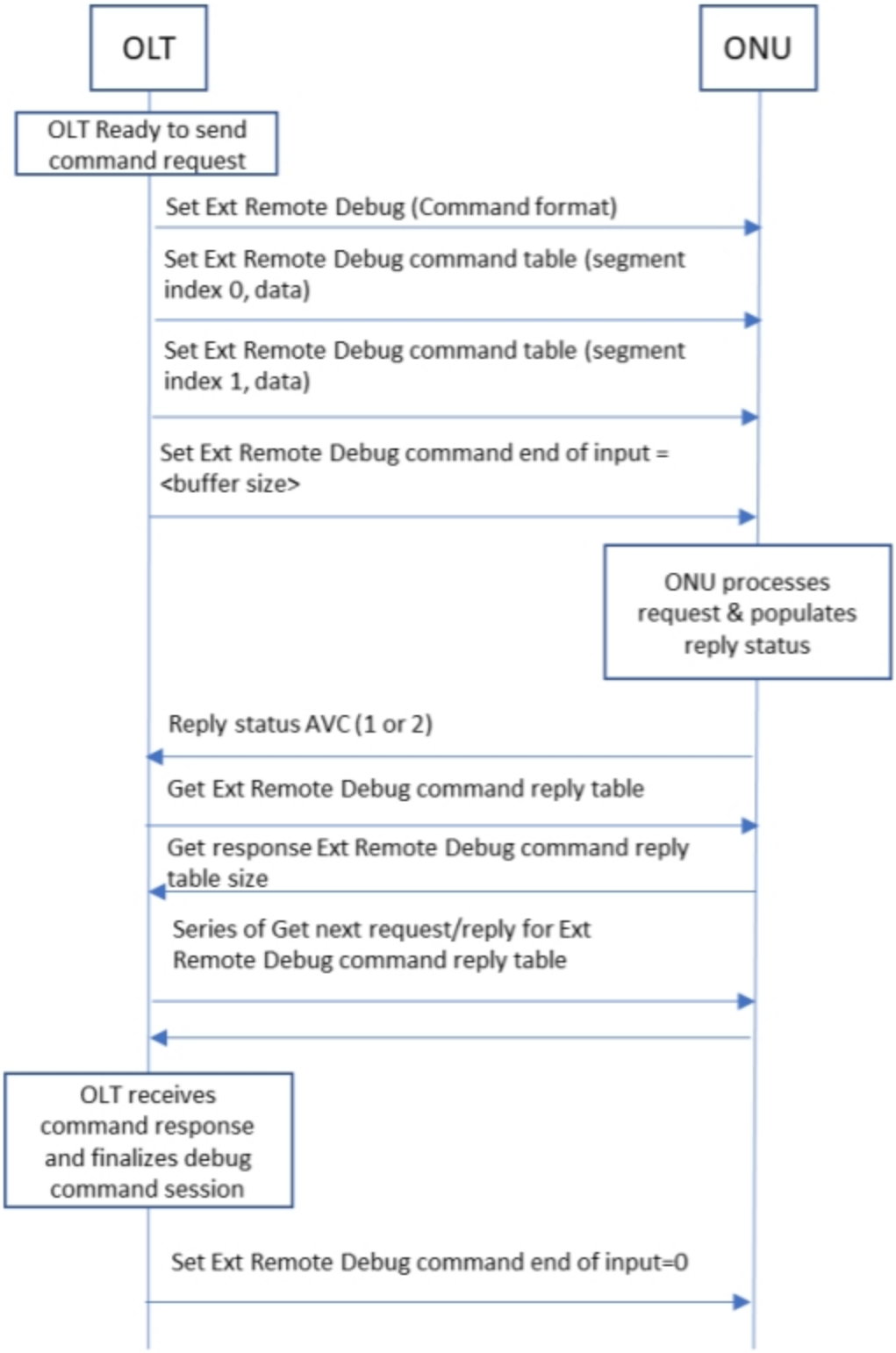


Figure 5-1 – Conceptual 3rd party and native debug cases

The Extended Remote Debug ME has the ability to send large debug requests and collect up to 0xFFFFFFFE bytes of response. The information exchange may be ASCII or opaque coded. The ME ID of this object is always zero. Since the object is created by the ONU, no other ME IDs are possible. The remote debug capability of an ONU is discovered through the MIB upload discovery mechanism. Command syntax (in either mode) is vendor-specific, as is the reply information. However, some general guidelines for the ASCII mode are suggested as best practice. The ASCII command help should be supported by the ONU, such that the ONU would then reply with the available commands that may be supported by the remote debug process. In addition, if a command is not recognized or cannot be parsed by the ONU, a reply to that nature should be returned in the specified format. The use of OMCI error codes to indicate an error in the ASCII command (not the OMCI command) is not advised. Vendors should instead embed within the command reply table a suitable error code/error string.

Figure 5-2 below illustrates a potential Extended Remote Debug ME exchange. In this example, the OLT sends a command string to the ONU that the ONU successfully processes and sends a response. The sequence of events in this example are as follows: - OLT sets the command format and sets the command end of input with a length in bytes of the request. In the case of ASCII formatted commands, the length must include the NULL terminating byte for ASCII formatted commands. - OLT sets the command table incrementing the segment index for each segment of the data - OLT sets the command end of input with the length in bytes of the request including a NULL terminating byte for ASCII formatted commands - ONU initiates processing the request (including automatically resetting the command table) - ONU populates the reply status and generates an associated AVC - OLT reads the reply table (for response available statuses) - OLT finalizes the transaction by writing code point 0 (reset) to the end of input attribute.


OLT
ONU
OLT Ready to send command request
Set Ext Remote Debug (Command format)
Set Ext Remote Debug command table (segment index 0, data)
Set Ext Remote Debug command table (segment index 1, data)
Set Ext Remote Debug command end of input = <buffer size>
ONU processes request & populates reply status
Reply status AVC (1 or 2)
Get Ext Remote Debug command reply table
Get response Ext Remote Debug command reply table size
Series of Get next request/reply for Ext Remote Debug command reply table
OLT receives command response and finalizes debug command session
Set Ext Remote Debug command end of input=0

1

Figure 5-2 – Example of successful remote debug exchange

6. Modified G.988 Managed entities

The modifications are shown in orange font.

6.1 Adaptation of FEC PMHD

According to the explanation in clause 1.3.2 of the present document, this clause modifies the specification of the FEC performance monitoring history data ME to ensure generalized applicability in the TWDM PON context.

6.1.1 Clause 9.2.9: FEC performance monitoring history data

NOTE: The managed entity modifications originally specified in this section have since been incorporated into the ITU-T Rec G.988, and an enhanced version of the ME, using 64 bit thresholds, has been provided. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.2.22. The remainder of this clause is retained for information and reference only.

This managed entity collects performance monitoring data associated with PON downstream FEC counters. Instances of this managed entity are created and deleted by the OLT.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of the ANI-G managed entity or an instance of the TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the ANI-G or TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 managed entity that contains PM threshold values. Since no threshold value attribute number exceeds 7, a threshold data 2 ME is optional. (R, W, Set-by-create) (mandatory) (2 bytes)

Corrected bytes: This attribute counts the number of bytes that were corrected by the FEC function. (R) (mandatory) (4 bytes)

Corrected code words: This attribute counts the code words that were corrected by the FEC function. (R) (mandatory) (4 bytes)

Uncorrectable code words: This attribute counts errored code words that could not be corrected by the FEC function. (R) (mandatory) (4 bytes)

Total code words: This attribute counts the total received code words. (R) (mandatory) (4 bytes)

FEC seconds: This attribute counts seconds during which there was a forward error correction anomaly. (R) (mandatory) (2 bytes)

Actions

Create, delete, get, set

Get current data (optional)

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	Corrected bytes	1
1	Corrected code words	2
2	Uncorrectable code words	3
4	FEC seconds	4
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1 managed entity.		

6.2 Configuration server NOTIFY-related errors

Based on the Verizon SIP UNI requirement, this section adds three NOTIFY-related alarms to the VoIP config data ME.

6.2.1 Clause 9.9.18: VoIP config data

The VoIP configuration data managed entity defines the configuration for VoIP in the ONU. The OLT uses this ME to discover the VoIP signaling protocols and configuration methods supported by this ONU. The OLT then uses this ME to select the desired signaling protocol and configuration method. The entity is conditionally required for ONUs that offer VoIP services.

An ONU that supports VoIP services automatically creates an instance of this managed entity.

Relationships

One instance of this managed entity is associated with the ONU.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Available signaling protocols: This attribute is a bit map that defines the VoIP signaling protocols supported in the ONU. The bit value 1 specifies that the ONU supports the associated protocol.

- 1 (LSB) SIP
- 2 ITU-T H.248
- 3 MGCP

(R) (mandatory) (1 byte)

Signaling protocol used: This attribute specifies the VoIP signaling protocol to use. Only one type of protocol is allowed at a time. Valid values are:

- 0 None
- 1 SIP
- 2 ITU-T H.248
- 3 MGCP
- 0xFF Selected by non-OMCI management interface

(R, W) (mandatory) (1 byte)

Available VoIP configuration methods: This attribute is a bit map that indicates the capabilities of the ONU with regard to VoIP service configuration. The bit value 1 specifies that the ONU supports the associated capability.

- 1 (LSB) ONU capable of using the OMCI to configure its VoIP services.
- 2 ONU capable of working with configuration file retrieval to configure its VoIP services.
- 3 ONU capable of working with [BBF TR-069] to configure its VoIP services.
- 4 ONU capable of working with IETF sipping config framework to configure its VoIP services.

Bits 5..24 are reserved by ITU-T. Bits 25..32 are reserved for proprietary vendor configuration capabilities. (R) (mandatory) (4 bytes)

VoIP configuration method used: Specifies which method is used to configure the ONU's VoIP service.

- 0 Do not configure – ONU default
- 1 OMCI

2	Configuration file retrieval
3	Broadband Forum TR-069
4	IETF sipping config framework
5..240	Reserved by ITU-T
241..255	Reserved for proprietary vendor configuration methods

(R, W) (mandatory) (1 byte)

VoIP configuration address pointer: If this attribute is set to any value other than a null pointer, it points to a network address managed entity, which indicates the address of the server to contact using the method indicated in the VoIP configuration method used attribute. This attribute is only relevant for non-OMCI configuration methods.

If this attribute is set to a null pointer, no address is defined by this attribute. However, the address may be defined by other methods, such as deriving it from the ONU identifier attribute of the IP host config data ME and using a well-known URI schema.

The default value is 0xFFFF (R, W) (mandatory) (2 bytes)

VoIP configuration state: Indicates the status of the ONU VoIP service.

0	Inactive: configuration retrieval has not been attempted
1	Active: configuration was retrieved
2	Initializing: configuration is now being retrieved
3	Fault: configuration retrieval process failed

Other values are reserved. At ME instantiation, the ONU sets this attribute to 0. (R) (mandatory) (1 byte)

Retrieve profile: This attribute provides a means by which the ONU may be notified that a new VoIP profile should be retrieved. By setting this attribute, the OLT triggers the ONU to retrieve a new profile. The actual value in the set action is ignored because it is the action of setting that is important. (W) (mandatory) (1 byte)

Profile version: This attribute is a character string that identifies the version of the last retrieved profile. (R) (mandatory) (25 bytes)

Actions

Get, set

Notifications

Attribute value change

Number	Attribute value change	Description
1..7	N/A	
8	Profile version	Version of last retrieved profile
9..16	Reserved	

Alarm

Alarm number	Alarm	Description
0	VCD config server name	Failed to resolve the configuration server name.
1	VCD config server reach	Cannot reach configuration server (the port cannot be reached, ICMP errors)
2	VCD config server connect	Cannot connect to the configuration server (due to bad credentials or other faults after the port has responded)
3	VCD config server validate	Cannot validate the configuration server
4	VCD config server auth	Cannot authenticate the configuration session (e.g., missing credentials)
5	VCD config server timeout	Timeout waiting for response from configuration server
6	VCD config server fail	Failure response received from configuration server
7	VCD config file error	Configuration file received has an error
8	VCD subscription name	Failed to resolve the subscription server name
9	VCD subscription reach	Cannot reach subscription server (the port cannot be reached, ICMP errors)
10	VCD subscription connect	Cannot connect to subscription server (due to bad credentials or other faults after the port has responded)
11	VCD subscription validate	Cannot validate subscription server
12	VCD subscription auth	Cannot authenticate subscription session (e.g., missing credentials)
13	VCD subscription timeout	Timeout waiting for response from subscription server
14	VCD subscription fail	Failure response received from subscription server
15	VCD reboot request	A non-OMCI management interface has requested a reboot of the ONU. NOTE – This alarm is used only to indicate the request and not to indicate that a reboot has actually taken place.
16 (208)	VCD Notify timeout	Failure to receive the NOTIFY that the server is required to send following acceptance of a SUBSCRIBE request.

17 (209)	VCD Notify malformed	Malformed NOTIFY request
18 (210)	VCD Notify Rejected	NOTIFY request specifies that the subscription is terminated because it has been rejected by the server or the server has no resources to accept it (this may be received following a SUBSCRIBE to which the server returned a 202 (Accepted) response)
19..207	Reserved	
208..223	Vendor-specific alarms	Not to be standardized

6.3 Power shedding attribute default values

Verizon OpenOMCI specification provides the default values for the attributes of the ONU power shedding ME (133). The following text modifies the *Attributes* section of the ME description. Other sections of the ME description are referred to clause 9.1.7/G.988.

6.3.1 Clause 9.1.7: ONU power shedding

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this ME. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Restore power timer reset interval: The time delay, in seconds, before resetting the power-shedding timers after full power restoration. Upon ME instantiation, the ONU sets this attribute to 0. (R, W) (mandatory) (2 bytes)

For each class of service (CoS), an interval attribute is defined below. The value 0 disables power shedding, while the value 1 enables immediate power shedding, i.e., as soon as AC power fails. Other values specify the time, in seconds, to keep the service active after AC failure before shutting them down and shedding power. For the purposes of Verizon OpenOMCI specification, upon ME instantiation, the ONU sets the default values of the interval as specified below. If left unspecified, the default value of an interval attribute is 0.

Data class shedding interval: (R, W) (mandatory) (2 bytes)
Default value: 0x0384 (that is, 15 min).

Voice class shedding interval: This attribute only pertains to voice services that terminate on the ONU and are under the management control of the OMCI. (R, W) (mandatory) (2 bytes)
Default value: 0x0000 (disabled).

Video overlay class shedding interval: (R, W) (mandatory) (2 bytes) Default: 0x0001 (immediate power shedding).

Video return class shedding interval: (R, W) (mandatory) (2 bytes) Default: 0x0001 (immediate power shedding).

Digital subscriber line (DSL) class shedding interval: (R, W) (mandatory) (2 bytes)

ATM class shedding interval: (R, W) (mandatory) (2 bytes)

CES class shedding interval: (R, W) (mandatory) (2 bytes)

Frame class shedding interval: (R, W) (mandatory) (2 bytes)

Sdh-sonet class shedding interval: (R, W) (mandatory) (2 bytes)

Shedding status: Binary indication of power-shedding status for each shedding class. If this 2 byte field is depicted 0b ABCD EFGH IJKL MNOP, its bits are assigned as follows-

A	Data class
B	Voice class
C	Video overlay class
D	Video return class
E	DSL class
F	ATM class
G	CES class
H	Frame class
I	Sdh-sonet class
J..P	Reserved and set to 0

The ONU sets each bit to 1 when power shedding is active, and clears it to 0 when the service is restored. (R) (optional) (2 bytes)

6.4 ONU-G alarms

Verizon OpenOMCI v2.2 enhances the ONU-G (256) ME to support autonomous Rogue ONT mitigation. The set of ONU-G alarms is extended and a clarifying text is added to the ME preamble.

6.4.1 Clause 9.1.1: ONU-G

This ME represents the ONU as equipment. The ONU automatically creates an instance of this ME. It assigns values to read-only attributes according to data within the ONU itself.

This ME has evolved from the ONT-G of [ITU-T G.984.4].

The additional ONU-G ME alarms, which are presently specified in the vendor-specific number space, are used to provide an indication of detectable ONU transceiver conditions

that may lead to failure or rogue behavior of the ONU. The ONU monitors the Tx_Fault condition of the optical transceiver interface and, once the Tx_Fault flag is raised, obtains the reason code and follows the internal logic to translate the reason code into an appropriate ONU-G alarm and to provide embedded Dying Gasp indication. The embedded Dying Gas indication (see the appropriate TC layer specification) should not be confused with the OMCI-based Loss-of-power-specific Dying Gasp alarm. Note that the ONU-G Tx_Fault alarms represent a best-effort signaling mechanism, since a transceiver fault may prevent the OLT from reading those alarms.

Relationships

In ITU-T GTC based PON applications, all other MEs in this Recommendation are related directly or indirectly to the ONU-G entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this ME. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Vendor ID: This attribute identifies the vendor of the ONU. It is the same as the four most significant bytes of the ONU serial number as specified in the respective transmission convergence (TC) layer specification. (R) (mandatory) (4 bytes)

Version: This attribute identifies the version of the ONU as defined by the vendor. The character value 0 indicates that version information is not available or applicable. (R) (mandatory) (14 bytes)

Serial number: The serial number is unique for each ONU. It is defined in the respective TC layer specification and contains the vendor ID and version number. The first four bytes are an ASCII-encoded four-letter vendor ID. The second four bytes are a binary encoded serial number, under the control of the ONU vendor. (R) (mandatory) (8 bytes)

Traffic management option: This attribute identifies the upstream traffic management function implemented in the ONU. There are three options:

0 Priority controlled and flexibly scheduled upstream traffic. The traffic scheduler and priority queue mechanism are used for upstream traffic.

1 Rate controlled upstream traffic. The maximum upstream traffic of each individual connection is guaranteed by shaping.

2 Priority and rate controlled. The traffic scheduler and priority queue mechanism are used for upstream traffic. The maximum upstream traffic of each individual connection is guaranteed by shaping.

For a further explanation, see Appendix II.

Downstream priority queues are managed via the GEM port network CTP ME.

Upon ME instantiation, the ONU sets this attribute to the value that describes its implementation. The OLT must adapt its model to conform to the ONU's selection. (R) (mandatory) (1 byte)

Deprecated: This attribute is not used. If it is present, it should be set to 0. (R) (optional) (1 byte)

Battery backup: This Boolean attribute controls whether the ONU performs backup battery monitoring (assuming it is capable of doing so). *False* disables battery alarm monitoring; *true* enables battery alarm monitoring. (R, W) (mandatory) (1 byte)

Administrative state: This attribute locks (1) and unlocks (0) the functions performed by the ONU as an entirety. Administrative state is further described in clause A.1.6. (R, W) (mandatory) (1 byte)

Operational state: This attribute reports whether the ME is currently capable of performing its function. Valid values are enabled (0) and disabled (1). (R) (optional) (1 byte)

ONU survival time: This attribute indicates the minimum guaranteed time in milliseconds between the loss of external power and the silence of the ONU. This does not include survival time attributable to a backup battery. The value zero implies that the actual time is not known. (R) (optional) (1 byte)

Logical ONU ID: This attribute provides a way for the ONU to identify itself. It is a text string, null terminated if it is shorter than 24 bytes, with a null default value. The mechanism for creation or modification of this information is beyond the scope of this Recommendation, but might include, for example, a web page displayed to a user. (R) (optional) (24 bytes)

Logical password: This attribute provides a way for the ONU to submit authentication credentials. It is a text string, null terminated if it is shorter than 12 bytes, with a null default value. The mechanism for creation or modification of this information is beyond the scope of this Recommendation. (R) (optional) (12 bytes)

Credentials status: This attribute permits the OLT to signal to the ONU whether its credentials are valid or not. The behaviour of the ONU is not specified, but might, for example, include displaying an error screen to the user. (R, W) (optional) (1 byte)

Values include:

0 Initial state, status indeterminate
1 Successful authentication
2 Logical ONU ID (LOID) error

3 Password error
4 Duplicate LOID
Other values are reserved.

Extended TC-layer options: This attribute is meaningful in ITU-T G.984 systems only. It is a bit map that defines whether the ONU supports (1) or does not support (0) various optional TC-layer capabilities of [ITU-T G.984.3]. Bits are assigned as follows.

Bit	Meaning
1 (LSB)	Annex C of [ITU-T G.984.3], PON-ID maintenance.
2	Annex D of [ITU-T G.984.3], PLOAM channel enhancements: swift_POPUP and Ranging_adjustment messages.
3..16	Reserved

(R) (optional) (2 bytes)

Actions

Get, set

Reboot: Reboot the ONU.

Test: Test the ONU. The test action can be used either to perform equipment diagnostics or to measure parameters such as received optical power, video output level, battery voltage, etc. Test and test result messages are defined in Annex A/G.988.

Synchronize time: This action synchronizes the start time of all PM MEs of the ONU with the reference time of the OLT. All counters of all PM MEs are cleared to 0 and restarted. Also, the value of the interval end time attribute of the PM MEs is set to 0 and restarted. See clause I.4 for further discussion of PM.

NOTE – This function is intended only to establish rough 15 min boundaries for PM collection. High precision time of day synchronization is a separate function, supported by the OLT-G ME.

Notifications

Test result: Test results are reported via a test result message if the test is invoked by a test command from the OLT.

Attribute value change

Number	Attribute value change	Description
1..7	N/A	
8	Op state	Operational state change
9	N/A	
10	LOID	Logical ONU ID
11	Lpw	Logical password
12..16	Reserved	

1

Alarm

Alarm number	Alarm	Description
0	Equipment alarm	Functional failure on an internal interface
1	Powering alarm	Loss of external power to battery backup unit. This alarm is typically derived through an external interface to a battery backup unit, and indicates that AC is no longer available to maintain battery charge.
2	Battery missing	Battery is provisioned but missing
3	Battery failure	Battery is provisioned and present but cannot recharge
4	Battery low	Battery is provisioned and present but its voltage is too low
5	Physical intrusion	Applies if the ONU supports detection such as door or box open
6	ONU self-test failure	ONU has failed autonomous self-test
7	Loss-of-power-specific Dying gasp	ONU is powering off imminently due to loss of power to the ONU itself. This alarm may be sent in conjunction with the powering alarm if the backup unit cannot supply power and the ONU is shutting down.
8	Temperature yellow	No service shutdown at present, but the circuit pack is operating beyond its recommended range.
9	Temperature red	Some services have been shut down to avoid equipment damage. The operational state of the affected PPTPs indicates the affected services.
10	Voltage yellow	No service shutdown at present, but the line power voltage is below its recommended minimum. Service restrictions may be in effect, such as permitting no more than *N* lines off-hook or ringing at one time.
11	Voltage red	Some services have been shut down to avoid power collapse. The operational state of the affected PPTPs indicates the affected services.
12	ONU manual power off	The ONU is shutting down because the subscriber has turned off its power switch.

Alarm

Alarm number	Alarm	Description
13	Inv-Image	Software image is invalid (Note)
14	PSE overload yellow	Indicates that the ONU is nearing its maximum ability to supply the known PoE demand of the attached PDs. The thresholds for declaring and clearing this alarm are vendor-specific.
15	PSE overload red	Indicates that the ONU is unable to supply all of the PoE demand of the attached PDs and has removed or reduced power to at least one PD.
16..207	Reserved	
208	Temporal rogue interference	ONU has identified itself as a potential source of upstream transmission outside of the allocated time interval, either via correlation of TX_SD and TX_Burst_Enable or due to Tx_Fault with Rogue ONU Fault reason flag.
209	Bias voltage fault	Tx_Fault with Bias Voltage Fault reason flag
210	Mod voltage fault	Tx_Fault with Mod Voltage Fault reason flag.
211	PIN voltage fault	Tx_Fault with PIN Voltage Fault reason flag.
212	Optics Module temp	Optical transceiver temperature outside of normative operation range
213..223	Vendor-specific alarms	Not to be standardized
NOTE – The ONU should declare this alarm only outside the software download process.		

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7. Additional MEs in the vendor-specific space

Table 1: Additional MEs in the vendor-specific space

ME class	Managed entity	Comments	Standards-track or G.988 ME class
65400	Verizon OpenOMCI		No
65401	TWDM system profile		442
65402	TWDM channel		443
65403	Watchdog config data		Yes
65404	Watchdog PM history data		Yes
65420	Flexible Configuration Status Portal		Yes
65421	Flexible Configuration Status Portal PM history data		Yes
65422	ONU3-G		441
65405	SIP UNI Application server alarm status		Yes
65406	TWDM channel PHY/LODS PM history data	Per Tab 14-1/G.989.3	444
65407	TWDM channel XGEM PM history data	Per Tab 14-1/G.989.3	445
65408	TWDM channel PLOAM PM history data part 1	Per Tab 14-1/G.989.3	446
65409	TWDM channel PLOAM PM history data part 2	Per Tab 14-1/G.989.3	447
65410	TWDM channel PLOAM PM history data part 3	Per Tab 14-1/G.989.3	448
65411	TWDM channel tuning PM history data part 1	Per Tab 14-1/G.989.3	449
65412	TWDM channel tuning PM history data part 2	Per Tab 14-1/G.989.3	450
65413	TWDM channel tuning PM history data part 3	Per Tab 14-1/G.989.3	451

65414	TWDM channel OMCI PM history data	Per Tab 14-1/G.989.3	452
65415	POTS UNI extension		Yes
65416	VoIP call diagnostics part 1		Yes
67417	VoIP call diagnostics part 2		Yes
65418	VoIP call diagnostics part 3		Yes
65423	IP host performance monitoring history data part 2		Yes
65424	ONU operational performance monitoring history data		Yes

7.1 Core OpenOMCI MEs

7.1.1 Verizon OpenOMCI managed entity

This managed entity provides the means for the ONT to declare its type and to declare and negotiate the effective version of the Verizon OpenOMCI specification. The only instance of this ME is instantiated autonomously by the ONU.

Relationships

The instance of this managed entity is implicitly associated with ONU-G ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. There is only one instance of this ME with ID = 0. (R) (mandatory) (2 bytes).

Supported specification version: This attribute uniquely identifies the highest version of the Verizon OpenOMCI specification which the ONU supports. The version is represented by a pair of integer values (R, V), where R, the two most significant bytes, is the major release, and V, the least significant bytes, is the version within release. For backward compatibility purposes the ONU is expected to support all lower numbered versions within the same release of OpenOMCI specification, as well as the generic G.988 without OpenOMCI features. (R) (mandatory) (4 bytes).

PON device type: This attribute refers to the ONU type specified by Verizon in the appropriate requirement documents. Together with the Supported specification version attribute, it unambiguously identifies the set of MEs, attributes and features supported by the ONU. The following table provides the PON device type values supported in the present version on the Verizon OpenOMCI specification.

PON device type	PON device
0x0004	NG-PON2 SFU ONT
0x0006	NG-PON2 ETH ONT
0x0008	NG-PON2 SOHO ONT
0x000C	NG-PON2 IBONT
0x000E	NG-PON2 BHR

(R) (mandatory) (2 bytes).

Specification version in use: This attribute is populated by the OLT to indicate an agreement to use the OpenOMCI specification and its effective version. If the OLT does not access the Verizon OpenOMCI ME, or if it sets the value of the Specification Version in Use attribute to (0,0), the ONT should presume that Verizon OpenOMCI is not supported and employ the common G.988 set of the OMCI MEs, attributes, and features. (R, W) (mandatory) (4 bytes).

Actions

Get, set.

7.1.2 TWDM System Profile managed entity

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. However, due to an inadvertent editorial mistake, the timer attributes incorrectly appeared in ITU-T Rec G.988 (2017) Amd. 2 (08/2019) as R-only. Compliance with Verizon OpenOMCI v2.2 implies that implementation of this ME should follow ITU-T Rec G.988 (2017) Amd. 5, Clause 9.16.1. The remainder of this clause is retained for information and reference only.

This managed entity models the TWDM subsystem of NG-PON2 system. An instance of this ME corresponds to a physical or virtual slot of the ONU housing one or more access network interfaces. The instances of this ME are instantiated autonomously by the ONU.

Relationships

An instance of this managed entity is associated with an instance of a circuit pack that supports a PON interface function. It is, therefore, implicitly associated with all ANI-G MEs whose managed entity ID refers the specific Slot ID.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. This two-byte number is represented as 0xSS00, where SS indicates the slot ID (as defined in clause 9.1.5 and referenced in clause 9.2.1 of G.988. (R) (mandatory) (2 bytes)

Total TWDM channel number: This attribute indicates the number of distinct TWDM channels the ONT supports in given slot. (R) (mandatory) (1 byte)

Channel partition index: Channel partition index represented as 0x0P, and maintained as a part of the OMCI MIB, rather than a TC layer config parameter. See clause 6.1.5.9/G.989.3 for complete description. (R, W) (mandatory) (1 byte)

Channel partition waiver timer: An unsigned integer representing the time interval measured in seconds for which the ONU is blocked from an activation attempt on Channel Partition restriction. The timer corresponds to the Tcpi parameter of G.989.3A1 and measures the elapsed time from the moment an ONU finds a downstream wavelength channel belonging to a non-matching channel partition, to the moment the ONU resets its CPI in non-volatile memory to the default value (zero) in order to waive the CPI restriction. The default is 300 seconds. The value of 0xFFFF indicates infinity (no Channel Partition waiver is granted). (R, W) (mandatory) (4 bytes)

LODS re-initialization timer: This attribute, which corresponds to timer TO2 of G.989.3 expressed as an integer number of PHY frame intervals, specifies the duration of time an ONU without configured wavelength channel protection (WLCP = OFF) waits in the Intermittent LODS (O6) state before transitioning into the Initial (O1) state for reactivation. The default value upon instantiation is 1000 (125 ms). (R, W) (mandatory) (4 bytes)

LODS protection timer: This attribute, which corresponds to timer TO3 of G.989.3 expressed as an integer number of PHY frame intervals, specifies the duration of time an ONU with configured wavelength channel protection (WLCP = ON) waits in the Intermittent LODS (O6) state before transitioning into the Downstream tuning (O8) state to tune into the pre-configured protection wavelength channel. The default value upon instantiation is 200 (25 ms). (R, W) (mandatory) (4 bytes)

Downstream tuning timer: This attribute, which corresponds to timer TO4 of G.989.3 expressed as an integer number of PHY frame intervals, specifies the duration of time an ONU in the Downstream tuning (O8) state attempts to validate the specified target downstream wavelength channel (obtaining DWLCH ok to work), before transitioning into the Initial (O1) state for reactivation. Note that the Rx tuning time proper is included into this interval. The default value upon instantiation is 1000 (125 ms). (R, W) (mandatory) (4 bytes)

Upstream tuning timer: This attribute, which corresponds to timer TO5 of G.989.3 expressed as an integer number of PHY frame intervals, specifies the duration of time an ONU in the Upstream tuning (O9) state attempts to obtain the upstream tuning confirmation in the specified target upstream wavelength channel before transitioning into the Initial (O1) state for reactivation. The default value upon instantiation is 1000 (125 ms). (R, W) (mandatory) (4 bytes)

Location label 1: This attribute represents the first part of the field, which is written by the OLT to provide the topological location information for the specific OLT channel termination within the operator domain. This attribute is not interpreted by the ONU, but may be used by a dual-managed ONU as a part of an alarm report provided over non-OMCI management channel. (R, W) (mandatory) (24 bytes)

Location label 2: This attribute represents the second part of the field, which is written by the OLT to provide the topological location information for the specific OLT channel termination within the operator domain. This attribute is not interpreted by the ONU, but may be used by a dual-managed ONU as a part of an alarm report provided over non-OMCI management channel. (R, W) (mandatory) (24 bytes)

Actions

Get, set.

7.1.3 TWDM channel managed entity

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.2.

Considering that the G.988 version of this ME contains a modified specification of the **Active channel indication** attribute, care should be taken in implementing this attribute. In particular, the second sentence of the attribute description in G.988 should be interpreted as follows:

"The ONU sets the attribute to true when it receives the **non-void** Channel_Profile PLOAM messages for that channel."

The remainder of this clause is retained for information and reference only.

This managed entity provides an anchor for the MEs involved in collection of performance monitoring statistics per TWDM channel, as stipulated by Clause 14, G.989.3. Instances of this managed entity are instantiated autonomously by the ONU.

Relationships

One or more instances of this managed entity are implicitly associated with the TWDM System profile ME. The number of instances created is announced by the Total TWDM channel number attribute of the TWDM System profile ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. This two-byte number is represented as 0xSSBB, where SS indicates the ONU slot ID, and BB is the TWDM channel ME number assigned by the ONU itself, starting from 0 in the ascending order. (R) (mandatory) (2 bytes)

Active channel indication: A Boolean attribute indicating whether the ME is associated with an active TWDM channel, in which the ONU can receive downstream optical signal and transmit upstream as instructed. The default value is FALSE. The ONU sets the attribute to TRUE, once it first confirms the channel active by successfully attaching to that channel. All TWDM channel MEs associated with a given slot/circuit pack can be active. The ONU reverts the attribute to FALSE, once the OLT withdraws Channel_Profile PLOAM messages for that channel. (R,) (mandatory) (1 byte)

Operational channel indication: A Boolean attribute which is set to TRUE for an active TWDM channel in which the ONT is currently operating. The operational statistics is accumulated in the Performance monitoring history data MEs associated with that TWDM channel. (R) (mandatory) (1 byte)

Downstream wavelength channel: For an active TWDM channel, this attribute identifies the downstream wavelength channel in reference to Table 11-2/G.989.2. For an inactive channel it has value 0xFF. (R) (mandatory) (1 byte)

Upstream wavelength channel: For an active TWDM channel, this attribute identifies the upstream wavelength channel in reference to Table VIII-5/G.989.2. For an inactive channel its value of 0xFF. (R) (mandatory) (1 byte)

Actions

Get, set.

7.1.4 Watchdog configuration data managed entity

This managed entity communicates the ONU's watchdog capabilities, which are applicable for rogue behavior prevention. The ONU implements a watchdog as a self-policing function to monitor its own upstream transmission parameters and to detect potentially adverse conditions in order to prevent behaviors that can manifest themselves as rogue from the OLT perspective. Watchdog config data ME is autonomously instantiated by the ONU upon instantiation of ANI-G ME.

Relationships

An instance of this managed entity is implicitly associated with the ANI-G ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through the identical ME ID, this ME is implicitly associated with an instance of ANI-G ME. (R) (mandatory) (2 bytes)

Upstream transmission timing drift self-monitoring capability: This attribute refers to the timing drift of the upstream transmission, expressed as an absolute value measured in the bit periods with respect to the nominal upstream line rate of 2.48832 Gbit/s, regardless of the actual upstream line rate of the ONU. The first two bytes of a four-byte structure contain a minimum monitored value (zero); the second two bytes, the maximum monitored value. The value of 0xFFFFFFFF indicates that the self-monitoring capability is not supported. (R) (mandatory) (4 bytes)

Upstream transmission wavelength drift self-monitoring capability: This attribute refers to the frequency drift of the upstream transmission, expressed as an absolute value measured in units of 1 GHz. The first two bytes of a four-byte structure contain a minimum monitored value (zero); the second two bytes, the maximum monitored value. The value of 0xFFFFFFFF indicates that the self-monitoring capability is not supported. (R) (mandatory) (4 bytes)

Mean in-channel optical power self-monitoring capability: This attribute refers to the mean launch optical power of burst-mode transmitter in the operating upstream wavelength channel, expressed as 2's complement in units of 0.1dBm. The first two bytes of a four-byte structure contain the minimum monitored value; the second two bytes, the maximum monitored value. The value of 0xFFFFFFFF indicates that the self-monitoring capability is not supported. (R) (mandatory) (4 bytes)

Mean out-of-channel optical power spectral density self-monitoring capability: This attribute refers to the out-of-channel optical power spectral density (OOC-PSD) with respect to the current operating upstream wavelength channel and the spectral averaging interval of 15 GHz, expressed as a positive value in units of 0.1dBm. The first two bytes of a four-byte structure contain the minimum monitored value; the second two bytes, the maximum monitored value. The value of 0xFFFFFFFF indicates that the self-monitoring capability is not supported. (R) (mandatory) (4 bytes)

Mean optical power spectral density "when not enabled" self-monitoring capability: This attribute refers to optical power spectral density when not enabled (WNE-PSD) with respect to the spectral averaging interval of 15 GHz, expressed as a positive value in units of 0.1dBm. The first two bytes of a four-byte structure contain the minimum monitored value; the second two bytes, the maximum monitored value. The value of 0xFFFFFFFF indicates that the self-monitoring capability is not supported. (R) (mandatory) (4 bytes)

Dying Gasp enabled: This attribute provides an indication whether the ONU currently supports the Dying Gasp function. A stand-alone ONU supporting Dying Gasp by design statically sets this attribute to 0x01. A stand-alone ONU unable to support Dying Gasp by design statically sets this attribute to 0x00. A pluggable ONU determines whether the host supports the Dying Gasp function and conveys an indication of the same to the OLT using this attribute. Thus, upon instantiation of the ME, an SFP+ ONU initially sets this attribute to 0x00; then changes the value to 0x01, once the voltage is detected on pin 7 of the host interface, and maintains statically at 0x01 thereafter. Note that the implied behavior of the host in this

case is based upon functional overloading of pin 7, beyond the capabilities specified in SFF-8472. (R) (mandatory) (1 byte)

Actions

Get.

Notifications

None.

7.1.5 Watchdog performance monitoring history data

This managed entity reports the results of ONU's self-monitoring of its transmission parameters. Each attribute is an appropriately filtered value based on the most recent observations. Instances of this managed entity are instantiated and deleted by the OLT.

Relationships

An instance of this managed entity is implicitly associated with the ANI-G ME and Watchdog config data ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. With respect to the Watchdog PM history data ME, this attribute is not used. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Upstream transmission timing drift: This attribute reports the self-monitored value based on the recent observations. It is expressed as an absolute value measured in the bit periods with respect to the nominal upstream line rate of 2.48832

Gbit/s, regardless of the actual upstream line rate of the ONU. (R) (mandatory) (2 bytes)

Upstream transmission wavelength drift: This attribute reports the self-monitored value based on the recent observations and expressed as an absolute value measured in units of 1 GHz. (R) (mandatory) (2 bytes)

Mean in-channel optical power: This attribute reports the self-monitored value based on the recent observations and expressed in units of 0.1dBm. (R) (mandatory) (2 bytes)

Mean out-of-channel optical power spectral density: This attribute reports the self-monitored value based on the recent observations and expressed as a positive value in units of 0.1dBm with respect to the spectral averaging interval of 15 GHz. (R) (mandatory) (2 bytes)

Mean optical power spectral density "when not enabled" short time scale: This attribute reports the self-monitored short-time peak value based on the recent observations and expressed as a positive value in units of 0.1dBm with respect to the spectral averaging interval of 15 GHz. (R) (mandatory) (2 bytes)

Mean optical power spectral density "when not enabled" long time scale: This attribute reports the self-monitored long-time average value based on the recent observations and expressed as a positive value in units of 0.1dBm with respect to the spectral averaging interval of 15 GHz. (R) (mandatory) (2 bytes)

Actions

Create, delete, get, set.

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	Timing draft warning	1
1	Timing drift shut-off	2
2	Wavelength drift warning	3
3	Wavelength drift shut-off	4

4	N/A	
5	Transmit optical power too high warning	6
6	Transmit optical power too high shut-off	7
7	OOC-PSD too high warning	8
8	OOC-PSD too high shut-off	9
9	Short time scale WNE-PSD too high warning	10
10	Short time scale WNE-PSD too high shut-off	11
11	Long time average WNE-PSD too high warning	12
12	Long time average WNE-PSD too high shut-off	13
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.1.6 Flexible Configuration Status Portal

This managed entity provides a means to configure and report status for a wide range of services and applications running on the ONU. The ME is constructed to support IP-based (streaming message) and OMCI-based (block-oriented) management protocols. Only one method would be used for a given service type.

This ME does not have any services specific attributes, deferring these to the details of the configuration table or to IP datagrams. An instance of this managed entity is created by an ONU for each entity that can be supported by this ME. The OLT can create additional instances as needed.

The configuration portal's structure is not visible to G.988. However the configuration portal is modeled as a table, each row being 25 bytes. The first byte of the row is the row index and is not part of the configuration information.

Relationships

An instance of this managed entity is explicitly associated with the instance of the ME represented by the attributes "Associated ME class" and "Associated ME class instance".

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. (R, W, Set-by-create) (mandatory) (2 bytes)

Service Instance: This attribute identifies the specific service type supported by the given instance this ME. The Service Instance consists of three parts.

The first two bytes contain the Service Type ID, as documented below.

The third byte identifies the transport protocol on top of the IP protocol to be used to carry the service. 0 = UDP; 1 = TCP; 2 = SCTP; 0xFF means not used (for message based configuration)

The fourth byte identifies the instance of the Service Type ID on the associated ME-class and ME instances. Typically only one instances of a service will be instantiated on a given entity.

The mapping of Service Type ID to service follows IANA "Service Name and Transport Protocol Number Registry". Services which are not in the registry are assigned specific code points. This specification supports the following Service Type IDs.

.

Service	Service Type ID (IANA port number)	Protocol
NETCONF over SSH	830	TCP
IPFIX	4739	UDP
MCIT	1028	0xFF
XFP/SFP MSA Data	0	0xFF

(R, W) (mandatory) (4 bytes)

Configuration Method: This attribute indicates the configuration/status management method used for this service instance. The two management methods are IP or message based. The management methods for the configuration and the status can be independently set, although typically both would be set to the same value. Bit value of 0 means the configuration and status is carried over an IP path; value of 1 means the configuration and status is carried over the configuration and status portals.

Bit	**Meaning**
1. (LSB)	Configuration management method

2. Status management method

(R, W) (mandatory) (2 bytes)

Network Address: This is a pointer to a network address ME. Used if Bit 1 and/or Bit 2 of Configuration Method is set to 0. Null means network address is not used. (R, W) (mandatory) (2 bytes)

Administrative State: This attribute allows to administratively control the service over OMCI. The value of 0x00 indicates the service is unlocked, that is, allowed to operate normally. The value of 0x01 indicates the service is locked, that is, should stop. As a rule, the default value upon instantiation is 0x01. (R, W) (mandatory) (1 byte)

Operational State: This value represents the operational state of the service. The value of 0 indicates normal operation; 1 indicates stopped; other values are Service Type dependent. (R) (mandatory) (1 bytes)

Cause for last abnormal halt: This attribute represents a service type specific code for the last abnormal halt of the service. It complements the operational state attribute to reflect the cause for the most recent abnormal halt of the service. Writing this attribute clears the setting. The default value is 0xFFFF (halt has not occurred yet) (R, W) (mandatory) (2 bytes)

Configuration Portal Update Available: This attribute indicates to the service that new data is available in the Configuration Portal. The default value is 0. The OLT sets the attribute to 1 to indicate new data in the Configuration Portal. This value should be set to non-zero only after the Configuration Portal Result attribute is zero. The OLT sets the attribute to 0 after it reads the Configuration Portal Result attribute having a non-zero value. (R, W) (mandatory) (2 bytes)

Configuration Portal Table: This attribute contains configuration information directed from the OLT towards the service. This attribute is used if Bit 1 of Configuration Method is set to 1. Each row of the table is defined as follows

Index into the table (1 byte)

Configuration Information (24 bytes)

The format of the message is service-type dependent. (R, W) (mandatory) (25N bytes)

Configuration Portal Result: This attribute reports the status of the service reading the configuration information via the Configuration Portal. The code points are: 0 indicates not read, 1 indicates read, and 2 indicates an internal error on read. The ONT sets the value to 1 or 2 after the Configuration Portal Update Available is set to non-zero and after it has read the data in the Configuration Portal. The ONT sets the value to 0 after it reads the Configuration Portal Update Available attribute is zero. (R, W) (mandatory) (1 byte).

Status Message Available This attribute indicates to the OLT that new data is available in the Status Message. The default value is 0. The ONT sets the attribute to N to indicate that the first N bytes of the Status Message contain new data and should occur only when the Status Message Result attribute is zero. The ONT sets the attribute to 0 after it reads the Status Message Result attribute having a non-zero value. (R, W), (mandatory) (2 bytes)

Status Message:

This attribute contains status information about the service. The format of the message is service-type dependent. The format of the message is a TLV based set of content that is service-type dependent. The expected format of the content is zero or more TLVs of the form:

- byte offset 0..1 : tag class identifier
- byte offset 2..3 : tag item identifier
- byte offset 4..5 : content length
- byte offset 6..N : information content

The OLT shall be able to ignore unknown tag class/item content and skip over it to the next potentially interpretable TLV. The following tag classes are defined:

- Tag class 0x0000 – Common Definition Class. Utilized for items of general and interoperable use.
- Other tag class code points are reserved.

The tag item identifiers, which are service-specific, are summarized in the following table.

Tag item identifier	Semantics

0x0001	SFF INF-8077i MSA serial ID data -- Serial address A0H upper memory table 01H, bytes 128-255.
0x0002	SFF INF-8077i Digital diagnostic – Serial address A0H lower memory table, bytes 0-118.
0x0003	SFF INF-8077i User EEPROM data – Serial address A0H upper memory map table 02H, bytes 128-255.
0x0004	SFF-8472 MSA serial ID data – Serial address A0H, bytes 0-95.
0x0005	SFF-8472 Digital diagnostic – Serial address A2H, bytes 0-119.
0x0006	SFF-8472 Vendor specific data – Serial address A0H, bytes 96-127.
0x0007	Pluggable transceiver module Supplier name, ASCII format.
0x0008	PTM Supplier part number, ASCII format.
0x0009	PTM OEM name, ASCII format.
0x000A	PTM OEM part number, ASCII format.
0x000B	Informational Text, ASCII format. For use by the ONT to provide opaque printable text that could be displayed by the North-bound interface.
0x000C	Error Code – 2 byte code point - 0 – ok /success - 1 – processing error - 2 – not supported - 3 – parameter error - 4 – unknown attribute - 5 – unknown attribute instance - 6 – device busy - 7 – instance exists - 8 – unsupported attribute value - 9 – attribute failed - 10 – action aborted - 11 – action in progress - 12 – remote failure - 13 – local failure

The get, get next sequence must be used with this attribute since its size is unspecified. Upon ME instantiation, the ONU sets this attribute to 0. (R) (mandatory) (x bytes)

Status Message Result: This attribute reports the status of the OLT reading the Status Message. The code points are: 0 indicates not read, 1 indicates read. The OLT sets the value to 1 after the Status Message Available is set to 1 and after it has read the data in the Status Message. The OLT sets the value to 0 after it reads the Status Message Available attribute is zero. (R, W) (mandatory) (1 byte).

Associated ME Class: This attribute identifies the ME class that this ME is associated with. (R, W) (mandatory) (2 bytes)

Associated ME Class Instance: This attribute identifies the MEID of the member of the Associated ME Class that this ME is associated with. (R, W) (mandatory) (2 bytes)

Actions

Create, Delete, Get, Set, Get Next, Set table (optional)

Notifications

Attribute value change

Number	Attribute value change	Description
5	Operational Status	Change in operational state of the service
09	Configuration Portal Result	Change in the Configuration Portal Result attribute
10	Status Message Available	Change in the Status Message Available attribute

Alarms

Number	Alarm	Description
0	Receive Configuration Timeout	ONU service has not received expected configuration information.
1	Status Acknowledgement timeout	ONU service has not received update on status result
2	Service requires attention – medium	ONU service has an error condition that requires attendtion; medium priority

3	Service requires attention - high	ONU service has an error condition that requires immediate attendtion; high priority

7.1.7 Flexible Configuration Status Portal PM history data

This managed entity provides statistics for the flexible configuration status portal. This ME is created by the OLT.

Relationships

An instance of this managed entity is implicitly associated with the instance of the Flexible Configuration Status Portal ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the Flexible Configuration Status Portal. (R, SBC) (mandatory) (2 bytes)

Service Up Time: This attribute reports the number of seconds this service has been instantiated. (R) (mandatory) (4 bytes)

Number of Configuration Octets Received: This attribute reports the number of configuration octets received. (R) (mandatory) (8 bytes)

Number of Configuration Messages Received: This attribute reports the number of configuration messages received. (R) (mandatory) (8 bytes)

Number of Status Octets Transmitted: This attribute reports the number of status octets transmitted. (R) (mandatory) (8 bytes)

Number of Status Messages Transmitted: This attribute reports the number of status messages transmitted. (R) (mandatory) (8 bytes)

Actions

Create, Delete, Get, Set.

7.1.8 ONU3-G

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this

ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.1.15. The remainder of this clause is retained for information and reference only.

This managed entity contains additional attributes and alarms associated with a PON ONU. The ONU automatically creates an instance of this managed entity. Its attributes are populated according to data within the ONU itself.

Upon instantiation of this ME, the Total number of status snapshots *S*, the Number of valid status snapshots *M*, and Next status snapshot index *K* are populated from the non-volatile memory. If the non-volatile memory values are not available (e.g., at the initialization of an off-the-shelf ONU), the Total number of status snapshots attribute is set to the maximum size of status snapshot record table the ONU can maintain., which a static capability parameter, while both the Number of valid status snapshots and the Next status snapshot index attributes are set to zero.

The Status snapshot record table is implemented as a circular buffer containing up to *S* record of size *N*. The size and format of the snapshot record are vendor-specific. Each time the ONU takes and stores a status snapshot, it increments the Number of valid status snapshots *M*, saturating at *S*, and increments Next status snapshot index *K* in modulo *S*:

$K := (K+1) \bmod S$.

By writing into the Snap action attribute, the OLT instructs the ONU to immediately take a status snapshot and to store it in the Status snapshot table. By writing into Reset action attribute, the OLT instructs the ONU to erase the Status snapshot record table. The OLT uses the attribute value change indication of the Next status snapshot index and Number of valid status snapshots attributes to confirm that its instructions have been executed by the ONU. If the OLT has issued no Snap action instructions, a change in the value of Next status snapshot index attributes between two consecutive reads indicates that a condition has arisen that has caused the ONU to record a status snapshot.

Two table attributes, the Status snapshot record table, and the Most recent status snapshot, provide the OLT access the status snapshot records. The former allows to retrieve the entire Status snapshot record table, the latter provide a quick access to the latest snapshot record.

By performing the Get operation on the Most recent status snapshot, the OLT can obtain the vendor-specific size of an individual snapshot record. The OLT is expected to pass the status snapshot records transparently, without parsing or interpreting them.

Relationships

This managed entity is associated with the ONU-G managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Flash memory performance value: A number in the range from 0 to 100 that characterizes the condition of the flash memory, with 0 representing factory fresh device, 100 representing end of life. (R) (mandatory) (1 byte)

Latest restart reason: The following code points are defined:

0x00 – Unspecified other;

0x01 – User initiated software restart;

0x02 – User initiated hardware restart;

0x03 – Self-monitor timer expiration;

0x04 – Hardware error (bus time-out, misaligned memory access, etc);

0x05 – Hardware auto-restart (on-board voltage monitor auto-restart, etc.);

0x06 – Over temperature;

0x07 – Software out of memory;

0x08 – Software auto-restart (unresolvable references, critical internal inconsistency);

0x09..0xDC – Reserved for future use;

0xDD..0xFF – Reserved for the ONU vendor use (requires documentation in the public domain).

Other codepoints reserved. (R) (mandatory) (1 byte)

Total number of status snapshots: The maximum size *S* of status snapshot record table. (R) (mandatory) (2 bytes)

Number of valid status snapshots: The number *M* of valid status snapshot records. (R) (mandatory) (2 bytes)

Next status snapshot index: This attribute identifies the index (ranging from 0 to *S* -- 1) of the next snapshot record to be taken in the snapshot record table. (R,) (mandatory) (2 bytes)

Status snapshot record table: The table of *M* status snapshot records. The size *N* and format of the snapshot record is vendor dependent. (R) (mandatory) (MxN bytes)

Snap action: Once the OLT writes this attribute, the ONU takes and records an urgent snapshot without shutting down the transceiver. (W) (mandatory) (1 byte)

Most recent status snapshot: This attribute provides access to the most recently taken status snapshot record. (R) (mandatory) (N bytes)

Reset action: Once the OLT writes this attribute, the ONU sets the Number of valid status snapshots and Next status snapshot index attributes to zero. (W) (mandatory) (1 byte)

Actions

Get, Get-next, set

Notifications

Attribute value change

Number	Attribute value change	Description
1	Flash mem perf	Flash memory performance value change
2	N/A	
3	N/A	
4	No of valid snapshots	A new snapshot has been recorded
5	N/A	
6	N/A	
7	N/A	
8..16	Reserved	

Alarm

Alarm number	Alarm	Description
0	Flash memory performance yellow	

Alarm

Alarm number	Alarm	Description
1	Flash memory performance red	
2	Loss of redundant power supply	In an ONU with redundant power supplies, an indication of the loss of one of the two redundant power supplies.
3	Loss of redundant power feed	In an ONU with dual -48VDC power feeds, an indication of the loss of one of the two power feeds.
4	Ground Fault	Ground fault; ONU has detected a loss of grounding or a degradation in the ground connection.

7.1.9 MAC swap loop configuration

An ONU that supports this ME automatically creates an instance of it. Immediately following the start-up phase, the OLT should set the ONU to the desired configuration.

Relationships

The single instance of this ME is associated with the ONU-G ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this ME. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Related Interface Pointer: This is a reference to the interface desired for the MAC swap loop function. This attirbute comprises 4 bytes. The first 2 bytes are the ME Class of the associated interface.

The following ME Classes are supported:

17 Physical path termination point Ethernet UNI

329 Virtual Ethernet interface point

The last 2 bytes are the ME ID pointer of the associated interface.

(R, W) (mandatory) (4 bytes)

Active flag: This is an indicator that is set to one when the MAC swap loop function is activated. (R, W) (mandatory) (1 byte)

VLAN-specific: This is an indicator restricting the MAC swap function to a single VLAN on the specified Physical path termination point Ethernet UNI. If set to zero, the MAC swap loop function applies to the Ethernet UNI as a whole, and, when the function is active, all services at this UNI are interrupted; that is, any upstream traffic arriving at the UNI from the user is blocked. Otherwise, the MAC swap loop function applies to the specific VLAN identiifed by the

subsequent attrobute, and, when the function is active, the services on this VLAN are interrupted, but other services on the UNI remain unaffected: any upstream traffic from the user with the specified VLAN ID is blocked, but Ethernet frames with other VLAN IDs are still delivered over the UNI both downstream and upstream. (R, W) (mandatory) (1 byte)

VLAN ID: This is a 12-bit identifier of the VLAN for which the the MAC swap loop function is configured. Set to 0x0000 upon instantiation and whenever the function is not VLAN-specific. (R, W) (mandatory) (2 bytes).

Actions

Get, set.

Notifications

None.

7.1.10 Extended remote debug

This ME is used for information exchange between the ONU and OLT for the purpose of debugging an ONU from an OLT. An OLT will send a vendor specific command format to the ONU, and the ONU will respond back with a vendor specific command response. Two formats are supported: ASCII and opaque format. Command request and reply are vendor specific. An ONU that supports remote debugging automatically creates an instance of this ME.

Note: Unlike ONU Remote Debug (158), this ME is reported during MIB upload to aid an OLT in identifying its support.

Relationships

One instance of this ME is associated with the ONU ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this ME. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Capabilities: This attribute specifies the supported debug capabilities. It is represented as a 16-bit bitmap with the individual indicator bits as described below. NOTE: It may be desirable for an OLT to use an ASCII request which generates a binary response from the ONU (e.g., gzip file).

(Bit 16) RRRR RRRR RRRR DCBA (Bit 1)

Bit 1 (A)	ASCII reply support	0: supported 1: not supported
Bit 2 (B)	Opaque reply support	0: supported 1: not supported
Bit 3 (C)	ASCII request support	0: supported 1: not supported
Bit 4 (D)	Opaque request support	0: supported 1: not supported
Bits 5–16 (R)	Reserved	Instantiated to 0; ignored on get.

(R) (mandatory) (2 bytes)

Command format: This attribute sets the format used by the OLT. Values are: 0: ASCII, 1 Opaque (W) (mandatory) (1 byte)

Command table: Command request data. Each row contains the following format:

Byte 2–25	Byte 1
24 Bytes of ASCII or opaque data. If ASCII data format is used, the command should be null terminated.	Segment Index used to validate the receipt of all expected command request data. Valid values are 0..255

(W) (mandatory) (N*25 bytes)

Command End of Input: This attribute conveys the command end of input action from the OLT's perspective. Valid values are:

0: reset request buffer

1..4095: number of bytes in the request buffer to act upon. For ASCII format this should include a NULL (0) terminator.

4096..65535: reserved.

(W) (mandatory) (2 bytes)

Command Reply Status: This attribute conveys the availability of ONU response data. Valid values are:

0: reset / no response available;

1: ASCII response available;

2: opaque response avaialble;

3: processing error;

4: busy, ONU reports busy if the response is not available within 30 seconds.

Other values are reserved.

(R, W) (mandatory) (1 byte)

Command Reply Table: This attribute contains the command response. The contents are vendor-specific. The get, get next sequence must be used with this attribute since its size is unspecified. (R) (mandatory) (N bytes)

Actions

Get, get next, set

Notifications

Attribute value change

Number	Attribute value change	Description
1..4	N/A	
5	Command Reply status	Status of command reply
6	N/A	

Alarm

None

7.2 SIP Alarms

The alarms required by VZ SIP UNI spec are partially supported by G.988 VoIP config data (138) ME, and are partially incorporated into IP host PM history data (135) ME (DHCP-related alarm specifically) and VoIP config data (138) ME. One new ME covers the alarms associated with the SIP application server.

7.2.1 SIP UNI Application Server Alarm Status

The SIP UNI Application Server Alarm Status managed entity reports the Application Server alarms defined by the VZ SIP UNI Specification (section 7.1.2)

when implemented by ONTs. The entity is required for ONTs that offer SIP-based VoIP services on per POTS UNI port.

An ONT that is configured for SIP-based VoIP services automatically creates an instance of this managed entity for each POTS UNI port.

Note: some alarms described in the VZ SIP UNI Specification are already covered by the VoIP Configure Data ME.

There are two types of alarms defined in this ME:

1. REG: Registration server alarms
2. INVITE: Notify Alarms

Relationships

One instance of this managed entity is associated with an instance of PPTP POTS UNI Managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical Managed entity ID, this ME is implicitly linked to an instance of the PPTP POTS UNI ME (R) (mandatory) (2 bytes)

Actions

Get, set

Notifications

Alarm

Alarm number	Alarm	Description
0	REG Domain Name	Cannot resolve domain name
1	REG ICMP	ICMP Error (Destination unreachable, TTL exceeded, etc.)
2	REG TCP	Cannot open TCP Socket
3	REG TLS	Cannot establish TLS session (e.g., cannot validate server certificate)
4	REG Auth	Cannot authenticate (e.g., requires authorization but no credentials have been provisioned or credentials are not accepted)
5	REG Timeout	Request and all attempted retransmissions timed out

6	REG Fail	Failure response received from server
7..9	Reserved	Reserved for future SUBSCRIPTION alarms
10	INVITE Domain Name	Cannot resolve domain name
11	INVITE ICMP	ICMP Error (Destination unreachable, TTL exceeded, etc.)
12	INVITE TCP	Cannot open TCP Socket
13	INVITE TLS	Cannot establish TLS session (e.g., cannot validate server certificate)
14	INVITE Auth	Cannot authenticate (e.g., requires authorization but no credentials have been provisioned or credentials are not accepted)
15	INVITE Timeout	Request and all attempted retransmissions timed out
16	INVITE Fail	Failure response received from server (except that 480 and 486 are not to be considered failure responses for the purpose of this alarm)
28-233	Reserved	Reserved for future CONFIGURATION alarms

7.3 MEs supporting G.989.3 Clause 14 performance monitoring

7.3.1 TWDM channel PHY/LODS performance monitoring history data

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.3. The remainder of this clause is retained for information and reference only.

This managed entity collects certain performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, and a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Total received words protected by BIP-32: The count of 4-byte words included in BIP-32 check. This is a product of the number of downstream FS frames received by the size of the downstream FS frame after the FEC parity byte, if any, have been removed. The count applies to the entire downstream data flow, whether or not addressed to that ONT. (R) (mandatory) (8 bytes)

BIP-32 bit error count: Count of the bit errors in the received downstream FS frames as measured using BIP-32. If FEC is supported in the downstream direction, the BIP-32 count applies to the downstream FS frame after the FEC correction has been applied and the FEC parity bytes have been removed. (R) (mandatory) (4 bytes)

Corrected PSBd HEC error count: The count of the errors in either CFC or OCS fields of the PSBd block which have been corrected using the HEC technique. (R) (mandatory) (4 bytes)

Uncorrectable PSBd HEC error count: The count of the errors in either CFC or OCS fields of the PSBd block which could not be corrected using the HEC technique. (R) (mandatory) (4 bytes)

Corrected downstream FS header HEC error count: The count of the errors in the downstream FS header which have been corrected using the HEC technique. (R) (mandatory) (4 bytes)

Uncorrectable downstream FS header HEC error count: The count of the errors in the downstream FS header which could not be corrected using the HEC technique. (R) (mandatory) (4 bytes)

Total number of LODS events: The count of the state transitions from O5.1/O5.2 to O6, referring to the ONU activation cycle state machine, Clause 12/G.989.3. (R) (mandatory) (4 bytes)

LODS events restored in operating TWDM channel: The count of LODS events cleared automatically without retuning. (R) (mandatory) (4 bytes)

LODS events restored in protection TWDM channel: The count of LODS events resolved by retuning to a pre-configured protection TWDM channel. The event is counted against the original operating channel. (R) (mandatory) (4 bytes)

LODS events restored in discretionary TWDM channel: The count of LODS events resolved by retuning to a TWDM channel chosen by the ONU, without retuning. Implies that the Wavelength channel protection for the operating channel is not active. The event is counted against the original operating channel (R) (mandatory) (4 bytes)

LODS events resulting in reactivation: The count of LODS events resolved through ONU reactivation; that is, either TO2 (without WLCP) or TO3+TO4 (with WLCP) expire before the downstream channel is reacquired, referring to the ONU activation cycle state machine, Clause 12/G.989.3. The event is counted against the original operating channel (R) (mandatory) (4 bytes)

LODS events resulting in reactivation after retuning to protection TWDM channel: The count of LODS events resolved through ONU reactivation after attempted protection switching, which turns unsuccessful due to a handshake failure. (R) (mandatory) (4 bytes)

LODS events resulting in reactivation after retuning to discretionary TWDM channel: The count of LODS events resolved through ONU reactivation after attempted retuning to a discretionary channel, which turns unsuccessful due to a handshake failure. (R) (mandatory) (4 bytes)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	N/A	
1	BIP-32 bit error count	2
2	PSBd HEC errors – corrected	3
3	PSBd HEC errors – uncorrectable	4
4	FS header errors – corrected	5
5	FS header errors – uncorrectable	6
6	Total LODS event count	7
7	LODS – restored in operating TWDM ch.	8
8	LODS – restored in protection TWDM ch.	9
9	LODS – restored in discretionary TWDM ch.	10
10	LODS -- reactivations	11
11	LODS – handshake failure in protection ch.	12
12	LODS – handshake failure in discretionary ch.	13
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.2 TWDM channel FEC performance monitoring history data

This managed entity attributes and notifications are completely identical to those of the FEC PM history data ME defined in section 9.2.9/G.988 and its enhanced version defined in section 9.2.22/G.988. Therefore, the latter can be reused in the context of NG-PON2 systems, provided its ME ID should be implicitly associated with the instances of TWDM channel ME, rather than ANI-G ME.

7.3.3 TWDM channel XGEM performance monitoring history data

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.4.

Note that G.988 employs **Threshold data 64 bit ID** attribute instead of the **Threshold data 1/2 ID,** and has renumbered TCA alarms.

The remainder of this clause is retained for information and reference only.

This managed entity collects certain XGEM-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Total transmitted XGEM frames: The counter aggregated across all XGEM ports of the given ONU. (R) (mandatory) (8 byte)

Transmitted XGEM frames with LF bit not set: The counter aggregated across all XGEM ports of the given ONU identifies the number of fragmentation operations. (R) (mandatory) (8 byte)

Total received XGEM frames: The counter aggregated across all XGEM ports of the given ONU. (R) (mandatory) (8 byte)

Received XGEM frames with XGEM header HEC errors: The counter aggregated across all XGEM ports of the given ONU identifies the number of loss XGEM frame delineation events. (R) (mandatory) (8 byte)

FS words lost to XGEM header HEC errors: The counter of the FS frame words lost due to XGEM frame header errors that cause loss of XGEM frame delineation. (R) (mandatory) (8 byte)

XGEM encryption key errors: The counter aggregated across all XGEM ports of the given ONU identifies the number of received XGEM frames that have to be discarded because of unknown or invalid encryption key. The number is included into the

Total received XGEM frame count above. (R) (mandatory) (8 byte)

Total transmitted bytes in non-idle XGEM frames: The counter aggregated across all XGEM ports of the given. (R) (mandatory) (8 byte)

Total received bytes in non-idle XGEM frames: The counter aggregated across all XGEM ports of the given ONU. (R) (mandatory) (8 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	N/A	
1	N/A	
2	N/A	
3	Received XGEM header HEC errors	4
4	FS words lost to XGEM header HEC errors	5
5	XGEM encryption key errors	6
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.4 TWDM channel PLOAM performance monitoring history data part 1

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.5. The remainder of this clause is retained for information and reference only.

This managed entity collects certain PLOAM-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

The downstream PLOAM message counts of this ME include only the received PLOAM messages pertaining to the given ONU, that is:

- Unicast PLOAM messages, addressed by ONU-ID;
- Broadcast PLOAM messages, addressed by Serial Number;
- Broadcast PLOAM messages, addressed to all ONUs on the PON.

This ME includes all PLOAM PM counters characterized as **mandatory** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

PLOAM MIC errors: The counter of received PLOAM messages that remain unparseable due to MIC error. (R) (mandatory) (4 byte)

Downstream PLOAM message count: The counter of received broadcast and unicast PLOAM messages pertaining to the given ONU. (R) (mandatory) (4 byte)

Ranging_Time message count: The counter of received Ranging_Time PLOAM messages. (R) (mandatory) (4 byte)

Protection_Control message count: The counter of received Protection_Control PLOAM messages. (R) (mandatory) (4 byte)

Adjust_Tx_Wavelength message count: The counter of received Adjust_Tx_Wavelength PLOAM messages. (R) (mandatory) (4 byte)

Adjust_Tx_Wavelength adjustment amplitude: An estimator of the absolute value of the transmission wavelength adjustment. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	PLOAM MIC errors	1
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.5 TWDM channel PLOAM performance monitoring history data part 2

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.6.

Note that G.988 has renumbered TCA alarms.

The remainder of this clause is retained for information and reference only.

This managed entity collects additional PLOAM-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

The downstream PLOAM message counts of this ME include only the received PLOAM messages pertaining to the given ONU, that is:

- Unicast PLOAM messages, addressed by ONU-ID;
- Broadcast PLOAM messages, addressed by Serial Number;

- Broadcast PLOAM messages, addressed to all ONUs on the PON.

All these counters are characterized as **optional** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

System_Profile message count: The counter of received System_Profile PLOAM messages. (R) (mandatory) (4 byte)

Channel_Profile message count: The counter of received Channel_Profile PLOAM messages. (R) (mandatory) (4 byte)

Burst_Profile message count: The counter of received Burst_Profile PLOAM messages. (R) (mandatory) (4 byte)

Assign_ONU-ID message count: The counter of received Assign_ONU-ID PLOAM messages. (R) (mandatory) (4 byte)

Unsatisfied Adjust_Tx_Wavelength requests: The counter of Adjust_Tx_Wavelength requests not applied or partially applied due to target US wavelength being out of Tx tuning range. (R) (mandatory) (4 byte)

Deactivate_ONU-ID message count: The counter of received Deactivate_ONU-ID PLOAM messages. (R) (mandatory) (4 byte)

Disable_Serial_Number message count: The counter of received Disable_Serial_Number PLOAM messages. (R) (mandatory) (4 byte)

Request_Registration message count: The counter of received Request_Registration PLOAM messages. (R) (mandatory) (4 byte)

Assign_Alloc-ID message count: The counter of received Assign_Alloc-ID PLOAM messages. (R) (mandatory) (4 byte)

Key_Control message count: The counter of received Key_Control PLOAM messages. (R) (mandatory) (4 byte)

Sleep_Allow message count: The counter of received Sleep_Allow PLOAM messages. (R) (mandatory) (4 byte)

Tuning_Control/Request message count: The counter of received Tuning_Control PLOAM messages with Request operation code. (R) (mandatory) (4 byte)

Tuning_Control/Complete_d message count: The counter of received Tuning_Control PLOAM messages with Complete_d operation code. (R) (mandatory) (4 byte)

Calibration_Request message count: The counter of received Calibration_Request PLOAM messages. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	N/A	
1	N/A	
2	N/A	
3	N/A	
4	Unsatisfied Adjust_Tx_Wavelength requests	5
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.6 TWDM channel PLOAM performance monitoring history data part 3

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.7.

Note that G.988 has renumbered TCA alarms.

The remainder of this clause is retained for information and reference only.

This managed entity collects remaining PLOAM-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

This ME contains the counters related to the transmitted upstream PLOAM messages. All these counters are characterized as **optional** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Upstream PLOAM message count: The aggregate counter of PLOAM messages, other than Acknowledgement PLOAM message type, transmitted by the given ONU. (R) (mandatory) (4 byte)

Serial_Number_ONU (in-band) message count: The counter of transmitted in-band Serial_Number_ONU PLOAM messages. (R) (mandatory) (4 byte)

Serial_Number_ONU (AMCC) message count: The counter of transmitted AMCC channel Serial_Number_ONU PLOAM messages. (R) (mandatory) (4 byte)

Registration message count: The counter of transmitted Registration PLOAM messages. (R) (mandatory) (4 byte)

Key_Report message count: The counter of transmitted Key_Report PLOAM messages. (R) (mandatory) (4 byte)

Acknowledgement message count: The counter of transmitted Registration PLOAM messages. (R) (mandatory) (4 byte)

Sleep_Request message count: The counter of transmitted Sleep_Request PLOAM messages. (R) (mandatory) (4 byte)

Tuning_Response (ACK/NACK) message count: The counter of transmitted Tuning_Response PLOAM messages with ACK/NACK operation code. (R) (mandatory) (4 byte)

Tuning_Response (Complete_u/Rollback) message count: The counter of transmitted Tuning_Response PLOAM messages with Complete_u/Rollback operation code. (R) (mandatory) (4 byte)

Power_Consumption_Report message count: The counter of transmitted Power_Consumption_Report PLOAM messages. (R) (mandatory) (4 byte)

Change_Power_Level parameter error count: The counter of transmitted Acknowledgement PLOAM messages with Parameter Error completion code in response to Change_Power_Level PLOAM message. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0		1
1		2
2		3
3		4

4		5
5		6
6		7
7		8
8		9
9	Change_Power_Level parameter error count	10
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.7 TWDM channel tuning performance monitoring history data part 1

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.8.

Note that G.988 has renumbered TCA alarms.

The remainder of this clause is retained for information and reference only.

This managed entity collects certain tuning-control-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

The relevant events this ME is concerned with are counted towards the performance monitoring statistics associated with the source TWDM channel. The attribute descriptions refer to the ONU activation cycle states and timers specified in Clause 12/G.989.3. This ME contains the counters characterized as **mandatory** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Tuning control requests for Rx only or Rx and Tx: The counter of received Tuning_Control PLOAM messages with Request operation code that contain tuning instructions either for receiver only or for both received and transmitter. (R) (mandatory) (4 byte)

Tuning control requests for Tx only: The counter of received Tuning_Control PLOAM messages with Request operation code that contain tuning instructions for transmitter only. (R) (mandatory) (4 byte)

Tuning control requests rejected/INT_SFC: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and INT_SFC response code, indicating inability to start transceiver tuning by the specified time (SFC). (R) (mandatory) (4 byte)

Tuning control requests rejected/DS_xxx: The aggregate counter of transmitted Tuning_Response PLOAM messages with NACK operation code and any DS_xxx response code, indicating target downstream wavelength channel inconsistency. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_xxx: The aggregate counter of transmitted Tuning_Response PLOAM messages with NACK operation code and any US_xxx response code, indicating target upstream wavelength channel inconsistency. (R) (mandatory) (4 byte)

Tuning control requests fulfilled with ONU reacquired at target channel: The counter of controlled tuning attempts for which an upstream tuning confirmation has been obtained in the target channel. (R) (mandatory) (4 byte)

Tuning control requests failed due to target DS wavelength channel not found: The counter of controlled tuning attempts that failed due to timer TO4 expiration in the DS Tuning state (O8) in the target channel. (R) (mandatory) (4 byte)

Tuning control requests failed due to no feedback in target DS wavelength channel: The counter of controlled tuning attempts that failed due to timer TO5 expiration in the US Tuning state (O9) in the target channel. (R) (mandatory) (4 byte)

Tuning control requests resolved with ONU reacquired at discretionary channel: The counter of controlled tuning attempts for which an upstream tuning confirmation has been obtained in the discretionary channel. (R) (mandatory) (4 byte)

Tuning control requests Rollback/COM_DS: The counter of controlled tuning attempts that failed due to communication condition in the target channel, as indicated by the Tuning_Response PLOAM message with Rollback operation code and COM_DS response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/DS_xxx: The aggregate counter of controlled tuning attempts that failed due to target downstream wavelength channel inconsistency, as indicated by the Tuning_Response PLOAM message with Rollback operation code and any DS_xxx response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_xxx: The aggregate counter of controlled tuning attempts that failed due to target upstream wavelength channel parameter violation, as indicated by the Tuning_Response PLOAM message with Rollback operation code and US_xxx response code. (R) (mandatory) (4 byte)

Tuning control requests failed with ONU reactivation: The counter of controlled tuning attempts that failed on any reason, with expiration of timers TO4 or TO5 causing the ONU transition into state O1. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0		1
1		2
2	Tuning control requests rejected/INT_SPC	3
3	Tuning control requests rejected/DS_xxx	4
4	Tuning control requests rejected/US_xxx	5
5		6
6	Tuning control requests failed/TO4 exp.	7
7	Tuning control requests failed/TO5 exp.	8
8		9
9	Tuning control requests Rollback/COM_DS	10
10	Tuning control requests Rollback/DS_xxx	11
11	Tuning control requests Rollback/US_xxx	12
12	Tuning control requests failed/Reactivation	13
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.8 TWDM channel tuning performance monitoring history data part 2

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.9. The remainder of this clause is retained for information and reference only.

This managed entity collects additional tuning-control-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

The relevant events this ME is concerned with are counted towards the performance monitoring statistics associated with the source TWDM channel. This ME contains the counters characterized as **optional** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Tuning control requests rejected/DS_ALBL: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and DS_ALBL response code, indicating downstream administrative label inconsistency. (R) (mandatory) (4 byte)

Tuning control requests rejected/DS_VOID: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and DS_VOID response code, indicating that the target downstream wavelength channel descriptor is void. (R) (mandatory) (4 byte)

Tuning control requests rejected/DS_PART: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and DS_PART response code, indicating that tuning request involves channel partition violation. (R) (mandatory) (4 byte)

Tuning control requests rejected/DS_TUNR: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and DS_TUNR response code, indicating that the target DS wavelength channel is out of receiver tuning range. (R) (mandatory) (4 byte)

Tuning control requests rejected/DS_LNRT: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and DS_LNRT response code, indicating the

downstream line rate inconsistency in the target channel. (R) (mandatory) (4 byte)

Tuning control requests rejected/DS_LNCD: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and DS_LNCD response code, indicating the downstream line code inconsistency in the target channel. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_ALBL: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_ALBL response code, indicating the upstream administrative label inconsistency. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_VOID: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_VOID response code, indicating that the target upstream wavelength channel descriptor is void. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_TUNR: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_TUNR response code, indicating that the target US wavelength channel is out of transmitter tuning range. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_CLBR: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_CLBR response code, indicating that the transmitter has insufficient calibration accuracy in the target US wavelength channel. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_LKTP: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_LKTP response code, indicating the upstream optical link type inconsistency. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_LNRT: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_LNRT response code, indicating the upstream line rate inconsistency in the target channel. (R) (mandatory) (4 byte)

Tuning control requests rejected/US_LNCD: The counter of transmitted Tuning_Response PLOAM messages with NACK operation code and US_LNCD response code, indicating the upstream

line code inconsistency in the target channel. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	Tuning control requests rejected/DS_ALBL	1
1	Tuning control requests rejected/DS_VOID	2
2	Tuning control requests rejected/DS_PART	3
3	Tuning control requests rejected/DS_TUNR	4
4	Tuning control requests rejected/DS_LNRT	5
5	Tuning control requests rejected/DS_LNCD	6
6	Tuning control requests rejected/US_ALBL	7
7	Tuning control requests rejected/US_VOID	8
8	Tuning control requests rejected/US_TUNR	9
9	Tuning control requests rejected/US_CLBR	10
10	Tuning control requests rejected/US_LKTP	11
11	Tuning control requests rejected/US_LNRT	12
12	Tuning control requests rejected/US_LNCD	13
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.9 TWDM channel tuning performance monitoring history data part 3

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.10. The remainder of this clause is retained for information and reference only.

This managed entity collects remaining tuning-control-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are

created and deleted by the OLT.

The relevant events this ME is concerned with are counted towards the performance monitoring statistics associated with the source TWDM channel. This ME contains the counters characterized as **optional** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

Tuning control requests Rollback/DS_ALBL: The counter of controlled tuning attempts that failed due to downstream administrative label inconsistency, as indicated by the Tuning_Response PLOAM message with Rollback operation code and DS_ALBL response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/DS_LKTP: The counter of controlled tuning attempts that failed due to downstream optical link type inconsistency, as indicated by the Tuning_Response PLOAM message with Rollback operation code and DS_LKTP response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_ALBL: The counter of controlled tuning attempts that failed due to upstream administrative label violation, as indicated by the Tuning_Response PLOAM message with Rollback operation code and US_ALBL response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_VOID: The counter of controlled tuning attempts that failed due to the target upstream wavelength channel descriptor being void, as indicated by the

Tuning_Response PLOAM message with Rollback operation code and US_VOID response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_TUNR: The counter of controlled tuning attempts that failed due to the transmitter tuning range violation, as indicated by the Tuning_Response PLOAM message with Rollback operation code and US_TUNR response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_LKTP: The counter of controlled tuning attempts that failed due to the upstream optical link type violation, as indicated by the Tuning_Response PLOAM message with Rollback operation code and US_LKTP response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_LNRT: The counter of controlled tuning attempts that failed due to the upstream line rate violation, as indicated by the Tuning_Response PLOAM message with Rollback operation code and US_LNRT response code. (R) (mandatory) (4 byte)

Tuning control requests Rollback/US_LNCD: The counter of controlled tuning attempts that failed due to the upstream line code violation, as indicated by the Tuning_Response PLOAM message with Rollback operation code and US_LNCD response code. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	Tuning control requests Rollback/DS_ALBL	1
1	Tuning control requests Rollback /DS_LKTP	2
2	Tuning control requests Rollback/US_ALBL	3
3	Tuning control requests Rollback /US_VOID	4
4	Tuning control requests Rollback/US_TUNR	5
5	Tuning control requests Rollback /US_LKTP	6
6	Tuning control requests Rollback/US_LNRT	7

7	Tuning control requests Rollback /US_LNCD	8
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.3.10 TWDM channel OMCI performance monitoring history data

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.0 implies that implementation of this ME should follow ITU-T Rec G.988 (08/2019) Amd. 2, Clause 9.16.11.

Note that G.988 has renumbered TCA alarms.

The remainder of this clause is retained for information and reference only.

This managed entity collects OMCI-related performance monitoring data associated with the slot/circuit pack, hosting one or more ANI-G MEs, for a specific TWDM channel. Instances of this managed entity are created and deleted by the OLT.

The counters maintained by this ME are characterized as **optional** in Clause 14/G.989.3.

For a complete discussion of generic PM architecture, refer to clause I.4.

Relationships

An instance of this managed entity is associated with an instance of TWDM channel managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the TWDM channel ME. (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 and 2 managed entities that contains PM threshold values. (R, W, Set-by-create) (mandatory) (2 bytes)

OMCI baseline message count: The counter of baseline format OMCI messages directed to the given ONU. (R) (mandatory) (4 byte)

OMCI extended message count: The counter of extended format OMCI messages directed to the given ONU. (R) (mandatory) (4 byte)

OMCI MIC error count: The counter of OMCI messages received with MIC errors. (R) (mandatory) (4 byte)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0		1
1		2
2	OMCI MIC error count	3
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1/2 managed entities.		

7.4 OMCI SIP extensions

The managed entities specified in this section serve for SIP-based VoIP service troubleshooting purposes. This group of MEs includes:

- POTS UNI Extension ME: This ME includes SIP signaling call status information (G.988 VoIP Line status expresses POTS call in terms of the analog call status).
- VoipCallStatistics and VoipCallStatisticEx2 : This ME differentiates call drops initiated from the subscriber and its peer and contains a more complete set of status information for Voip lines.
- VoipCallStatistics3 and VoipCallStatisticEx4. This ME contains RTP packet counter information for the send and receive directions (G.988 doesn't provide this level of specificity).

7.4.1 POTS UNI Extension managed entity

This managed entity contains call status information for POTS ports using VoIP services. This ME supplements the Voip Line Status (141) ME. An ONU that supports VoIP automatically creates or deletes an instance of this managed entity upon creation or deletion of a PPTP POTS UNI.

Relationships

An instance of this managed entity is associated with a PPTP POTS UNI.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the PPTP POTS UNI. (R) (mandatory) (2 bytes)

Administratively controlled POTS holdover timer: This attribute specifies the duration of time, in seconds, during which the POTS loop voltage should be held up administratively. (R,W) (mandatory) (4 bytes)

Remaining administrative POTS holdover time: This attribute specifies the remaining time, in seconds, during which the POTS loop voltage is administratively held up. It is initialized to the Administratively controlled POTS holdover timer value at the moment of time the latter is written, and counts down to zero. (R) (mandatory) (4 bytes)

Actions

Get

Notifications

None

7.4.2 VoIP call diagnostics part 1

This managed entity provides status information about a Voice Line. It is one of a group of 4 MEs that provide the complete set of status information for Voice Lines. An ONU that supports IP-configured VoIP automatically creates or deletes an instance of this managed entity upon creation or deletion of a PPTP POTS UNI.

Relationships

An instance of this managed entity is associated with a PPTP POTS UNI.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the POTS PPTP UNI. (R) (mandatory) (2 bytes)

SIP Reg Attempts count: This attribute counts the number of SIP Register message requests. (R) (mandatory) (4 bytes)

SIP Reg Challenges count: This attribute counts the number of SIP Registration challenge message received. (R) (mandatory) (4 bytes)

SIP Reg Rejects count: This attribute counts the number of SIP Registration Rejection/denies. (R) (mandatory) (4 bytes)

SIP Reg Grants count: This attribute counts the number of SIP Registration granted OK. (R) (mandatory) (4 bytes)

SIP Inbound Call Attempts count: This attribute counts the number of SIP Outbound Call Attempts. (R) (mandatory) (4 bytes)

SIP Inbound Call Completion count: This attribute counts the number of SIP Inbound Call Completions. (R) (mandatory) (4 bytes)

SIP Inbound Call Busy count: This attribute counts the number of SIP Inbound Calls blocked due to busy (nework and peer). (R) (mandatory) (4 bytes)

SIP Inbound Call Peer Disconnects count: This attribute counts the number of SIP Inbound calls disconnected (initiated by peer). (R) (mandatory) (4 bytes)

SIP Inbound Call ONT Disconnects count: This attribute counts the number of SIP Inbound calls disconnected (initiated by subscriber). (R) (mandatory) (4 bytes)

SIP Outbound Call Attempts count: This attribute counts the number of SIP Outbound Call Attempts. (R) (mandatory) (4 bytes)

SIP Outbound Call Completions count: This attribute counts the number of SIP Outbound Call Completions. (R) (mandatory) (4 bytes)

SIP Outbound Call Busy count: This attribute counts the number of SIP Outbound Call blocked by Busy (network and peer). (R) (mandatory) (4 bytes)

Actions

Get

Notifications

None

7.4.3 VoIP call diagnostics part 2

This managed entity provides status information about a Voice Line. It is one of a group of 4 MEs that provide the complete set of status information for Voice Lines. An ONU that supports VoIP automatically creates or deletes an instance of this managed entity upon creation or deletion of a PPTP POTS UNI.

Relationships

An instance of this managed entity is associated with a PPTP POTS UNI.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the POTS PPTP UNI. (R) (mandatory) (2 bytes)

SIP Outbound Call Peer Disconnects count: This attribute counts the number of SIP Outbound Disconnects by the far-end peer (R) (mandatory) (4 bytes)

SIP Outbound Call ONT Disconnects count: This attribute counts the number of SIP Outbound Call Disconnect initiated by subscriber. (R) (mandatory) (4 bytes)

SIP Emergency call attempt count: This attribute counts the number of emergency calls initiated by subscriber. (R) (mandatory) (4 bytes)

SIP Emergency call completion count: This attribute counts the number of emergency calls completed. (R) (mandatory) (4 bytes)

SIP Emergency call busy count: This attribute counts the number of emergency calls blocked due to busy (network and peer). (R) (mandatory) (4 bytes)

SIP Emergency call disconnect by peer count: This attribute counts the number of emergency calls disconnected (initiated by peer). (R) (mandatory) (4 bytes)

SIP Emergency call on hook count: This attribute counts the number of emergency calls on hook event which have occurred. (R) (mandatory) (4 bytes)

VMWI Notification – Msg waiting count: This attribute counts the number of SIP Notify received with message-waiting “yes” events (R) (mandatory) (4 bytes)

VMWI Notification – No Msg waiting count: This attribute counts the number of SIP Notify received with message-waiting “no” events (R) (mandatory) (4 bytes)

RTP packets sent count: This attribute counts the number of RTP packets sent. (R) (mandatory) (4 bytes)

RTP packets received count: This attribute counts the number of RTP packets received. (R) (mandatory) (4 bytes)

RTP Packet Size: This attribute displays the last received RTP packet size (R) (mandatory) (4 bytes)

Active Call Counter count: Total cumulative usage of the line. This counter is incremented every 100 seconds a call is active (R) (mandatory) (4 bytes)

Actions

Get

Notifications

None

7.4.4 VoIP call diagnostics part 3

This managed entity provides status information about a Voice Line. It is one of a group of 4 MEs that provide the complete set of status information for Voice Lines. An ONU that supports VoIP automatically creates or deletes an instance of this managed entity upon creation or deletion of a PPTP POTS UNI.

Relationships

An instance of this managed entity is associated with a PPTP POTS UNI.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the POTS PPTP UNI. (R) (mandatory) (2 bytes)

IP Line Status: This attribute indicates, using a bit map, the current IP status of the voip port. The invidual bit values are:

```
0x0001 indicates that the line is administratively turned
   on. The LSB value of zero implies that the attribute
   value is 0x00.
0x0002 indicates that the line has RTP transmit enabled.
0x0004 indicates that the line has RTP receive enabled.
0x0008 indicates that the line has been put on hold.
0x0010 indicates that the line is in 3way conference call.
0x0020 indicates that the call is waiting on the line."
```

(R) (mandatory) (2 bytes)

Clear Call counters: Writing a 1 to this attribute will reset the call counters in all three VoIP call diagnostics MEs. (R, W) (mandatory) (1 byte)

Actions

Get, Set

Notifications

None

7.5 Additional performance monitoring MEs

7.5.1 IP host performance monitoring history data part 2

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988. Compliance with Verizon OpenOMCI v2.2 implies that implementation of this ME should follow ITU-T Rec G.988 (2017), Clause 9.4.6, as specified in Amd. 4 (09/2021). The remainder of this clause is retained for information and reference only.

This managed entity collects additional performance monitoring data related to an IP host, related in particular to the DHCP server access errors. Instances of this managed entity are created and deleted by the OLT.

Relationships

An instance of this managed entity is associated with an instance of the IP host config data or IPv6 host config data managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. Through an identical ID, this managed entity is implicitly linked to an instance of the IP host configuration data or IPv6 host configuration data ME, as well as to the corresponding IP host PMHD ME (135). (R, Set-by-create) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 managed entity that contains PM threshold values. Since no threshold value attribute number exceeds 7, a threshold data 2 ME is optional. (R, W, Set-by-create) (mandatory) (2 bytes)

DHCP Attempts count: This attribute counts the number of DHCP discover request. (R) (mandatory) (4 bytes)

DHCP Acks received count: This attribute counts the number of successful DHCP attempt (number of times the ONT DHCP client obtained a lease). (R) (mandatory) (4 bytes)

DHCP Nacks count: This attribute counts the number of Negative acknowledgements (NACKS) received for requests. Number of times the ONT's DHCP Client was denied a lease. (R) (mandatory) (4 bytes)

DHCP response error count: This attribute is incremented whenever the ONU receives a malformed/badly formatted response from the DHCP server. (R) (mandatory) (2 bytes)

DHCP response incomplete count: This attribute is incremented whenever the DHCP server response does not contain all the parameters required to successfully set up the IP configuration. (R) (mandatory) (2 bytes)

Actions

Create, delete, get, set

Get current data

Notifications

Threshold crossing alert

Alarm number	Threshold crossing alert	Threshold value attribute # (Note)
0	DHCP response error	1
1	DHCP response incomplete	2
NOTE – This number associates the TCA with the specified threshold value attribute of the threshold data 1 managed entity.		

7.5.2 ONU operational performance monitoring history data

NOTE: The managed entity originally specified in this section has been incorporated into the ITU-T Rec G.988, with necessary changes supported by Verizon and approved by SG15. Compliance with Verizon OpenOMCI v2.2 implies that implementation of this ME should follow ITU-T Rec G.988 (2017) Clause 9.1.18, as introduced in Amd. 4 (09/2021) and further clarified in Amd. 5. The remainder of this clause is retained for information and reference only.

This managed entity collects performance monitoring data associated with the ONU Instances of this managed entity are created and deleted by the OLT.

For a complete discussion of generic PM architecture, refer to clause I.4

Relationships

This managed entity is associated with the ONU-G managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. There is only one instance, number 0. (R) (mandatory) (2 bytes)

Interval end time: This attribute identifies the most recently finished 15-minute interval. (R) (mandatory) (1 byte)

Threshold data 1/2 ID: This attribute points to an instance of the threshold data 1 managed entity that contains PM threshold values. Since no threshold value attribute number exceeds 7, a threshold data 2 ME is optional. (R, W, Set-by-create) (mandatory) (2 bytes)

Temperature sensor value: A table of one-byte temperature sensor values, each being represented by a 2s complement integer that specifies the temperature of temperature sensor on the ONU. Valid values are –40 to +127 °C in 1 °C increments. The special values: 0x80 indicates that the temperature sensor is not availabe; 0x81, the sensor has malfunctioned. (R) (mandatory) (N byte)

Temperature sensor description: A table of 25-byte long temperature sensor descriptions, each represented by a character string that includes the physical location on the ONU or the component being measured. Strings shorter than 25 bytes are padded with null characters. (R) (mandatory) (25N bytes).

CPU Percent Utilization: Average CPU utilization (percent). This attribute is an integer from 0 to 100. The value of 0xFF indicates that no reliable measurement is available. (R) (mandatory) (1 byte)

RAM Available Amount: Available RAM size in Megabytes. This attribute is an integer from 1 to 2^32 – 2. The value of 0x0 indicates no RAM is available. The value of 0xFFFFFFFF indicates that RAM size report is not reliable. (R) (mandatory) (4 bytes)

RAM Utilization: Average RAM utilization. This attribute is an integer from 0 to 2^32 – 2. The value of 0xFFFFFFFF indicates that no reliable measurement is available. (R) (mandatory) (4 byte)

FLASH Available Amount: Available FLASH size in Megabytes. This attribute is an integer from 1 to 2^32 – 2. The value of 0x0 indicates no FLASH is available. The value of 0xFFFFFFFF indicates that FLASH size report is not reliable. (R) (mandatory) (4 bytes)

FLASH Utilization: Average FLASH utilization. This attribute is an integer from 0 to 2^32 – 2. The value of 0xFFFFFFFF indicates that no reliable measurement is available. (R) (mandatory) (4 byte)

Software Errors: A count of the number of software errorsdetected. A software error is an error, flaw, failure or fault in a computer program that causes it to produce an incorrect or unexpected result, or to behave in unintended ways. Examples include internal logical inconsistencies, divide by zero, referencing to non-existant memory, writing to read-only-memory and "exceptions" in certain programming languages (such as C++ and Java) (R) (mandatory) (4 byte)

Errors in operations: A count of the number of detected errors in operations, not due to a software error. Examples include reading MEs that have not do not exist, provisioning services on entities that do not exist, deleting entities that do not exist. (R) (mandatory) (4 byte)

Actions

Create, Delete, Get, Get-next, set

Notifications

Threshold crossing alerts

Alarm Number	Attribute value change	Threshold value attribute #
0	CPU Utilization	1
1	RAM Utilization	2
2	FLASH Utilization	3
3	Software Errors	4
4	Errors in operations	5

7.5.3 VoIP call statistics

The VoIP call statistics ME supports the per-call RTCP statistics for a particular POTS line. The format of this ME is different from that of a traditional PMHD type ME, because each record of the Call history table attribute is associated with a specific event (VoIP call) and remains stable, after the event is competed. An instance of this managed entity is created by the ONU for each instance of the POTS PPTP managed entity.

Relationships

The instance of this managed entity is implicitly associated with each instance of POTS PPTP managed entity.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this managed entity. The value of the attribute is the same as that of the POTS PPTP ME the present managed entity is associated with. (R) (mandatory) (2 bytes).

Call history table: This attribute lists a history of up to N calls. The table contains information and statistics for those calls. (R) (mandatory) (120*N bytes. N is the number of calls in the call table).

The Call history table record has the following structure:

Date: Date (YY-MM-DD) when the call was initiated (start of ringing for terminating call, off-hook for originating call). (R) (mandatory) (8 byte).

A string of NULL characters $(0x00)_8$, if not supported. The Date should reflect any settings in the Time qualification block of the ONU time configuration ME [Clause 9.1.17/G.988].

Time: Time (HH:MM:SS) when the call was initiated. (R) (mandatory) (8 bytes).
A string of NULL characters $(0x00)_8$, if not supported. The Time should reflect any settings in the Time qualification block of the ONU time configuration ME [Clause 9.1.17/G.988].

Call Duration: Duration of call (seconds) (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

Called Number: Called number (character string) (R) (mandatory) (25 bytes). A string of NULL characters $(0x00)_{25}$, if not supported.

Calling Number: Calling number (character string) (R) (mandatory) (25 bytes). A string of NULL characters $(0x00)_{25}$, if not supported.

RTP Tx Packets: Number of RTP packets sent. (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTP Rx Packets: Number of RTP packets received. (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTP Rx Packets Lost: Number of RTP packets that were not received (which can be determined from missing sequence numbers). (R) (mandatory) (4 byte). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTP Packets Discarded: Number of RTP packets discarded due to errors. (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTP Over-runs: Number of jitter buffer over-runs (number of RTP packets discarded because the jitter buffer was full). (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTP Under-runs: Number of jitter buffer under-runs (number of RTP packets that were not processed to

provide PCM voice because the jitter buffer was empty). (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

Average Jitter: Average jitter (ms) in the received RTP stream. (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTCP Participation: Whether or not the far end participated in RTCP (NO = 0, YES = 1). (R) (mandatory) (1 bytes). 0xFF if not supported.

Peak Jitter: Peak jitter (ms) in the received RTP stream. (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

Average Jitter Buffer Depth: Average jitter buffer depth (ms) during the call. (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

RTCP-XR Participation: Whether or not the far end participated in RTCP-XR (NO = 0x00, YES = 0x01). (R) (mandatory) (1 bytes). 0xFF if not supported.

Average MOS: Average Mean Opinion Score (MOS). (R) (mandatory) (4 bytes). Unsigned integer. Range of values from 0 to 50 represent MOS scores from 0.0 to 5.0 (i.e., units are in tenths). All ones $(0xFF)_4$, if not supported.

Peak Round Trip Delay: Peak round trip delay (in ms). (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

Average Round Trip Delay: Average round trip delay (in ms). (R) (mandatory) (4 bytes). Unsigned integer. All ones $(0xFF)_4$, if not supported.

Actions

Get, Get-next

Notifications

None

7.5.4 MAC swap loop monitor

This ME collects some of the PM data for the MAC swap loopback function. The instances of this ME are created and deleted by the OLT.

Relationships

An instance of this ME is associated with the instance of MAC swap loop configuration ME.

Attributes

Managed entity ID: This attribute uniquely identifies each instance of this ME. There is only one instance, number 0. (R, set-by-create) (mandatory) (2 bytes)

Control block: this attribute controls the behaviour of the data collection function:

Bit 1 (LSB) Clear counters: this is an action bit that always reads back as 0. When written to 1, it resets all PM attributes in the ME.

Bit 2..8 Reserved, should be set to 0 by the OLT and ignored by the ONU.

(R, W)(mandatory)(1 byte)

Collection Status: This attribute provides MAC swap loop status information available from the ONU at the time of the get action by the OLT.

Byte 1: The value of the Active flag indicator of the MAC swap loop configuration ME at time of the get action.

Byte 2..5: The 4-byte Related Interface Pointer attribute of the MAC swap loop configuration ME from most recent activation of the function (combines ME class and ME ID).

Byte 6: VLAN-specific attribute of the MAC swap loop configuration ME from most recent activation of the function.

Byte 7..8: VLAN ID of the MAC swap loop configuration ME from most recent activation of the function.

(R) (mandatory)(8 bytes)

Looped frames: The number of looped back downstream frames since most recent activation of the function or clear request; saturates upon reaching the maximum value. (R) (mandatory) (8 bytes)

Blocked frames: The number of blocked upstream frames since most recent activation of the function or clear request; saturates upon reaching the maximum value. (R) (mandatory) (8 bytes)

Actions

Create, delete, get, set

8. OMCI message extensions

8.1 VoIP diagnostic tests

VoIP diagnostic testing extensions are applicable to the Baseline OMCI message set.

8.1.1 Hotline Connectivity Test

The Hotline Connectivity test functionality is a part of Verizon SIP DBDT test suite that provides the ability for an ONT supporting SIP-based voice service to call a test line. When the test line answers the call, it generates a test tone. The ONT POTS UNI detects the tone and measures the time from when it went off-hook to the time of tone detection.

The present specification redefines Byte 26 of the Test Class 1 of the PPTP POTS UNI entity class test message format originally specified in section A.3.21.3 of G.988 (08/2019).

Test Class 1:

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	1	0						DB = 0, AR = 1, AK = 0 Bits 5-1: action = test
Device identifier	4	0	0	0	0	1	0	1	0	OMCI = 0x0A
Managed entity identifier	5-6									Entity class. NOTE – This format applies to entity class PPTP POTS UNI.
	7-8									Entity instance
Message content	9	a	0	0	1	x	x	x	x	a – test mode 0 normal; deny test if line busy 1 forced mode x Reserved
	10-25									ASCII string containing the number to be dialled. Trailing unused octets are padded with null bytes.
	26									Maximum wait time for test tone, in seconds, from 1 to 255. Value of zero indicates that the measurement is not requested.
	27-40									Zero padding
OMCI trailer	41-48									See Section 11.2.7/G.988 (08/2019).

The present specification further redefines Bytes 10-11 of the Test Class 1 of the PPTP POTS UNI entity class test result message format originally specified in section A.3.39.3 of G.988 (08/2019).

Test Class 1:

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	0	0						DB = 0, AR = 0, AK = 0 bits 5-1: action = test result
Device identifier	4	0	0	0	0	1	0	1	0	OMCI = 0x0A
Managed entity identifier	5-6									Entity class. NOTE – This message format pertains to PPTP POTS UNI entity class.
	7-8									Entity instance
Message content	9	0	0	0	1	x	y	y	y	yyy report the results of the test 000 Test failed 001 Test passed 010 Not completed, line off hook 011 Not completed, other reason 100 Reserved 101 Reserved 110 Reserved 111 Reserved x Reserved
	10-11									Measured tone detection time (in milliseconds). Range is 0 to 65535 ms.
	12-40									Zero padding
OMCI trailer	41-48									See Section 11.2.7/G.988 (08/2019).

8.1.2 POTS on-demand self-tests

The following BORSCHT tests are included in G.988 POTS Self-Tests:

- Battery Feed Test
- Ringing Test

The present specification modifies Byte 10 of the Test Class 0 of the PPTP POTS UNI entity class test result message format originally specified in section A.3.39.3 of G.988 (08/2019). Along with the passed/fail test result, the test result message reports the first self-test that failed (the ff-bits below). If one of the BORSCHT self-test fails, testing is stopped and a technician is expected to address the issue before proceeding with additional self-tests.

Test Class 0:

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	0	0						DB = 0, AR = 0, AK = 0 bits 5-1: action = test result
Device identifier	4	0	0	0	0	1	0	1	0	OMCI = 0x0A
Managed entity identifier	5-6									Entity class. NOTE – This message format pertains to PPTP POTS UNI entity class.
	7-8									Entity instance
Message contents	9	0	0	a	b	c	d	e	f	MLT drop test result
	10	0	0	0	0	f	f	x	x	Result of self-test or vendor-specific test: xx = 00: failed xx = 01: passed xx = 10: not completed Self-test failed test: ff=00: no information ff=01: battery feed failed ff=10: ringing failed ff=11: reserved.
	11-39									Other G.988 defined test result bytes (irrelevant to self-test)
	40									Zero padding
OMCI trailer	41-48									See Section 11.2.7/G.988 (08/2019).

8.2 Traceroute support

Verizon OpenOMCI R2.2 specification modifies the description of OMCI Test/Test result message formats:

A.2.21.2 – Test message, Extended message set

A.3.21.2 – Test message, Baseline message set

A.2.39 – Test result message, Extended message set

A.3.39 – Test result message, Baseline message set

The modification aims at overcoming the deficiency of ITU-T Rec. G.988, which (a) marginalizes Traceroute as a part of "time exceeded" test result code point, (b) by using as a template a single Baseline OMCI message, eliminates the possibility of Traceroute latency reporting, and (c) restricts the accuracy of latency reports.

The modification described herein:

- Assures basic control of the Traceroute parameters;
- Establishes the use of extensible Test result OMCI messages (multiple Test result messages in response to a single Test command);
- Includes latencies into the Traceroute report;
- Supports microsecond accuracy for Traceroute and Ping latency reports.

The Test message format is reused. For the Test result message format, a new test result code point with the contingent message contents is specified.

The newly proposed text is set in orange. The changes shown in red do not belong to the Traceroute modifications proper, but represent regular maintenance items which attempt to correct internal inconsistencies of the G.988 specification. The test parameter offset octet in the format of the Test message is denoted with *P*.

Note that Extended Ping test in this context implies indirect specification of the host address via a preconfigured large string ME at the ONT.

8.2.1 Test message – Extended message set

A.2.21.2 Format for IP host config data and IPv6 host config data entity classes

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	1	0						DB = 0, AR = 1, AK = 0 Bits 5-1: action = test
Device identifier	4	0	0	0	0	1	0	1	1	Extended OMCI = 0x0B

Field	Byte	8	7	6	5	4	3	2	1	Comments
Managed entity identifier	5-6									Entity class NOTE – This format applies to entity classes IP host config data and IPv6 host config data. The entity class (IP host config data ME or IPv6 host config data ME) implicitly defines the size of the address field
	7-8									Entity instance
Message contents length	9-10									Size of message contents field – ~~5 bytes (IPv4 address) or 17 bytes (IPv6 address)~~
Message contents	11	0	0	0	0	x	x	x	x	xxxx = select test 0001 Ping 0010 Traceroute 0011 Extended ping 0100..0111 Reserved 1000..1111 Vendor-specific use. The ICMP message is intended to be sent from the ONU upstream towards the network. See discussion related to the test result message.
	12-15									Option 1: IPv4 address of target (zero if byte 11 specifies extended ping test or the Traceroute test and the address is specified indirectly). The test parameter offset *P* = 16.
	12-27									Option 2: IPv6 address of target (zero if byte 11 specifies extended ping test or the Traceroute test and the address is specified indirectly). The test parameter offset *P* = 28.
	P									For the Ping or Extended ping tests, Number of times to ping. This field pertains to both explicit and extended ping tests. The value 0 or the absence of this field selects the ONU's internal default. For Traceroute test, the Maximum Number of Hops. Allowed range is 1 to 255. The value 0 indicates the default of 30.

Field	Byte	8	7	6	5	4	3	2	1	Comments
	(*P*+1).. (*P*+2)									Pointer to large string ME that identifies the target via a DNS-parsable string. This field is used only for the extended ping test and for the Traceroute test with indirectly specified address; otherwise, it set to 0x0000 or omitted (if the trailing octet of the Message contents is omitted as well). With a valid IPv4/IPv6 address, this field is ignored by the ONT.
	P+3	F	S	S	S	S	S	S	S	F is the “Don’t Fragment” flag: F = 0 – allow probe packet fragmentation; F = 1 – do not frgament probe packet. SSS SSSS – the seven most significant bits of the probe packet size, as applicable to the Ping and Traceroute tests.
	P+4									The eight least significant bits of the probe size. Probe size of 0x0000 indicates the test and protocol-specific default.
	P+5	R	0	C	C	T	T	T	T	For Traceroute test, R is the “Don’t resolve” flag: R = 0 – allow resolving addresses to hostnames; R = 1 – do not resolve addresses to hostnames; CC is the number of probe packets per hop (00 indicates the default of 3); TTTT is the the timeout for each probe packet, expressed in seconds (0000 indicates the default of 3 sec). Otherwise, is set to 0x00.
	P+6									Optional IANA Protocol number: 0x01 – ICMP 0x06 – TCP 0x11 – UDP Other code points reserved.
	(*P*+7).. (*P*+8)									0xPPPP – Optional 16 bit destination port.
MIC	(*P*+9).. (*P*+13)									Message integrity check

8.2.2 Test message – Baseline message set

A.3.21.2 Format for IP host config data and IPv6 host config entity classes

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	1	0						DB = 0, AR = 1, AK = 0 Bits 5-1: action = test
Device identifier	4	0	0	0	0	1	0	1	0	OMCI = 0x0A
Managed entity identifier	5-6									Entity class. NOTE – This format applies to entity classes IP host config data and IPv6 host config data. The entity class implicitly defines the size of the address field.
	7-8									Entity instance
Message contents	9	0	0	0	0	x	x	x	x	xxxx = select test 0001 = Ping 0010 = Traceroute 0011 = Extended ping 0100..0111 Reserved 1000..1111 Vendor-specific use The ICMP message is intended to be from the ONU upstream towards the network. See discussion related to the test result message.
	10-13									Option 1: IPv4 address of target (zero if byte 9 specifies extended ping test or the Traceroute test and the address is specified indirectly)

Field	Byte	8	7	6	5	4	3	2	1	Comments
	14-25									Option 1: 0x00 padding.
	10-25									Option 2: IPv6 address of target (zero if byte 9 specifies extended ping test or the Traceroute test and the address is specified indirectly)
	26									For the Ping or Extended ping tests, Number of times to ping. This field pertains to both explicit and extended ping tests. The value 0 selects the ONU's internal default. ~~NOTE – The number is bounded by the size of the test result message. It can be up to 15 for explicit ping and up to 7 for extended ping.~~ For Traceroute test, the Maximum Number of Hops. Allowed range is 1 to 255. The value 0 indicates the default of 30.
	27-28									Pointer to large string ME that identifies the target via a DNS-parsable string. This field is used only for the extended ping test and for the Traceroute test with indirectly specified address; otherwise, it set to 0x0000. With a valid IPv4/IPv6 address, this field is ignored by the ONT.
	29	F	S	S	S	S	S	S	S	F is the “Don’t Fragment” flag: F = 0 – allow probe packet fragmentation; F = 1 – do not frgament probe packet. SSS SSSS – the seven most significant bits of the probe packet size, as applicable to the Ping and Traceroute tests.
	30									The eight least significant bits of the probe size. Probe size of 0x0000 indicates the test and protocol-specific default.

Field	Byte	8	7	6	5	4	3	2	1	Comments
	31	R	0	C	C	T	T	T	T	For Traceroute test, R is the “Don’t resolve” flag: R = 0 – allow resolving addresses to hostnames; R = 1 – do not resolve addresses to hostnames; CC is the number of probe packets per hop (00 indicates the default of 3); TTTT is the the timeout for each probe packet, expressed in seconds (0000 indicates the default of 3 sec). Otherwise, is set to 0x00.
	32									Optional IANA Protocol number: 0x01 – ICMP 0x06 – TCP 0x11 – UDP Other code points reserved.
	33-34									0xPPPP – Optional 16 bit destination port.
	35-40									Zero padding
OMCI trailer	41-48									

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3 **8.2.3 Test result message – Extended message set**

4 **A.2.39.4 Format for test action invoked against IP host config data and IPv6 host config**
5 **data entity classes**

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	0	0						DB = 0, AR = 0, AK = 0 bits 5-1: action = test result
Device identifier	4	0	0	0	0	1	0	1	1	Extended OMCI = 0x0B
Managed entity identifier	5-6									Entity class NOTE – This format applies to entity classes IP host config data and IPv6 host config data.
	7-8									Entity instance

Field	Byte	8	7	6	5	4	3	2	1	Comments
Message contents length	9-10									Size of message contents field, bytes
Message content	11	0	0	0	0	0	x	x	x	Test result: xxx =000: timed out, no response xxx = 001: ICMP echo responses attached xxx = 010: ICMP time exceeded responses attached xxx = 011: Unexpected ICMP response xxx = 100: target address in large string ME could not be resolved xxx = 101: Extensible test report xxx = 110-111: Reserved
	If the Test result xxx = 101, the remainder of the Message contents field is specified as follows:									
	12	t	p	c	n	n	n	n	n	Control octet: Test type: t = 0 – Ping (regular or Extended) t = 1 – Traceroute. Protocol: p = 0 – IPv4 (4 byte address); p = 1 – IPv6 (16 byte address). Extensible continuation: c = 0 – this is the last Test Result message for a particular Test command; c = 1 – more Test Result messages for a particular Test command are expected. nnnnn = the ordinal number of the test response to a particular Test command.
	13-14									Confirmation copy of the test parameters – octets *P* and *P*+3 of the extended Test message.

Field	Byte	8	7	6	5	4	3	2	1	Comments
	15.. N-4									The test record, with the size determined by the parameters. Ping: Address (4 or 16 bytes) followed by the specified number of latencies. Traceroute: A set of tuples, each containing an address (4 or 16 bytes) and up to three latencies (12 bytes). Latency encoding: 32 bits unsigned integer with the value expressed in microseconds. The special code $(0xFF)_4$ denotes a timeout.
MIC	N-3.. N									Message intergrity check

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3 8.2.4 Test result message – Baseline message set

4 A.3.39.4 Format for test action invoked against IP host config data and IPv6 host config 5 data entity classes

Field	Byte	8	7	6	5	4	3	2	1	Comments
Transaction correlation identifier	1-2									
Message type	3	0	0	0						DB = 0, AR = 0, AK = 0 bits 5-1: action = test result
Device identifier	4	0	0	0	0	1	0	1	0	OMCI = 0x0A
Managed entity identifier	5-6									Entity class. NOTE – This format applies to entity classes IP host config data and IPv6 host config data.
	7-8									Entity instance

Field	Byte	8	7	6	5	4	3	2	1	Comments
Message contents	9	0	0	0	0	0	x	x	x	Test result: xxx =000: timed out, no response xxx = 001: ICMP echo responses attached xxx = 010: ICMP time exceeded responses attached xxx = 011: Unexpected ICMP response xxx = 100: target address in large string ME could not be resolved xxx = 101: Extensible test report xxx = 110-111: Reserved
	If the Test result xxx = 101, the remainder of the Message contents field is specified as follows:									
	10	t	p	c	n	n	n	n	n	Control octet: Test type: t = 0 – Ping (regular or Extended); t = 1 – Traceroute. Protocol: p = 0 – IPv4 (4 byte address); p = 1 – IPv6 (16 byte address). Extensible continuation: c = 0 – this is the last Test Result message for a particular Test command; c = 1 – more Test Result messages for a particular Test command are expected. nnnnn = the ordinal number of the test response to a particular Test command.
	11-12									Confirmation copy of the test parameters (octets 26 and 29 of the baseline Test message)

Field	Byte	8	7	6	5	4	3	2	1	Comments
	13-40									The test record, with the size determined by the parameters. Ping: Address (4 or 16 bytes) and 6 or 3 latencies (24 or 12 bytes)) Traceroute: A single hop report, including address (4 or 16 bytes) and up to three latencies (12 bytes). Latency encoding: 32 bits unsigned integer with the value expressed in *microseconds*. The special code $(0xFF)_4$ denotes a timeout. If necessary, the field is padded with the 0x00 symbols.
OMCI trailer	41-48									

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Annex A: Detailed Verizon OpenOMCI MIB description

Starting with Verizon OpenOMCI v.2.2, the Excel spreadsheet with details adaptation of the G.988 standard MEs, attributes, and notification to the Verizon OpenOMCI specification, which in the earlier versions embedded within this Annex, is accompanying the present document. This Annex is intentionally empty.

Annex B: Verizon OpenOMCI ME list

Table B1 contain the summary of the Verizon OpenOMCI supported managed entities.

The line items set in blue font indicate the standard G.988 MEs introduced since the approval of Verizon OpemOMCI specification version 1.0.

The leading superscripts in front of the ME name provide the following indications:

* (asterisk): The standard G.988 MEs subject to modification under Verizon OpenOMCI specification.

R : The MEs introduced by Verizon OpenOMCI specification version 1.0 that have since been incorporated into the normative text of ITU-T Rec G.988. The last column contains a reference to the clause of ITU-T Rec G.988 (08/2019) Amd. 2 that is mandatory for implementation in order to achieve compliance with Verizon OpenOMCI v2.0. The original clause of Verizon OpenOMCI v1.0 is retained as an informative reference.

D : The specification in ITU-T Rec G.988 (08/2019) Amd. 2 is a duplicate, which is expected to be removed at the next revision. The last column contains a reference to the clause of ITU-T Rec G.988 (08/2019) Amd. 2 that is mandatory for implementation in order to achieve compliance with Verizon OpenOMCI v2.0.

E : The enhanced version of the ME is available. The last column contains a reference to the clause of ITU-T Rec G.988 (08/2019) Amd. 2 that is mandatory for implementation in order to achieve compliance with Verizon OpenOMCI v2.0.

Table B1 – Verizon OpenOMCI managed entities

G.988 Clause	ME Class	Managed entity	Verizon Open OMCI
9.1.1	256	*ONU-G	M
9.1.2	257	ONU2-G	M
9.1.3	2	ONU Data	M
9.1.4	7	Software Image	M
9.1.5	5	Cardholder	M
9.1.6	6	Circuit Pack	M
9.1.7	133	ONU Power Shedding	M
9.1.8	297	Port Mapping	M
9.1.9	160	Equipment Extension Package	No
9.1.10	279	Protection Data	M
9.1.11	159	Equipment Protection Profile	M
9.1.12	158	ONU Remote Debug	M
9.1.13	331	ONU-E	No
9.1.14	336	ONU Dynamic Power Management	M
9.1.15	441	ONU3-G	M
9.1.16	456	ONU manufacturing data	M
9.1.17	457	ONU time configuration	M

9.1.18	459	ONU operational performance monitoring history data	M
9.2.1	263	ANI-G	M
9.2.2	262	T-CONT	M
9.2.3	268	GEM port network CTP	M
9.2.4	266	GEM interworking termination point	M
9.2.5	281	Multicast GEM Interworking Termination Point	M
9.2.7	272	GAL Ethernet Profile	M
9.2.8	276	GAL Ethernet performance monitoring history data	M
9.2.9	312	[E]FEC performance monitoring history data	9.2.22
9.2.10	277	Priority Queue	M
9.2.11	278	Traffic Scheduler	M
9.2.12	280	Traffic Descriptor	M
9.2.13	341	GEM port network CTP performance monitoring history data	M
9.2.14	343	Energy consumption performance monitoring history data	M
9.2.15	344	XG-PON TC performance monitoring history data	No
9.2.16	345	XG-PON downstream management PM history data	No
9.2.17	346	XG-PON upstream management PM history data	No
9.2.18	404	L2 multicast GEM interworking termination point	No
9.2.19	405	ANI-E	No
9.2.20	406	EPON downstream performance monitoring configuration	No
9.2.21	452	[D]TWDM channel OMCI performance monitoring history data	9.16.11
9.2.22	453	Enhanced FEC performance monitoring history data	M
9.2.23	454	Enhanced TC performance monitoring history data	No
9.3.1	45	MAC bridge service profile	M
9.3.2	46	MAC bridge configuration data	M
9.3.3	51	MAC bridge performance monitoring history data	M
9.3.4	47	MAC bridge port configuration data	M
9.3.5	48	MAC bridge port designation data	No
9.3.6	49	MAC bridge port filter table data	M
9.3.7	79	MAC bridge port filter pre-assign table	M
9.3.8	50	MAC bridge port bridge table data	M
9.3.9	52	MAC bridge port performance monitoring history data	M
9.3.10	130	IEEE 802.1p mapper service profile	M
9.3.11	84	VLAN tagging filter data	M
9.3.12	78	VLAN tagging operation configuration data	No
9.3.13	171	Extended VLAN tagging operation configuration data	M
9.3.14	290	Dot1X port extension package	No
9.3.15	291	Dot1X configuration profile	No
9.3.16	292	Dot1X performance monitoring history data	No
9.3.17	293	Radius performance monitoring history data	No
9.3.18	298	Dot1 rate limiter	M
9.3.19	299	Dot1ag maintenance domain	M

9.3.20	300	Dot1ag maintenance association	M
9.3.21	301	Dot1ag default MD level	M
9.3.22	302	Dot1ag MEP	M
9.3.23	303	Dot1ag MEP Status	M
9.3.24	304	Dot1ag MEP CCM database	M
9.3.25	305	Dot1ag CFM stack	M
9.3.26	306	Dot1ag chassis-management info	M
9.3.27	309	Multicast operations profile	M
9.3.28	301	Multicast subscriber config info	M
9.3.29	311	Multicast subscriber monitor	M
9.3.30	322	Ethernet frame PM history data upstream	No
9.3.31	321	Ethernet frame PM history data downstream	No
9.3.32	334	Ethernet frame extended PM	No
9.3.33	348	MAC bridge port ICMPv6 process pre-assign table	M
9.3.34	425	Ethernet frame extended PM 64-Bit	M
9.3.35	455	Link aggregation service profile	No
9.4.1	134	IP host config data	M
9.4.2	135	IP host performance monitoring history data	M
9.4.3	136	TCP/UDP config data	M
9.4.4	342	TCP/UDP performance monitoring history data	M
9.4.5	347	IPv6 host config data	M
9.4.6	458	IP host performance monitoring history data part 2	M
9.5.1	11	Physical path termination point Ethernet UNI	M
9.5.2	24	Ethernet performance monitoring history data	M
9.5.3	89	Ethernet performance monitoring history data 2	No
9.5.4	296	Ethernet performance monitoring history data 3	No
9.5.5	329	Virtual Ethernet interface point	M
9.5.6	349	PoE control	No
9.7.1	98	Physical path termination point xDSL UNI part 1	No
9.7.2	99	Physical path termination point xDSL UNI part 2	No
9.7.3	104	xDSL line configuration profile part 1	No
9.7.4	105	xDSL line configuration profile part 2	No
9.7.5	106	xDSL line configuration profile part 3	No
9.7.6	165	VDSL2 line configuration extensions	No
9.7.7	107	xDSL channel configuration profile	No
9.7.8	108	xDSL subcarrier masking downstream profile	No
9.7.9	109	xDSL subcarrier masking upstream profile	No
9.7.10	110	xDSL PSD mask profile	No
9.7.11	111	xDSL downstream RFI bands profile	No
9.7.12	100	xDSL line inventory and status data part 1	No
9.7.13	101	xDSL line inventory and status data part 2	No
9.7.14	166	xDSL line inventory and status data part 3	No

9.7.15	167	xDSL line inventory and status data part 4	No
9.7.16	168	VDSL2 line inventory and status data part 1	No
9.7.17	169	VDSL2 line inventory and status data part 2	No
9.7.18	170	VDSL2 line inventory and status data part 3	No
9.7.19	102	xDSL channel downstream status data	No
9.7.20	103	xDSL channel upstream status data	No
9.7.21	112	xDSL xTU-C performance monitoring history data	No
9.7.22	113	xDSL xTU-R performance monitoring history data	No
9.7.23	114	xDSL xTU-C channel performance monitoring history data	No
9.7.24	115	xDSL xTU-R channel performance monitoring history data	No
9.7.25	116	TC adaptor performance monitoring history data xDSL	No
9.7.26	323	VDSL2 line configuration extensions 2	No
9.7.27	324	xDSL impulse noise monitor PM history data	No
9.7.28	325	xDSL line inventory and status data part 5	No
9.7.29	326	xDSL line inventory and status data part 6	No
9.7.30	327	xDSL line inventory and status data part 7	No
9.7.31	408	xDSL xTU-C performance monitoring history data part 2	No
9.7.32	409	PTM performance monitoring history data xDSL	No
9.7.33	410	VDSL2 line configuration extensions 3	No
9.7.34	411	Vectoring line configuration extensions	No
9.7.35	412	xDSL channel configuration profile part 2	No
9.7.36	413	xTU data gathering configuration	No
9.7.37	414	xDSL line inventory and status data part 8	No
9.7.38	415	VDSL2 line inventory and status data part 4	No
9.7.39	416	Vectoring line inventory and status data	No
9.7.40	417	Data gathering line test, diagnostic and status	No
9.7.41	418	EFM bonding group	No
9.7.42	419	EFM bonding link	No
9.7.43	420	EFM bonding group PM history data	No
9.7.44	421	EFM bonding group PM history data part 2	No
9.7.45	422	EFM bonding link PM history data	No
9.7.46	423	EFM bonding port PM history data	No
9.7.47	424	EFM bonding port PM history data part 2	No
9.7.48	427	Physical path termination point xDSL UNI part 3	No
9.7.49	428	FAST line configuration profile part 1	No
9.7.50	429	FAST line configuration profile part 2	No
9.7.51	430	FAST line configuration profile part 3	No
9.7.52	431	FAST line configuration profile part 4	No
9.7.53	432	FAST channel configuration profile	No
9.7.54	433	FAST data path configuration profile	No
9.7.55	434	FAST vectoring line configuration extensions	No
9.7.56	435	FAST line inventory and status data	No

9.7.57	436	FAST line inventory and status data part 2	No
9.7.58	437	FAST xTU-C performance monitoring history data	No
9.7.59	438	FAST xTU-R performance monitoring history data	No
9.8.1	12	Physical path termination point CES UNI	No
9.8.2	13	Logical N × 64 kbit/s sub-port connection termination point	No
9.8.3	21	CES service profile	No
9.8.4	23	CES physical interface performance monitoring history data	No
9.8.5	282	Pseudowire termination point	No
9.8.6	283	RTP pseudowire parameters	No
9.8.7	284	Pseudowire maintenance profile	No
9.8.8	285	Pseudowire performance monitoring history data	No
9.8.9	286	Ethernet flow termination point	No
9.8.12	319	CES physical interface performance monitoring history data 2	No
9.8.13	320	CES physical interface performance monitoring history data 3	No
9.8.14	333	MPLS pseudowire termination point	No
9.8.15	337	PW ATM configuration data	No
9.8.16	338	PW ATM performance monitoring history data	No
9.8.17	339	PW Ethernet configuration data	No
9.8.18	400	Ethernet pseudowire parameters	No
9.9.1	53	Physical path termination point POTS UNI	M
9.9.2	153	SIP User Data	No
9.9.3	150	SIP Agent Config Data	No
9.9.4	139	VoIP voice CTP	No
9.9.5	142	VoIP media profile	No
9.9.6	58	Voice service profile	No
9.9.7	143	RTP profile data	No
9.9.8	146	VoIP application service profile	No
9.9.9	147	VoIP feature access codes	No
9.9.10	145	Network Dial Plan	No
9.9.11	141	Voip Line Status	M
9.9.12	140	Call control performance monitoring history data	M
9.9.13	144	RTP performance monitoring history data	M
9.9.14	151	SIP agent performance monitoring history data	M
9.9.15	152	SIP call initiation performance monitoring history data	M
9.9.16	155	MGC config data	M
9.9.17	156	MGC performance monitoring history data	M
9.9.18	138	*Voip Config Data	M
9.9.19	149	SIP config portal	M
9.9.20	154	MGC config portal	M
9.9.21	407	SIP agent config data 2	No
9.10.1	162	Physical path termination point MoCA UNI	No
9.10.2	163	MoCA Ethernet performance monitoring history data	No

9.10.3	164	MoCA interface performance monitoring history data	No
9.12.1	264	UNI-G	M
9.12.2	131	OLT-G	M
9.12.3	137	Network Address	M
9.12.4	148	Authentication security method	M
9.12.5	157	Large string	M
9.12.6	273	Threshold data 1	M
9.12.7	274	Threshold data 2	M
9.12.8	287	OMCI	No
9.12.9	288	Managed entity	No
9.12.10	289	Attribute	No
9.12.11	307	Octet string	M
9.12.12	308	General purpose buffer	M
9.12.13	318	File transfer controller	No
9.12.14	330	Generic status portal	M
9.12.15	335	SNMP configuration data	No
9.12.16	340	BBF TR-069 management server	M
9.12.17	426	Threshold data 64-bit	M
9.12.18	439	OpenFlow config data	No
9.12.19	440	Time status message	*
9.13.1	82	Physical path termination point video UNI	No
9.13.2	90	Physical path termination point video ANI	No
9.13.3	83	Physical path termination point LCT UNI	No
9.13.4	14	Interworking VCC termination point	No
9.13.5	16	AAL5 profile	No
9.13.6	18	AAL5 performance monitoring history data	No
9.13.9	269	VP network CTP	No
9.13.10	62	VP performance monitoring history data	No
9.13.11	332	Enhanced security control	M
9.14.1	313	RE ANI-G	No
9.14.2	314	Physical path termination point RE UNI	No
9.14.3	315	RE upstream amplifier	No
9.14.4	316	RE downstream amplifier	No
9.14.5	317	RE config portal	No
9.14.6	328	RE common amplifier parameters	No
9.15.1	401	Physical path termination point RS232/RS485 UNI	No
9.15.2	402	RS232/RS485 Port Operation Configuration data	No
9.15.3	403	RS232/RS485 performance monitoring history data	No
9.16.1	442	TWDM System Profile	M
9.16.2	443	TWDM channel	M
9.16.3	444	TWDM channel PHY/LODS performance monitoring history data	M
9.16.4	445	TWDM channel XGEM performance monitoring history data	M

9.16.5	446	TWDM channel PLOAM performance monitoring history data part 1	M
9.16.6	447	TWDM channel PLOAM performance monitoring history data part 2	M
9.16.7	448	TWDM channel PLOAM performance monitoring history data part 3	M
9.16.8	449	TWDM channel tuning performance monitoring history data part 1	M
9.16.9	450	TWDM channel tuning performance monitoring history data part 2	M
9.16.10	451	TWDM channel tuning performance monitoring history data part 3	M
9.16.11	452	TWDM channel OMCI performance monitoring history data	M
V7.1.1	65400	Verizon OpenOMCI	M
V7.1.2	65401	[R]TWDM system profile	9.16.1
V7.1.3	65402	[R]TWDM channel	9.16.2
V7.1.4	65403	Watchdog config data	M
V7.1.5	65404	Watchdog PM history data	M
V7.1.6	65420	Flexible Configuration Status Portal	M
V7.1.7	65421	Flexible Configuration Status Portal PM history data	M
V7.1.8	65422	[R]ONU3-G	9.1.15
V7.1.9	65425	MAC swap loop configuration	M
V7.1.10	65426	Extended remote debug	M
V7.2.1	65405	SIP UNI Application server alarm status	M
V7.3.1	65406	[R]TWDM channel PHY/LODS PM history data	9.16.3
V7.3.3	65407	[R]TWDM channel XGEM PM history data	9.16.4
V7.3.4	65408	[R]TWDM channel PLOAM PM history data part 1	9.16.5
V7.3.5	65409	[R]TWDM channel PLOAM PM history data part 2	9.16.6
V7.3.6	65410	[R]TWDM channel PLOAM PM history data part 3	9.16.7
V7.3.7	65411	[R]TWDM channel tuning PM history data part 1	9.16.8
V7.3.8	65412	[R]TWDM channel tuning PM history data part 2	9.16.9
V7.3.9	65413	[R]TWDM channel tuning PM history data part 3	9.16.10
V7.3.10	65414	[R]TWDM channel OMCI PM history data	9.16.11
V7.4.1	65415	POTS UNI extension	M
V7.4.2	65416	VoIP call diagnostics part 1	M
V7.4.3	67417	VoIP call diagnostics part 2	M
V7.4.4	65418	VoIP call diagnostics part 3	M
V7.5.1	65423	[R]IP host performance monitoring history data part 2	9.4.6
V7.5.2	65424	[R]ONU operational performance monitoring history data	9.1.18
V7.5.3	65427	VoIP call statistics	M
V7.5.4	65428	MAC swap loop monitor	M

Annex C: Flexible Configuration Status Portal

This annex provides an overview of the intended use and applications of the Flexible Configuration and Status Portal (FCSP).

C.1 Overview

The goal of the FCSP is to reduce changes in the Verizon Open OMCI specification as new features are added. Towards this goal, the FCSP uses OMCI as a transport mechanism and defers service specific configuration to the services providing or consuming the services. Verizon's use of FCSP is not to replace or deprecate the user of any G.988 MEs defining a service.

FCSP is intended to support a wide range of services that fall under two categories.

The first category is a service on the ONU that has an IP counterpart, either in a master/slave relationship or a peer to peer relationship. Examples include file transfer via FTP, time synchronization via SNTP, or configuration using SNMP or NETCONF. This category is implemented by FCSP attributes that define IP communications with a peer IP entity.

The second category are other services that are not well served by the IP peer model. Examples include Link-OAM, Link Aggregation or configuration of physical interfaces. These are served by G.988 transparent (undefined) portals.

C.1.1 Comparison to G.988 status portals

G.988 defines several MEs that serve a -portal function (MGC config portal, SIP config portal, generic config portal). These portals represent the configuration of a service that is configured by a protocol outside of the OLT/ONU management path, such as file-based SIP or MGC.. In these cases, the respective config portals reflect the configuration as a result of an external protocol.

In FCSP, configuration portal configures the service via OMCI, and the status reports the status of the service.

C.1.2 IP-based vs portal based services

Typically a service will use either the IP-related attributes or the portal-related attributes.

C.1.3 FCSP as a meta ME

FCSP ME on its own does not define any specific functionality. Each instance of the FCSP can define a unique service, or an additional instance of an already defined service. For example, once instance of the FCSP can be used for file transfer, another instance used for link aggregation and two instances used for Link OAM on two UNI ports.

The use/no use of the remaining attributes in the FCSP ME is based on the service type. When a new service type is defined, the definition must also identify which attributes are used.

C.2 Configuration and Status exchange

This section provides the temporal and causal description of the FCSP configuration and status exchange process. This informative text supplements the normative specification of the FCSP ME in the body of the Verizon Open Specification.

The Configuration Portal Update Available, Configuration Portal Table, Configuration Portal Result, Status Message Available, Status Message, Status Message Result attributes of the FCSP ME are used for non-IP (message) based configuration and status reporting. Configuration Portal Table and Status Message are the actual information bytes exchanged; the other attributes

are flags used to support handshaking between the service and ONU in exchanging data using the bulk data attributes. The usage of the flag attributes is shown below.

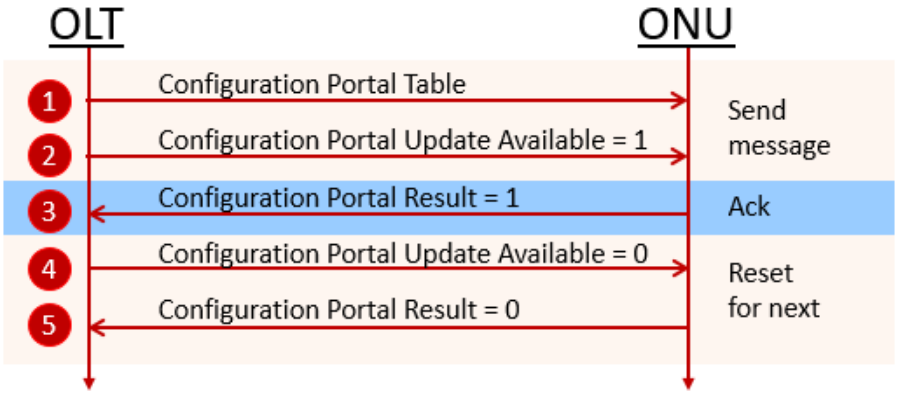

Figure 0-1 – Message Sequence Diagram for Using Configuration Portal

An alternate view of the use of the attributes is shown below. Note that the numbers referring to each line in the message sequence (1-5) refer to the events below numbered 1-5.

Format of Configuration Portal/Status Message: The format of the configuration portal/status message attributes (XML, binary, etc.) is specific to the service type.

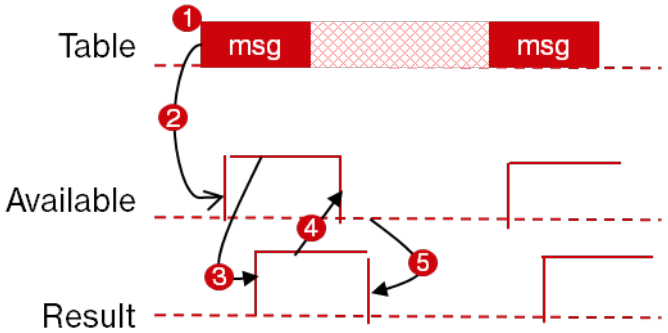

Figure 0-2 – Causal Event Diagram for Using Configuration Portal

The figure below shows the message sequence diagram for the use of the status message.

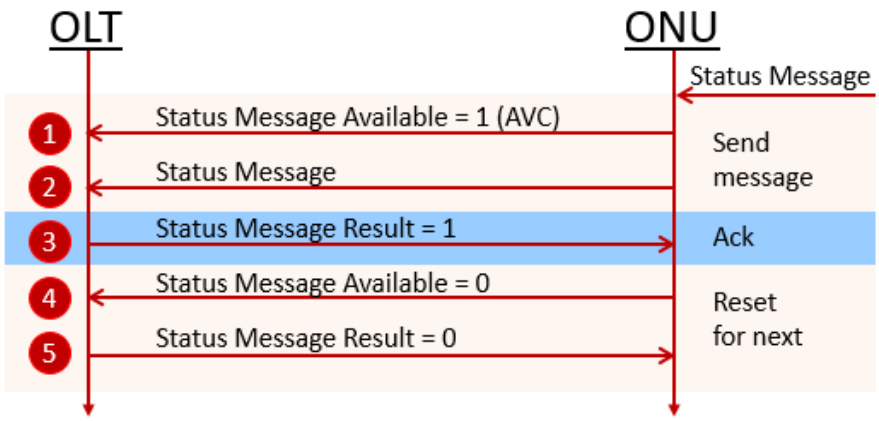

Figure 0-3 – Message Sequence Diagram for Using Status Message

An alternate view of the use of the attributes is shown below. Note that the numbers referring to each line in the message sequence (1-5) refer to the events below numbered 1-5.

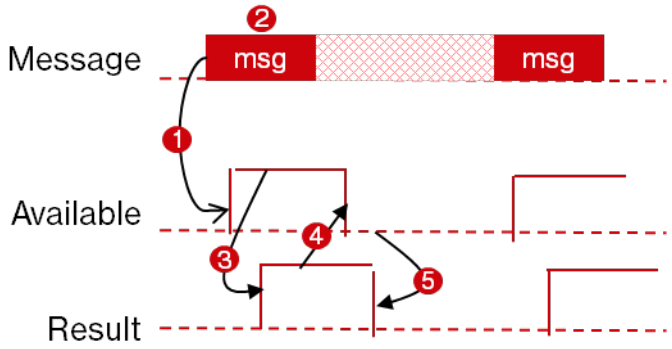

Figure 0-4 – Causal Event Diagram for Using Status Message

C.3 Expected use of attributes based on the management protocol

This table lists typical use of Flexible Configuration and Status Portal attributes, AVCs and alarms, and Flexible Configuration Status Portal PM attributes for each of the two management protocols (ip-based and message based).

Attribute	IP-based	Message Based	Notes
FCSP Attributes			
Managed entity ID	Y	Y	
Service Instance	Y	Y	
Configuration Method	Y	Y	

Network Address	Y	Y	MCIT only
Administrative State	Y	Y	
Operational State:	Y	Y	
Cause for last abnormal halt	Y	Y	
Configuration Portal Update Available	N	Y	
Configuration Portal Table	N	Y	
Configuration Portal Result	N	Y	
Status Message Available	N	Y	
Status Message	N	Y	
Status Message Result	N	Y	
Associated ME Class	Y	Y	
Associated ME Class Instance	Y	Y	
FCSP AVCs			
Operational Status	Y	Y	
Configuration Portal Result	N	Y	
Status Message Available	N	Y	
FCSP Alarms			
Receive Configuration Timeout	Y	Y	
Status Acknowledgement timeout	Y	Y	
Service requires attention – medium	Y	Y	
Service requires attention - high	Y	Y	
Flexible Configuration Status Portal PM Attributes			
Managed entity ID	Y	Y	
Service Up Time	Y	Y	
Number of Configuration Octets Received	Y	Y	
Number of Configuration Messages Received	Y	Y	
Number of Status Octets Transmitted	Y	Y	
Number of Status Messages Transmitted	Y	Y	

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C.4 Multicast Image Transfer based usage of FCSP

This utilization supports a multicast based ONT download image transfer protocol using the FCSP ME as a control conduit.

An ONU supporting this function will report an FCSP instance during MIB upload.

The following initial attribute settings would be expected for this FCSP instance:

- Service Instance:
- Service Type ID: 1028
- Protocol: 0xFF (N/A)
- Configuration Method: Bits 1 and 2 shall both have a value of 1.

When a download is requested the OLT would determine if the Multicast Image Transfer (MCIT) is applicable and appropriate, otherwise the download operation to the ONU would follow standard OMCI practices.

Assuming MCIT is appropriate the OLT will:

- Establish a multicast XGEM for transport of the desired image data.
- Configure a GEM port network CTP (9.2.3/G.988) corresponding to the allocated XGEM with the Direction attribute encoded as ANI-to-UNI (2).
- Configure a Multicast GEM interworking termination point (9.2.5/G.988) associated with the GEM port network CTP.
- Configure a Large String ME with the content: “mcit://<MACDA>/<version>”. Where <version> is replaced with the MCIT version in use and <MACDA> is replaced with the Ethernet MAC destination address that can uniquely identify this image. For example: mcit://00-01-02-03-04-05/1.0.
- Configure a Network address ME instance (9.12.3/ G.988) with a NULL Security Pointer and an Address Pointer referencing the Large String instance above.
- Configure the FCSP instance as follows:
    - Network Address: set to a reference to the Network Address instance created above.
    - Associated ME Class: This should identify the multicast GEM interworking TP ME class
    - Associated ME Class Instance: This should identify the multicast GEM interworking TP ME Class instance created above.
    - Configuration Portal Table: This attribute will be used for additional configuration for MCIT as well as to initiate actions related to MCIT. In the MCIT usage context the format of the Configuration Portal Table rows will be 1 index byte followed by 24 bytes of NULL terminated ASCII content. The ASCII content will be of the form ‘<name>: <value>’. If 24 bytes are not sufficient to encode the name/value pair the ASCII ‘\’ (back-slash) may be used to indicate the name/value pair will continue in the next numeric index received. The index byte only has significance when a set of name/value pairs is being transferred to the ONU. Following transfer uniqueness is identified by the ASCII <name>. The following attribute names are defined for MCIT v1.0:
        - me-ref: <representation_of_4_byte_me_class_an_me_id>. The instance associated with the requested download (e.g., Software Image – ME-ID 1: 0x00070001)
        - image-size: <size_in_bytes>. (optional) The Image size in bytes
        - action: {start|abort|clear|status|show-config}. The action request from OLT to ONU
            - start: initiate image acquisition

- abort: abort image acquisition
- clear: clear all MCIT related configuration
- status: report current acquisition status
- show-config: report current name/value pairs instantiated at the ONU including those with default values.

- Config Portal Result: used per section 7.1.6 of this document. A value of 2 would be used by the ONU to indicate a reject of the Configuration Portal Table content.
- Status Message Available: users per section 7.1.6 of this document.
- Status Message: This will be the main exchange medium for events from the ONU to OLT. The following TLVs are used for status message encoding related the MCIT v1.0:
  - New Tag item identifier: 0x000C – Error Code 2 byte code point
    - 0 – ok / success
    - 1 – processing error
    - 2 – not supported
    - 3 – parameter error
    - 4 – unknown attribute
    - 5 – unknown attribute instance
    - 6 – device busy
    - 7 – instance exists
    - 8 – unsupported attribute value
    - 9 – attribute failed
    - 10 – action aborted
    - 11 – action in progress
    - 12 – remote failure
    - 13 – local failure
  - Existing 0x000B – Information Text TLV will be utilized of additional error descriptions

Once MCIT type download is found to be applicable to the ONU the OLT will apply configuration to the ONT to allow the image acquisition path to be installed. Example Configuration Portal Table set:

BYTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	1	m	e	-	r	e	f	:		0	X	0	0	0	7	0	0	0	1						
	2	i	m	a	g	e	-	s	i	z	e	:		5	3	4	9	0	5	3	2				

The OLT would then update the Configuration Portal Update Available attribute to initiate ONU processing of the request.

The ONU would update the Configuration Portal Result with the basic result of the request: 1 – success; 2 – failure. Upon failure the ONU may optionally provide further error information via the Status Message.

Assuming success the OLT would then set the start action to indicate to the ONU that image acquisition can begin.

BYTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	1	a	c	t	i	o	n	:		s	t	a	r	t											

As the ONU proceeds with image acquisition it shall trigger events via the Status Message attribute:

- Event: First image block acquired: The status message shall indicate item identifier 0x000C with a value of 11 – action in progress.
- Event: Error or issue attributed to the ONU: The status message shall indicate item identifier 0x000C with a value of 13 – local failure.
- Event: Error or issue attributed to the OLT: The status message shall indicate item identifier 0x000C with a value of 12 – remote failure.
- Event: successful acquisition, validation, and storage of the image: The status message shall indicate item identifier 0x000C with a value of 0 – ok/success.
- Event: OLT initiated status action: The status message shall indicate item identifier 0x000C with a value applicable to the status: For example: 11 – action in progress for the image acquisition phase and 6 – device busy when finalizing storage in flash. It is recommended that the information text TLV be included with any useful information such as statistics: successful-blocks <num>, failed-blocks <num>, duplicate-blocks <num>, bytes-acquired <num>
- Event: OLT initiated show-config action: The status message shall include the informational text TLV and the content shall be the set of configuration attribute value pairs separated by new-line characters.

The ‘clear’ action can be used to flush all configuration type attributes acted upon via the Configuration Portal Table. This shall also cause the ONU to remove any internal configuration as a side-effect. For example removing any trap installed to process the image stream.

The OLT may also clear or change individual attributes by setting a new value for that attribute (including a NULL string). Example:

BYTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	1	i	m	a	g	e	-	s	i	z	e	:													

Each row set in the Configuration Portal table is expected to be 25 bytes. Unused bytes shall be padded with the value 0 or optionally an ASCII space.

When the ONU configuration is in place the OLT will begin to transmit image packets on a dedicated X-GEM port per the format in table C-4-1

Field	Byte	8	7	6	5	4	3	2	1	Comments
MAC DA (Image Identifier)	1-6									Destination Ethernet MAC which is correlated to the Network address contents referenced by the File transfer controller ME (9.12.13)

Field	Byte	8	7	6	5	4	3	2	1	Comments
MAC SA	7-12									Source Ethernet MAC
Ethertype	13-14									0x88b6 (Experimental 2)
Image Transfer Message Identifier	15-16									Two byte identifier to distinguish the packet format from other potential packets
Image Transfer Protocol Version – major	17	0	0	0	0	0	0	0	1	Version (1.0)
Image Transfer Protocol Version – minor	18	0	0	0	0	0	0	0	0	Version (1.0)
Image Size	19-22									Image size in bytes
Image CRC-32	23-26									CRC-32, computed over all bytes of the software image (excluding padding), as specified in [ITU-T I.363.5].
Image Offset	27-30									Image offset in bytes for this packet
Message contents length	31-32									Size of message contents field, bytes
Message contents	33-n									Software Image Data
Ethernet FCS										[IEEE 802.3]

Table C-4-1

The encoding will be as follows:

- Image Transfer Message Identifier: 0x4D49
- Image Transfer Protocol Version – major: 1
- Image Transfer Protocol Version – minor: 0
- MAC DA (Image Identifier): set per selection and coordinated with the large string value referenced by the network address ME referenced by the File transfer controller.
- Image Size: set to the overall image size of the image being transferred
- Image CRC-32: set to the CRC-32, computed over all bytes of the software image (excluding padding), as specified in [ITU-T I.363.5].
- Image Offset: The starting byte offset into the image for the Message contents included in this packet. The initial image packet should have an offset of 0.
- Message Contents Length: the number of image payload bytes included in the packet. The suggested range is (1..1944) to align with the OMCI Extended Message limit of 1980 bytes.

The OLT shall transmit the image frames in sequence encapsulated in the multicast X-GEM allocated for this purpose. The OLT may repeat the transmission multiple times to address any transmission issues that may be encountered by a given ONU.

The ONU upon receipt of the image packets will construct the desired image. Upon receiving the first accepted image block the ONU shall report an FCSP Status Message as indicated above with an error code TLV value of 11 – action in progress. Once all image blocks are known to the ONU, the ONU shall validate that the CRC-32 over the entire image matches the value provided in the Image Transfer Message

Image CRC-32 field and if the received image is valid will report an FCSP Status Message as indicated above with an error code TLV value of ‘0 – ok/success’. If the image validation is not successful, the ONU will report an FCSP Status Message as indicated above with an error code TLV value of ‘13 – Local failure’; erase any cached data and restart the image acquisition process. Other errors may be reported via the ‘13 – Local failure’ or ‘12 – Remote failure’ error code TLV selected based on the attributed source of the issue. For example if the characteristics for the image change during the acquisition process (e.g. the OLT changes the CRC value for the image in the transmitted packets) the ONU would report this as a ‘12 – Remote failure’ give that this is unexpected behavior from the OLT.

The OLT upon processing an FCSP status message with an error code TLV of ‘0 – ok/success’ will consider the image download complete and will remove the multicast image transfer configuration from the ONU. It is recommended that the OLT query the ONU for the expected downloaded image version following the completed transfer prior to removing the multicast image transfer configuration. If a version validation fails, the handling in the next paragraph should be followed for recovery.

The OLT upon processing an FCSP Status Message indicating a failure will either allow the ONU to attempt to acquire the image in another image transmission cycle or the OLT shall set the FCSP Configuration Portal Table action name/value pair to ‘abort’, remove the multicast image transfer configuration from the ONU and attempt a standard ONU image download. The OLT shall again set the FCSP Configuration Portal Table action name/value pair to ‘start’.if image acquisition retry is desired.

The description above would replace the standard Start software download, Download section and End software download messages used in the standard G.988 process. The Activate image and Commit image processes remain unchanged.

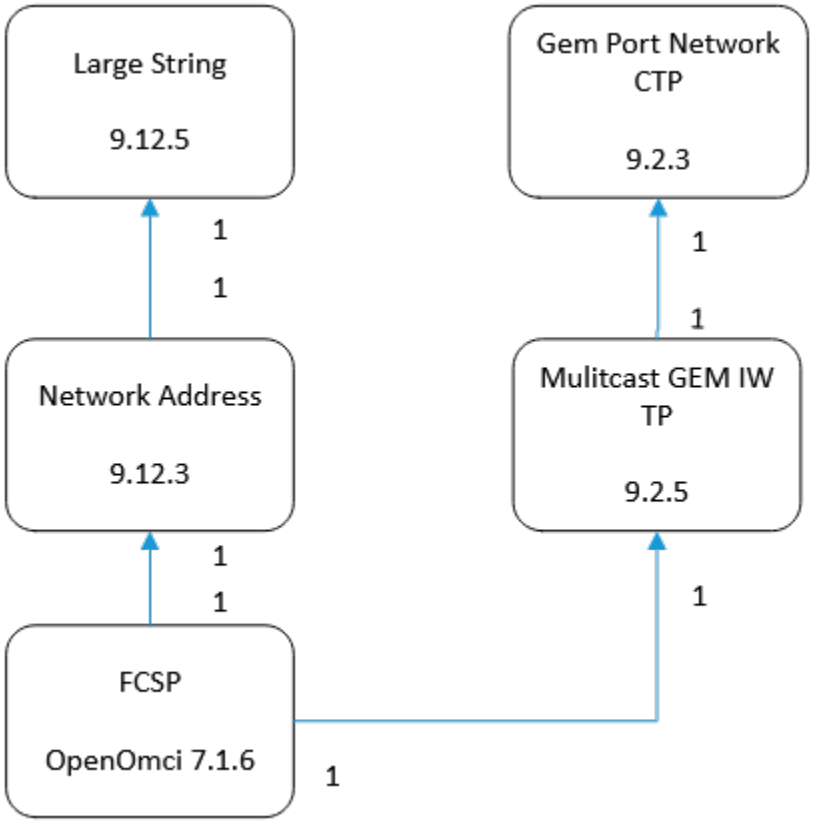


Figure C.4-1 – Illustration of Multicast Image Transfer Associations

C.4.1 Scenarios

Legend and Terms used in the figures below:

- OLT/OMCI: OMCI path from the OLTs perspective
- OLT/MC-GEM: downstream multicast X-GEM/GEM port utilized for transfer of image data
- ONU/OMCI: OMCI path from the ONUs perspective
- ONU/MC-GEM: ONUs termination of the downstream multicast X-GEM/GEM port utilized for transfer of image data
- MCIT Path: configuration of the FCSP instance for MCIT, GEM Multicast Interworking Termination Point and other elements described in the prior section that must be established before image content transmitted by the OLT can be processed by the ONU
- Image acquisition: the process of collecting image content blocks and assembling them into the desired ONU image.
- AVC indicate an AVC for the FCSP Status Message availability along with processing of the Status Message TLV content.

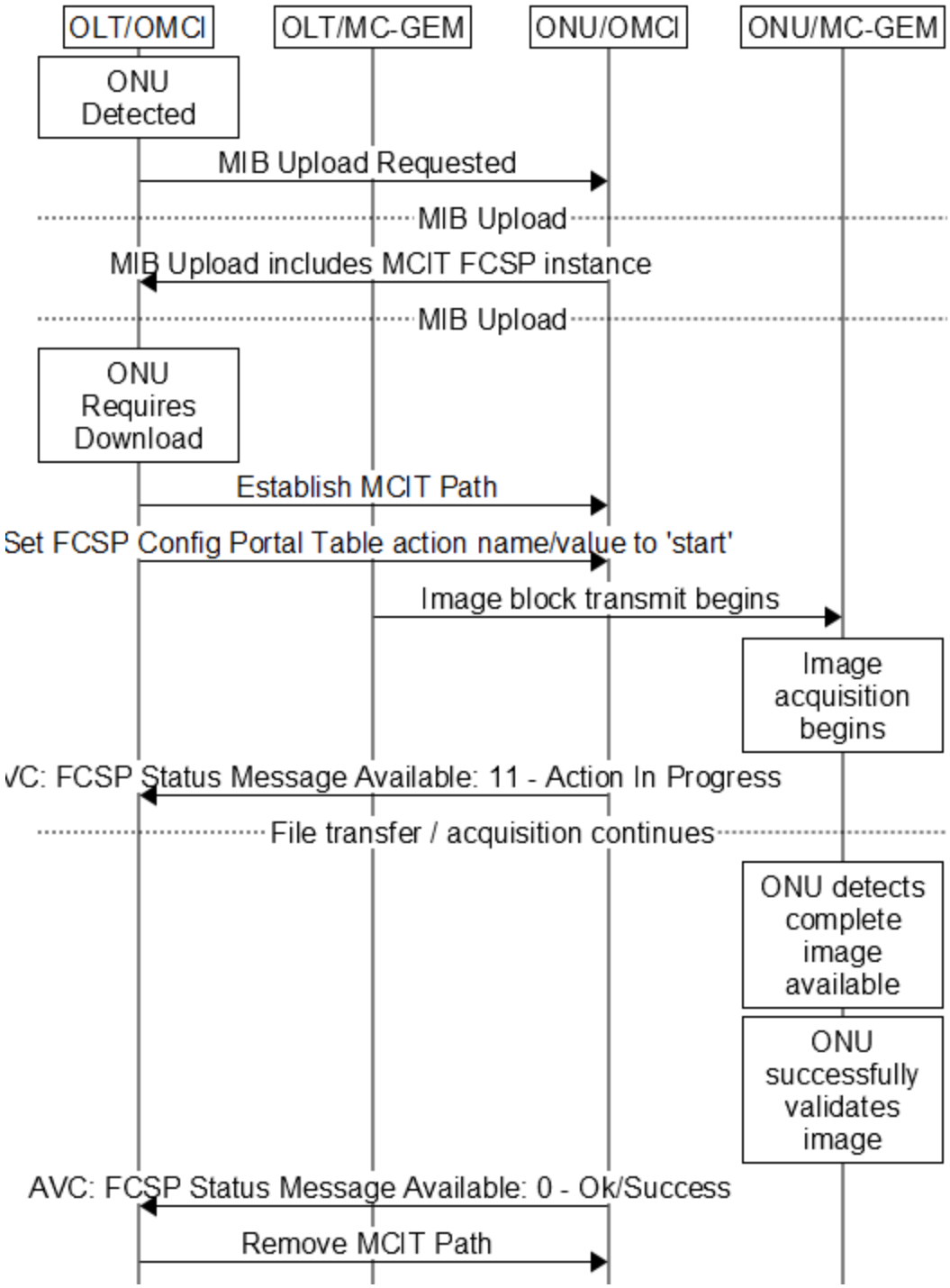


Figure C.4.1-1 – ONU successfully acquires image

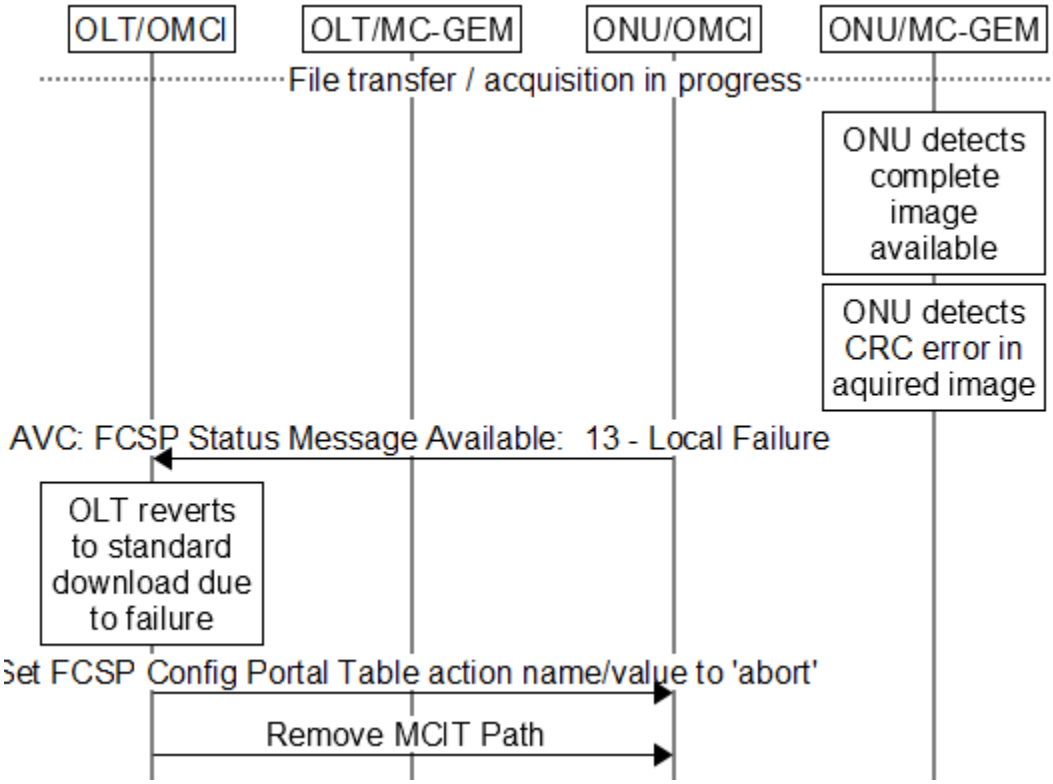


Figure C.4.1-2 – CRC or other error detected after image acquisition

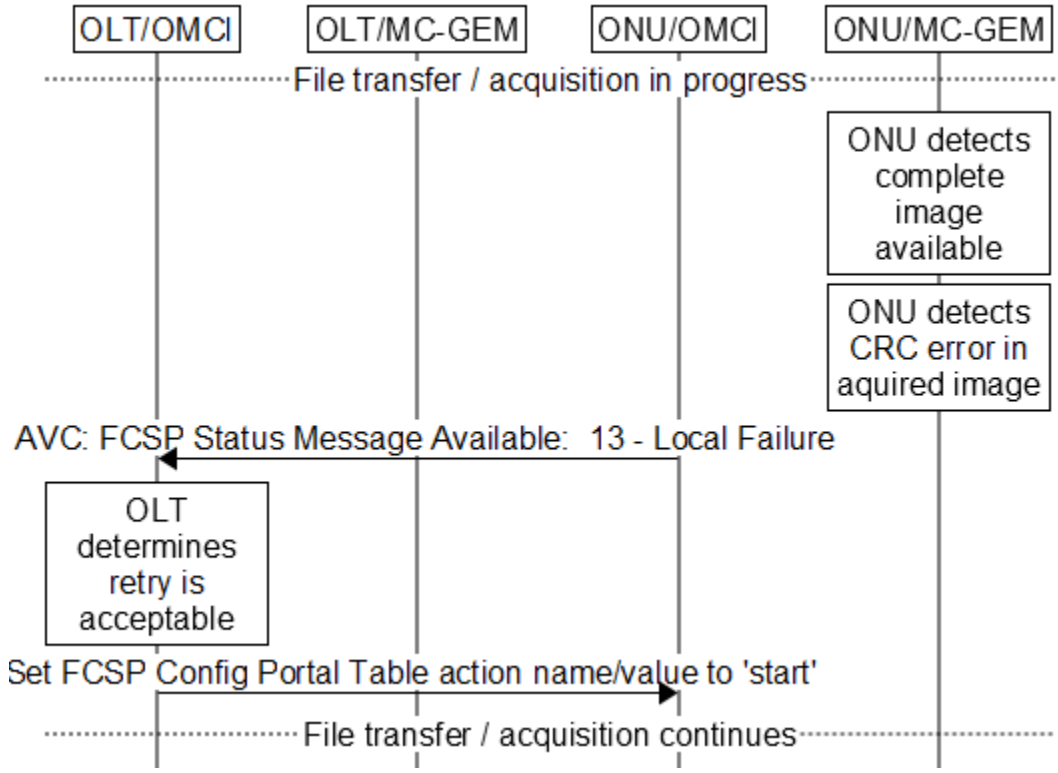
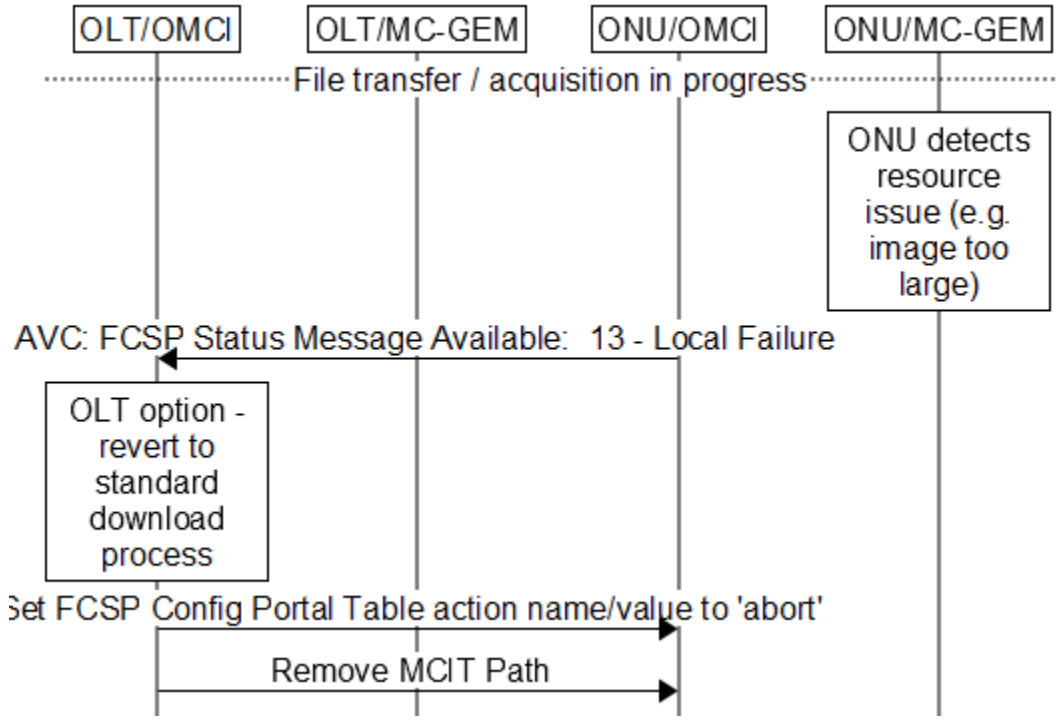


Figure C.4.1-3 – OLT determines to attempt retry after ONU reported failure



Filter C.4.1-4 – Resources unavailable for image at ONU

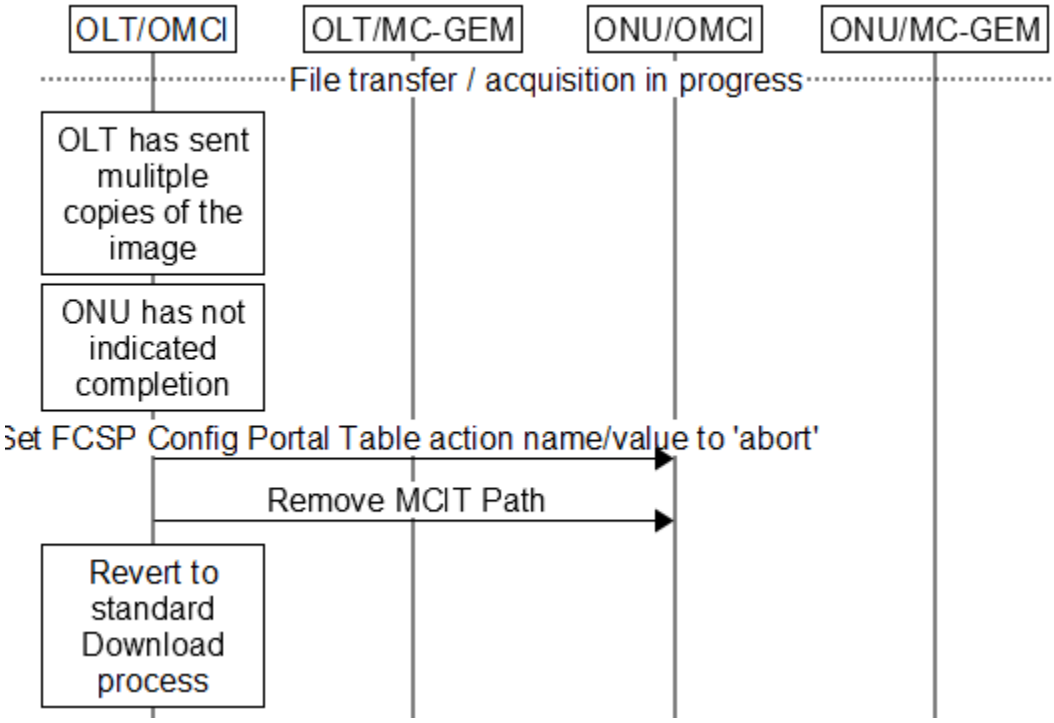


Figure C.4.1-4 – No acquisition progress detected by OLT