Common Provisioning and Management of PON
ITU-T PON Solutions for the Cable Industry

DOCSIS Provisioning of ITU-T PON

CPMP-TR-DOCSIS-Prov-V02-250519

RELEASED

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Key to Document Status Codes

Work in Progress	An incomplete document designed to guide discussion and generate feedback.
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1 INTRODUCTION AND SCOPE

Fiber optic technology has been integral to cable networks for over 40 years. It is most commonly used in hybrid fiber-coax (HFC) to extend the traditional radio frequency distribution network, but cable operators have been using it in passive optical network (PON) deployments since the 2000s to support fiber to the premises (FTTP). The point-to-multipoint topology of PON aligns well with existing and future cable access network designs, and because of its flexibility and economies of scale, PON has become the preferred FTTP technology.

PON has evolved in cable networks from radio frequency over glass (RFoG) to digital PON standards like GPON and EPON. As cable operators increasingly focus on deploying FTTP, they are adopting newer and higher capacity standards. For instance, several cable operators adopted 10G-EPON (standardized by [IEEE 802.3] and supported by the [DPoE] specification from CableLabs) in the early 2010s as they began to incorporate PON into their strategic and long-term network planning.

More recently, many cable operators are favoring XGS-PON from the ITU-T, which has driven investigation of ITU-T PON applicability to the cable space. Those operators are also looking to the future as 25GS-PON and 50G-PON are becoming more widely available. To support the adoption and use of these technologies by cable operators, this technical report will

- describe how ITU-T PON optical network units (ONUs) can be provisioned and managed in a cable network,
- describe how DOCSIS-style provisioning might be overlaid onto an ITU-T PON,
- provide detailed use cases for the application of these concepts in operators' networks,
- drive interoperability between OLTs and ONUs, and
- describe how a Cable OpenOMCI can help support this work.

2 REFERENCES

2.1 Informative References

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[DPoE]	DPoE Architecture Specification, DPoE-SP-ARCHv2.0-I08-230322, March 22, 2023, Cable Television Laboratories, Inc.
[eRouter]	IPv4 and IPv6 eRouter Specification, CM-SP-eRouter-I22-240503, May 5, 2024, Cable Television Laboratories, Inc.
[IEEE 802.3]	IEEE 802.3-2022, IEEE Standard for Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
[ITU-T G.984.3]	ITU-T Recommendation G.984.3, Amendment 1 (03/2020), Gigabit-Capable Passive Optical Networks (G-PON)—Transmission Convergence Layer Specification
[ITU-T G.984.4]	ITU-T Recommendation G.984.4, Amendment 3 (07/2010), Gigabit-Capable Passive Optical Networks (G-PON)—ONT Management and Control Interface Specification
[ITU-T G.988]	ITU-T Recommendation G.988, Amendment 1 (03/2024), ONU Management and Control Interface (OMCI) Specification
[ITU-T G.9804.1]	ITU-T Recommendation G.9804, Amendment 2 (01/2024), Higher Speed Passive Optical Networks—Requirements
[ITU-T G.9807.1]	ITU-T Recommendation G.9807.1 (02/2023), 10-Gigabit-Capable Symmetric Passive Optical Network (XGS-PON)
[MULPIv4.0]	DOCSIS 4.0 MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv4.0-I08-231211, December 11, 2023, Cable Television Laboratories, Inc.
[TR-069]	Broadband Forum, TR-069, CPE WAN Management Protocol, Amendment 6, Corrigendum 1, June 2020
[TR-104]	Broadband Forum, TR-104, Provisioning Parameters for VoIP CPE, September 2005
[TR-181]	Broadband Forum, TR-181, Device Data Model for CWMP Endpoints and USP Agents, Issue 2, Amendment 18, Corrigendum 1, September 2024

2.2 Reference Acquisition

- BBF: Broadband Forum, 39221 Paseo Padre Pkwy, Suite J, Fremont, CA 94538; www.broadband-forum.org
- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027; Phone: +1 303-661-9100; Fax: +1 303-661-9199; www.cablelabs.com
- IEEE: Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016-5997; Phone: +1 212-419-7900; Fax: +1 212-752-4929; www.ieee.org
- ITU-T Recommendations: International Telecommunication Union, Telecommunication Standardization Bureau, Place des Nations, 1211 Geneva 20, Switzerland; Phone: +41 22 730 5852; Fax: +41 22 730 5853; www.itu.int

3 TERMS AND DEFINITIONS

This document uses the following terms.

eMTA	Embedded multimedia terminal adaptor; generally refers to a PacketCable 1.x-compliant voice adapter.
eRouter	Embedded router; an eSAFE that is compliant with [eRouter], providing IPv4 and/or IPv6 data forwarding, address configuration, and domain name services to Internet Protocol host devices connected to the cable modem in a customer's premises. If a given device includes an eRouter entity, that eRouter controls the Ethernet and Wi-Fi LAN interfaces. *See residential gateway.*
GPON	2.5 Gbps/1.25 Gbps PON as defined in [ITU-T G.984.3] and [ITU-T G.984.4].
ITU-T PON	Family of PON standards developed by [ITU-T G.988]. For this specification, this term encompasses GPON, XG(S)-PON, 25GS-PON, and HSP.
managed entity	An OMCI-layer data element used to communicate control plane information between the ONU and OLT.
NETCONF	The Network Configuration Protocol; a network management protocol developed and standardized by IETF.
OLT	Optical line termination; the network operator equipment typically installed in an operator's facility or as part of the outside fiber plant. The OLT transmits downstream signals across a point-to-multipoint PON to one or more ONUs.
ONU	Optical network unit; the passive optical network (PON) CPE that transmits upstream optical signals across the PON. The term "optical network terminal" (ONT) is often used interchangeably with ONU or with the particular semantics of an ONU that is used for FTTP and includes the user port function. (See clause 5.9 of [ITU-T G.9807.1].) This report will consistently use the term ONU.
residential gateway	A Layer 3 forwarding device in the customer's premises that may include Ethernet and Wi-Fi LAN interfaces and may or may not include an embedded ONU.
Remote OLT	An intelligent access point in the PON architecture facilitating seamless connectivity for CPE or ONUs situated farther from the central facility and linking back to an aggregation or Layer 3 IP network.

4 ABBREVIATIONS

This document uses the following abbreviations.

10G-EPON	10 Gigabit Ethernet Passive Optical Network
25GS-PON	25 Gigabit symmetrical Passive Optical Network (ITU-T)
50G-PON	50 Gigabit Passive Optical Network (ITU-T)
ACS	automatic configuration server
BBF	Broadband Forum
BNG	broadband network gateway
BSS	business support system
CMIM	coexistence management interface module
COAM	customer owned and maintained
CPE	customer premise equipment
CTP	connection termination point
CWMP	CPE WAN Management Protocol
DCE	data circuit-terminating equipment
DAL	DOCSIS Adaptation Layer
DHCP	Dynamic Host Configuration Protocol
DOCSIS	Data-Over-Cable Service Interface Specifications
DPoE	DOCSIS Provisioning of EPON
DS	downstream
DSCP	differentiated services (DiffServ) code point
DTE	data terminating equipment
eDVA	embedded digital voice adapter
eMTA	embedded multimedia terminal adapter
EPON	Ethernet Passive Optical Network
FTTP	fiber to the premises
GAL	generic adaption layer
GEM	GPON encapsulation method
GPON	Gigabit Passive Optical Network
GW	gateway
HFC	hybrid fiber-coax
HSP	higher speed PON (defined in [ITU-T G.9804.1])
HSD	High-speed data
ID	identifier
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ITU-T	International Telecommunication Union Telecommunication Standardization Sector
LAN	local area network
LCI	link capacity information
MDI-X	medium dependent interface crossover

ME	managed entity
MTA	multimedia terminal adapter
NETCONF	Network Configuration Protocol
ODN	optical distribution network
OLT	optical line terminal
OMCI	ONU Management and Control Interface
ONU	optical network unit
OSS	Operations Support System
OTN	optical transport network
OTT	over the top
PON	Passive Optical Network
PPTP	Point-to-Point Tunneling Protocol
QoS	quality of service
RFoG	radio frequency over glass
RG	residential gateway
R-OLT	remote optical line terminal
SF	service flow
SIP	Session Initiation Protocol
SNMP	Simple Network Management Protocol
STB	set-top box
T-CONT	transmission container
TFTP	Trivial File Transfer Protocol
TLV	type-length-value
TP	traffic prioritization
TPID	tag protocol identifier
TR	technical report
UNI	user network interface
US	upstream
vCM	virtual cable modem
VEIP	virtual Ethernet interface point
VLAN	virtual local area network
WAN	wide area network
Wi-Fi	wireless fidelity
XGS-PON	10 Gigabit symmetrical Passive Optical Network
YANG	yet another next generation

5 BASELINE PON ARCHITECTURE

The baseline architecture for PON is a topology within a cable access network. This report will include components and functionality that are specific to that access network as well as additional information on the back-office systems that support the provisioning and management of the PON components.

The discussion of PON in this report is based on both the traditional centralized topology and a distributed or disaggregated topology (Figure 1).

- A centralized PON topology is the more traditional implementation for delivering broadband network access to subscribers. The most apparent distinction for this topology is that the OLT is in the hub/headend. Because of this implementation, and because this is a point-to-multipoint topology, the backhaul/transport fiber run from the hub/headend to the first split point may be longer, therefore reducing the total reach of the PON.
- A distributed PON is a newer implementation of a traditional PON topology. This implementation pushes the OLT further out into the optical distribution network (ODN), so the OLT is referred to as a remote OLT (R-OLT). Disaggregation of the access network is becoming a popular design and provides many advantages.

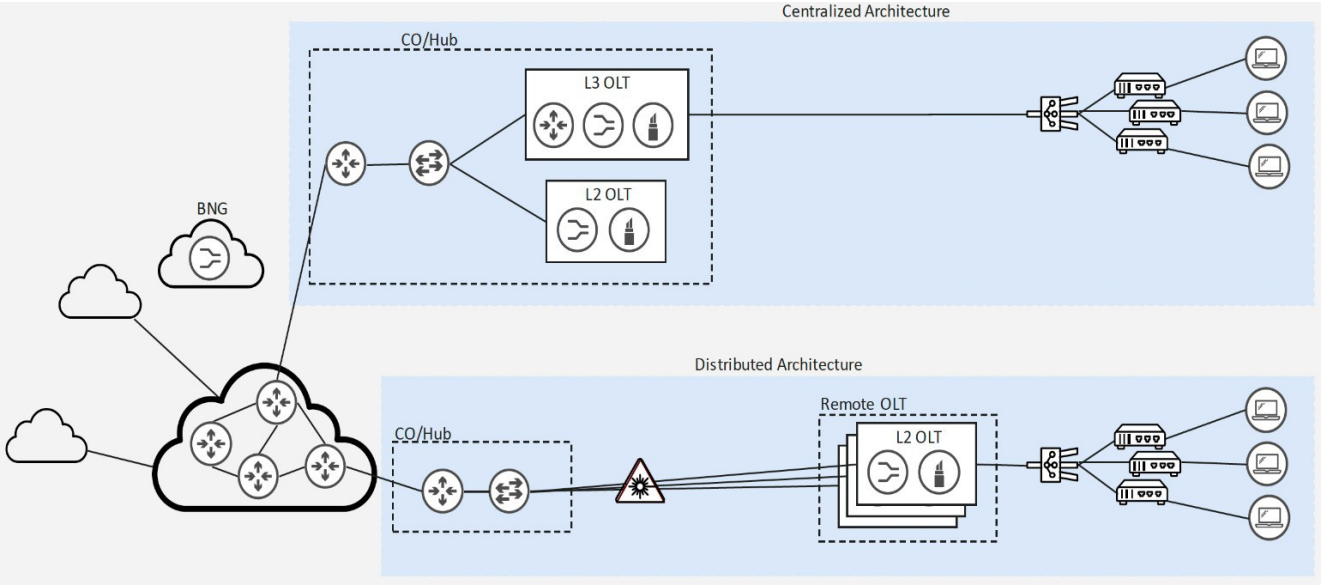


Figure 1 - Centralized and Distributed PON Topology

These two topologies will be used here to describe in detail the functionality required to support the objectives and intent laid out in Section 1. They are also supported by the [Cable OpenOMCI] specification.

This report will not discuss the advantages or disadvantages of either implementation. Commonalities in implementation will be provided where applicable, but both topologies have unique implementation aspects. This report and associated documents will call out any specific differences between them and will include support for those differences within the documentation.

6 DOCSIS BACK-OFFICE METHOD

The primary focus of this technical report is to describe the DOCSIS method to provision and manage ITU-T PON technologies. This approach includes a central premise that there is a DOCSIS Adaptation Layer (DAL) that will convert DOCSIS configuration parameters to an appropriate ONU configuration to support the intended use case. Figure 2 shows this DOCSIS adaptation layer. This approach also supports DOCSIS back-office components, including but not limited to the DHCP server, and TFTP.

For each common use case described, this report defines a DOCSIS configuration and provides an example of how this configuration would be translated to ONU Management and Configuration Interface (OMCI) managed entities (MEs) to appropriately configure the ONU. This is the fundamental process of the DAL.

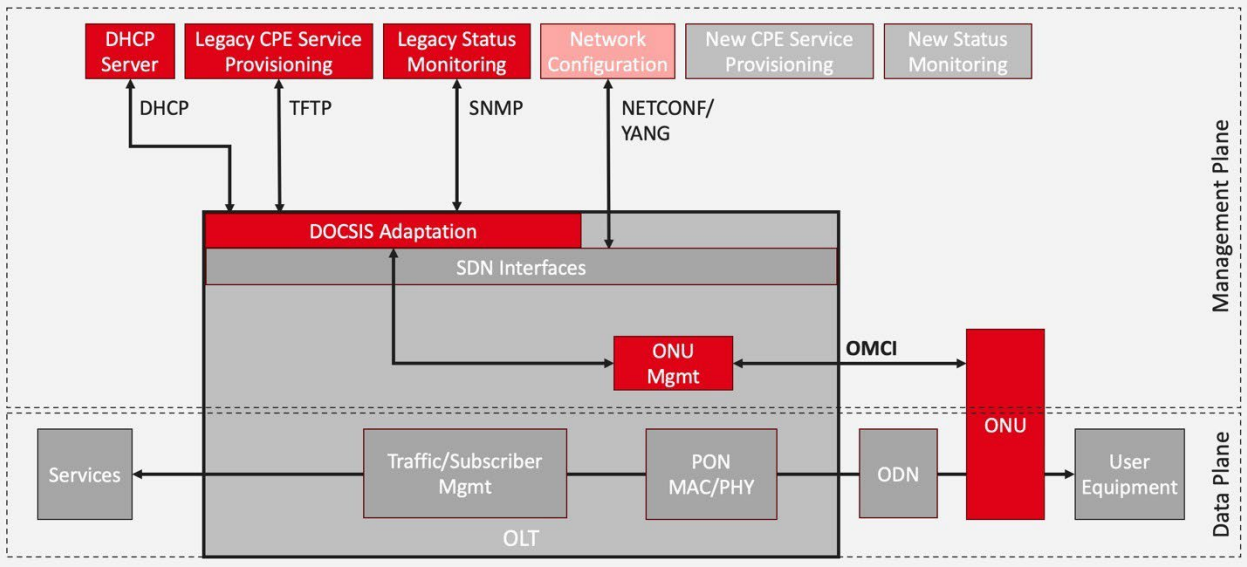


Figure 2 - Functionality to Leverage the DOCSIS Back-Office

When the DAL initiates DHCP communications with the DHCP Server on behalf of a given ONU, it is expected that the DAL will make use of the ONU MAC address to identify the DHCP client. The ONU MAC address is printed on the exterior of the ONU chassis and is included in its communications with the OLT. The OLT provides each ONU MAC address to the DAL for various purposes, including DHCP. Details on the ONU MAC address can be found in [Cable OpenOMCI].

7 OPERATOR USE CASES

The technical report lists a set of operator-defined use cases that will be used to build the appropriate DOCSIS configuration files, which will then be mapped into the [Cable OpenOMCI] functional sets with the necessary MEs. Table 1 lists the common use cases examined in this report.

Table 1 - Operator Use Cases

Use Case	CPE	Provisioning Method	Notes
HSD only	1 box: ONU	cfg-file	L2 CPE device with a single Ethernet UNI
HSD only	1 box: ONU	cfg-file	L2 CPE device with multiple Ethernet UNIs
HSD + embedded OTT-configured voice	1 box: ONU/eDVA	cfg-file + ACS/[TR-104], or cfg-file + eMTA cfg-file	Voice endpoint embedded in ONU
HSD + embedded OMCI-configured voice	1 box: ONU/eDVA	cfg-file + MTA cfg-file	Voice endpoint embedded in ONU
HSD + external voice + IP video (triple-play)	3 boxes: ONU + RG + IP-STB	cfg-file + ACS/[TR-104]/[TR-181]	Voice endpoint (eDVA) embedded in internal RG, OTT IP voice and RG configuration
HSD-only, ONU w/ embedded RG	1 box: ONU/RG	cfg-file + ACS/[TR-181]	Gateway with multiple LAN ports

7.1 Residential

7.1.1 High Speed Data (HSD) – ONU with Single UNI Interface and No Traffic Classifiers

This use case configures a 1 Gbps symmetrical HSD service for the end subscriber. Customer traffic is untagged.

Number of CPE MACs that are permitted to be learned by the ONU—1

ONU provisioning method—DOCSIS configuration file

CPE (may be COAM)—an external device behind the ONU such as a laptop or a residential gateway

OLT VLAN mode—N:1 with split-horizon to prevent user-to-user forwarding

HSD service VLAN ID—The VLAN for the HSD service is administratively configured using an unspecified manner outside the config file as VLAN 300, priority-bit 0, and TPID 0x8100.

ONU frame filtering and treatment—In OMCI, the extended VLAN tagging operation table is configured to filter on untagged customer traffic; add a VLAN tag with ID 300, priority-bit 0, and TPID 0x8100.

ONU frame classification—All frames are forwarded to the GEM port for the service.

OLT or BNG IP traffic management—Upstream traffic is rate limited per T-CONT. GEM port-based rate limiting is not required in the base functional specification. Downstream traffic management is performed outside the PON domain, in either a separate BNG or the OLT's integrated traffic management subsystem. In the latter case, the downstream traffic QoS parameters specified in the DOCSIS service flow reference TLVs are used to configure the downstream traffic management functions.

Subscriber service interface/UNI port—This example does not include a CMIM classifier TLV. When a CMIM classifier TLV is not included in the config file, the highest speed UNI port is configured for the service by default.

7.1.1.1 Example DOCSIS Configuration

```
Network Access Control: on
Maximum Number of CPEs: 1
Upstream Service Flow Encodings
  Service Flow Reference: 10
  Quality of Service Parameter Set: provisioned admitted active
```

```
  Upstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 20
  Quality of Service Parameter Set: provisioned admitted active
  Downstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
```

7.1.1.2 TLV-to-OMCI ME Mapping

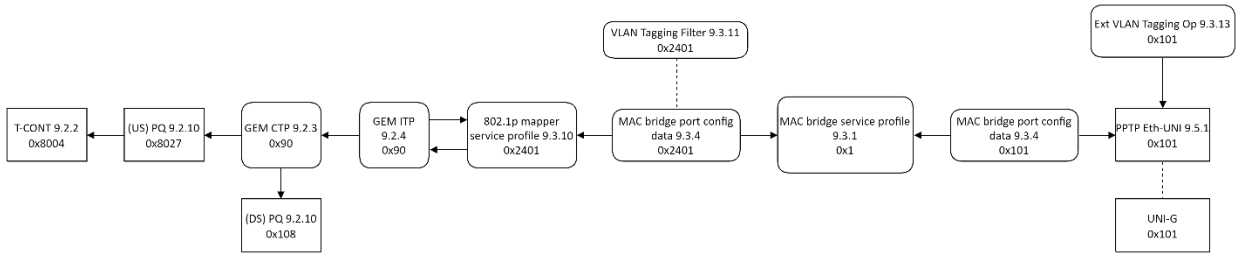
DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Network Access Control (3)		On (If this value is Off, then no MEs should be configured.)
Upstream Service Flow Encodings (24)	**T-CONT (ME-ID)**	
	Managed entity ID	*0x8004*
	Alloc-ID	*0x103*
	Policy	0x1 (Strict Priority)
	Type	*4 (BE) (OLT scheduler)*
Service Flow Reference (24.1)		*10*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Upstream Max Sustained Traffic Rate (24.8)	Max Rate	*125E6 (bytes/sec) (OLT scheduler)*
Data Rate Unit Setting (24.41)		*Mbps*
	PPTP Eth UNI	
	Managed entity ID	*0x101*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x101*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	MAC Bridge Service Profile	
	Managed entity ID	*0x1*
	Spanning tree ind	0x1
	Learning ind	0x1
	Port bridging ind	0x0
	Priority	0x1

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Max age	0xbb8
	Hello time	0x12c
	Forward delay	0x514
	Unknown MAC address discard	0x0
Maximum Number of CPEs (18)	MAC learning depth	*0x1*
	Dynamic filtering ageing time	0x12c
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*20*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E6 (bytes/sec)*
Maximum Traffic Burst (25.9)		*75E4*
Data Rate Unit Setting (25.41)		*Mbps*
	Priority Queue (US)	
	Managed entity ID	*0x8027*
Maximum Traffic Burst (24.9)	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80040007*
	Priority Queue (DS)	
	Managed entity ID	*0x108*
Maximum Traffic Burst (25.9)	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x900007 (assume slot-id is zero)*
	GEM port network CTP	
	Managed entity ID	*0x90*
	Port-ID	*0x90*
	T-CONT pointer	*0x8004*
	Direction	0x3 (bidirectional)
	Traffic management pointer for US	*0x8027*
	Priority queue pointer for DS	*0x108*
	Encryption key ring	0x0 (no encryption)
	802.1p mapper service profile	
	Managed entity ID	*0x2401*
	TP pointer	0xffff
	Interwork TP pointer for P-bit priority 0	*0x90*
	Interwork TP pointer for P-bit priority 1	0xffff
	Interwork TP pointer for P-bit priority 2	0xffff
	Interwork TP pointer for P-bit priority 3	0xffff
	Interwork TP pointer for P-bit priority 4	0xffff
	Interwork TP pointer for P-bit priority 5	0xffff
	Interwork TP pointer for P-bit priority 6	0xffff
	Interwork TP pointer for P-bit priority 7	0xffff
	Unmarked frame option	0x1 (set from Default P-bit assumption)

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	DSCP to P-bit mapping	0x0
	Default P-bit assumption	0x0
	GEM interworking termination point	
	Managed entity ID	*0x90*
	GEM port network CTP connectivity pointer	*0x90*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2401
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	MAC bridge port configuration data	
	Managed entity ID	*0x101 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x101*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x2401 (PON side)*
	Bridge ID pointer	*0x1*
	Port num	*0x5*
	TP type	0x3 (802.1p mapper service profile)
	TP pointer	0x2401
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	VLAN tagging filter data	
	Managed entity ID	*0x2401*
	VLAN filter list	*0x012c0000000000000 00000000000000000000000000000000 (Admit frames tagged with VLAN 300)*
	Forward operation	0x10
	Number of entries	0x1
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x101*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600000966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x101*
	DSCP to P-bit mapping	*0x0*

7.1.1.3 OMCI-ME Relationship Diagram



7.1.2 High Speed Data (HSD) – ONU with Multiple UNI Interfaces and No Traffic Classifiers

Number of CPE MACs that are permitted to be learned by the ONU—1

Provisioning method—DOCSIS configuration file

CPE (may be COAM)—an external device behind the ONU such as a laptop or home gateway

OLT VLAN mode—N:1 with split-horizon to prevent user-to-user forwarding

HSD service VLAN ID—The VLAN for the HSD service is administratively configured using an unspecified manner outside the config file as VLAN 300, priority-bit 0 and TPID 0x8100.

ONU frame filtering and treatment—In OMCI, the extended VLAN tagging operation table is configured to filter on untagged traffic; add a VLAN tag with ID set to 300, priority bit set to 0, and TPID 0x8100.

ONU Frame Classification—All frames are forwarded to the GEM port for the service.

OLT or BNG IP Traffic Management—Upstream traffic is rate limited per T-CONT. GEM port-based rate limiting is not required in the base functional specification. Downstream traffic management is performed outside the PON domain, in either a separate BNG or the OLT's integrated traffic management subsystem. In the latter case, the downstream traffic QoS parameters specified in the DOCSIS service flow reference TLVs are used to configure the downstream traffic management functions.

Subscriber Service Interface/UNI port—This example does not include a CMIM classifier TLV. When a CMIM classifier TLV is not included in the config file, the highest speed UNI port is configured for the service by default. In this case, because the ONU supports 4 UNI ports, only the highest speed UNI will forward traffic. If the ONU has only UNIs of the same speed, only the lowest numbered UNI will forward traffic.

7.1.2.1 Example DOCSIS Configuration

```
Network Access Control: on
Maximum Number of CPEs: 1
Upstream Service Flow Encodings
  Service Flow Reference: 10
  Quality of Service Parameter Set: provisioned admitted active
  Upstream Maximum Sustained Traffic Rate: 1000
```

```
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 20
  Quality of Service Parameter Set: provisioned admitted active
  Downstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
```

7.1.2.2 TLV-to-OMCI ME Mapping

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Network Access Control (3)		On (If this value is Off, then no MEs should be configured.)
Upstream Service Flow Encodings (24)	**T-CONT (ME-ID)**	
	Managed entity ID	*0x8004*
	Alloc-ID	*0x103*
	Policy	0x1 (Strict Priority)
	Type	*4 (BE) (OLT scheduler)*
Service Flow Reference (24.1)		*10*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Upstream Max Sustained Traffic Rate (24.8)	Max Rate	*125E6 (bytes/sec) (OLT scheduler)*
Data Rate Unit Setting (24.41)		*Mbps*
	PPTP Eth UNI	
	Managed entity ID	*0x101*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x101*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	PPTP Eth UNI	
	Managed entity ID	*0x102*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x102*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	PPTP Eth UNI	
	Managed entity ID	*0x103*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x103*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	PPTP Eth UNI	
	Managed entity ID	*0x104*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x104*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	MAC Bridge Service Profile	
	Managed entity ID	*0x1*
	Spanning tree ind	0x1

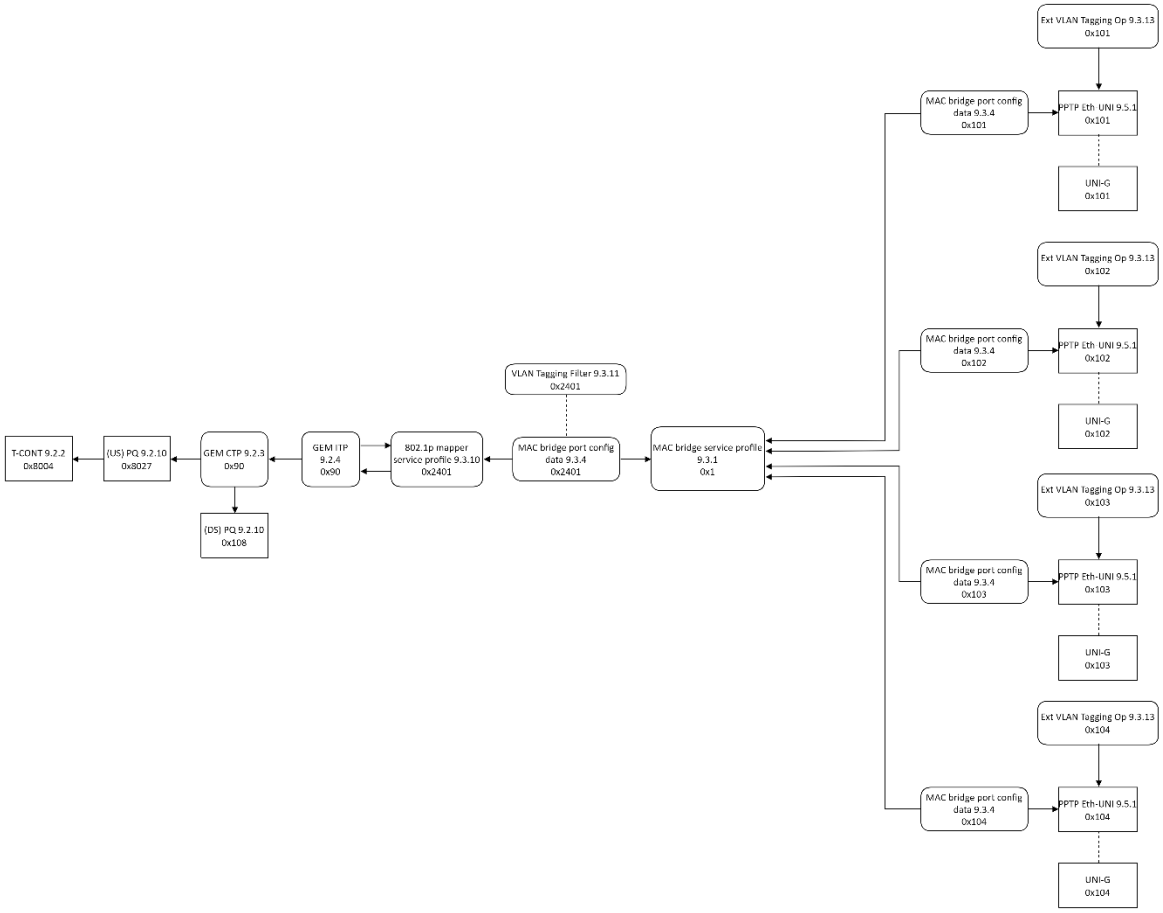
DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Learning ind	0x1
	Port bridging ind	0x1 (Bridging enable between UNIs)
	Priority	0x1
	Max age	0xbb8
	Hello time	0x12c
	Forward delay	0x514
	Unknown MAC address discard	0x0
Maximum Number of CPEs (18)	MAC learning depth	*0x1*
	Dynamic filtering ageing time	0x12c
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*20*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E6 (bytes/sec)*
Maximum Traffic Burst (25.9)		*75E4*
Data Rate Unit Setting (25.41)		*Mbps*
Maximum Traffic Burst (24.9)	**Priority Queue (US)**	
	Managed entity ID	*0x8027*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80040007*
Maximum Traffic Burst (25.9)	**Priority Queue (DS)**	
	Managed entity ID	*0x108*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x900007 (assume slot-id is zero)*
	GEM port network CTP	
	Managed entity ID	*0x90*
	Port-ID	*0x90*
	T-CONT pointer	*0x8004*
	Direction	0x3 (bidirectional)
	Traffic management pointer for US	*0x8027*
	Priority queue pointer for DS	*0x108*
	Encryption key ring	0x0 (no encryption)
	802.1p mapper service profile	
	Managed entity ID	*0x2401*
	TP pointer	0xffff
	Interwork TP pointer for P-bit priority 0	*0x90*
	Interwork TP pointer for P-bit priority 1	0xffff
	Interwork TP pointer for P-bit priority 2	0xffff
	Interwork TP pointer for P-bit priority 3	0xffff
	Interwork TP pointer for P-bit priority 4	0xffff
	Interwork TP pointer for P-bit priority 5	0xffff

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Interwork TP pointer for P-bit priority 6	0xffff
	Interwork TP pointer for P-bit priority 7	0xffff
	Unmarked frame option	0x1 (set from Default P-bit assumption)
	DSCP to P-bit mapping	0x0
	Default P-bit assumption	0x0
	GEM interworking termination point	
	Managed entity ID	*0x90*
	GEM port network CTP connectivity pointer	*0x90*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2401
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	MAC bridge port configuration data	
	Managed entity ID	*0x101 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x101*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x102 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x102*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x103 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x103*
	Port priority	0x1

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x104 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x104*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x2401 (PON side)*
	Bridge ID pointer	*0x1*
	Port num	*0x5*
	TP type	0x3 (802.1p mapper service profile)
	TP pointer	0x2401
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	VLAN tagging filter data	
	Managed entity ID	*0x2401*
	VLAN filter list	*0x012c0000000000000 00000000000000000000000000000000 (Admit frames tagged with VLAN 300)*
	Forward operation	0x10
	Number of entries	0x1
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x101*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600000966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x101*
	DSCP to P-bit mapping	0x0

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x102*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600000966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x102*
	DSCP to P-bit mapping	0x0
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x103*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600000966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x103*
	DSCP to P-bit mapping	0x0
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x104*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600000966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x104*
	DSCP to P-bit mapping	0x0

7.1.2.3 OMCI-ME Relationship Diagram



7.1.3 HSD + Embedded OTT Voice

Number of CPE MACs that are permitted to be learned by the ONU—2

Provisioning method—DOCSIS configuration file + ACS/[TR-104] or eDVA configuration file

This use case supports high speed data and voice services. It is a one-box solution with an ONU and an embedded digital voice adapter (eDVA). In this example, there are two service flows—one for the high-speed data and one for voice.

Voice services consist of voice signaling and bearer traffic. It can be configured with a single DOCSIS service flow for both, or it can be done with one DOCSIS service flow for the signaling and one for the bearer traffic. This example configures the former and requires Cable Modem Interface Mask (CMIM) classifiers.

Figure 3 depicts the upstream traffic flow for this use case, which includes T-CONT configuration for the upstream. Service flow one (SF_1) is configured to support the HSD service, and service flow two (SF_2) supports the voice service. In the upstream, each service flow is mapped to a single GEM port, which in turn is associated with a single T-CONT. In the downstream, the concept of T-CONTs are not applicable, and since unicast GEM ports are bidirectional, the OLT handles downstream traffic via the same pair of GEM ports used for the upstream traffic. In Figure 3, the GEM port blocks within the OLT are depicted with dashed lines in order to indicate they are not unique to the downstream but are instead a reference to the bidirectional GEM port blocks depicted within the ONU.

In the alternative case where bearer and signaling traffic are carried by different service flows, classification of traffic from the eDVA would be required to use DiffServ Code Point (DSCP). This is a different way to configure voice services and is not explored further in this technical report.

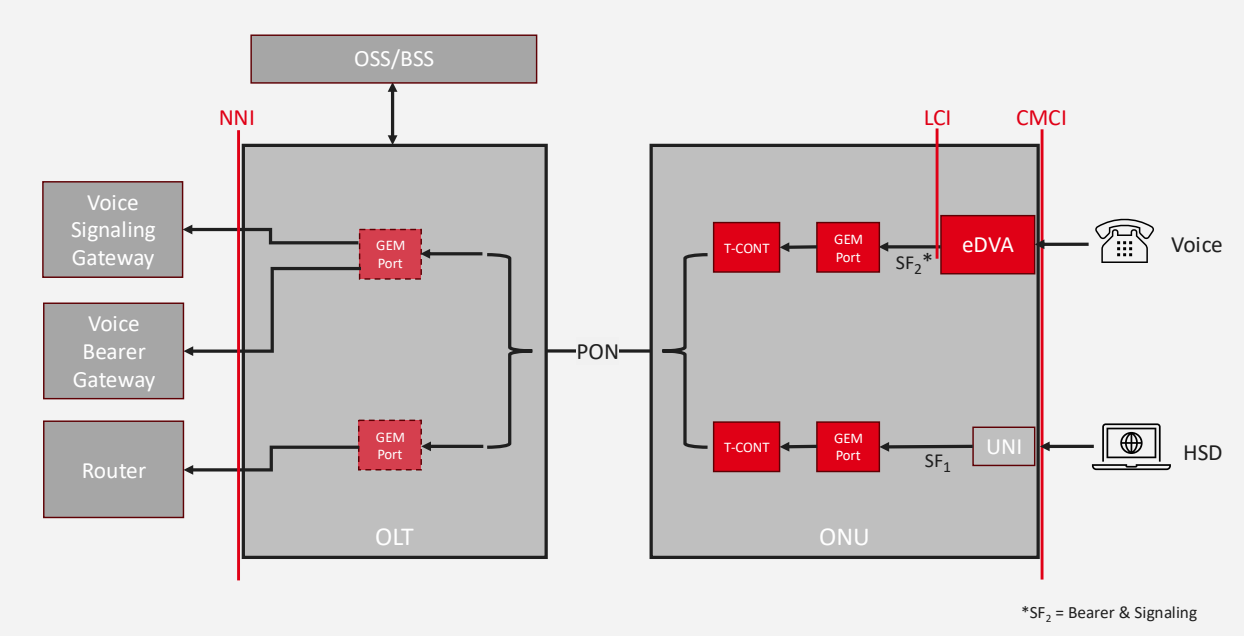


Figure 3 - Upstream Traffic Flow for HSD + Embedded OTT Voice

To further illustrate the use case for over-the-top configuration of voice, two sequence diagrams are provided. Figure 4 shows voice provisioning by ACS server, and Figure 5 shows provisioning by eMTA configuration file. For the ACS method, the configuration of voice is completely outside of DOCSIS management. For the configuration file method, a DOCSIS eMTA configuration file is used, and the embedded voice adaptor is required to obtain the file using TFTP, parse the file for the configuration settings, and apply them directly.

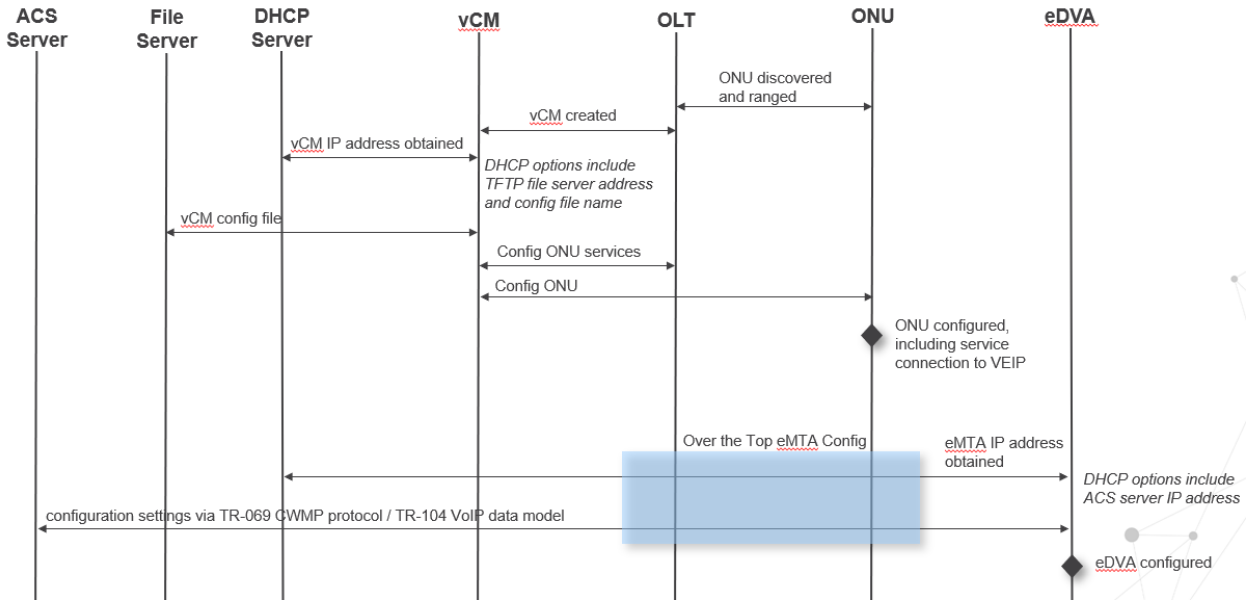


Figure 4 - Sequence Diagram for ACS Server Over-the-Top Voice Configuration

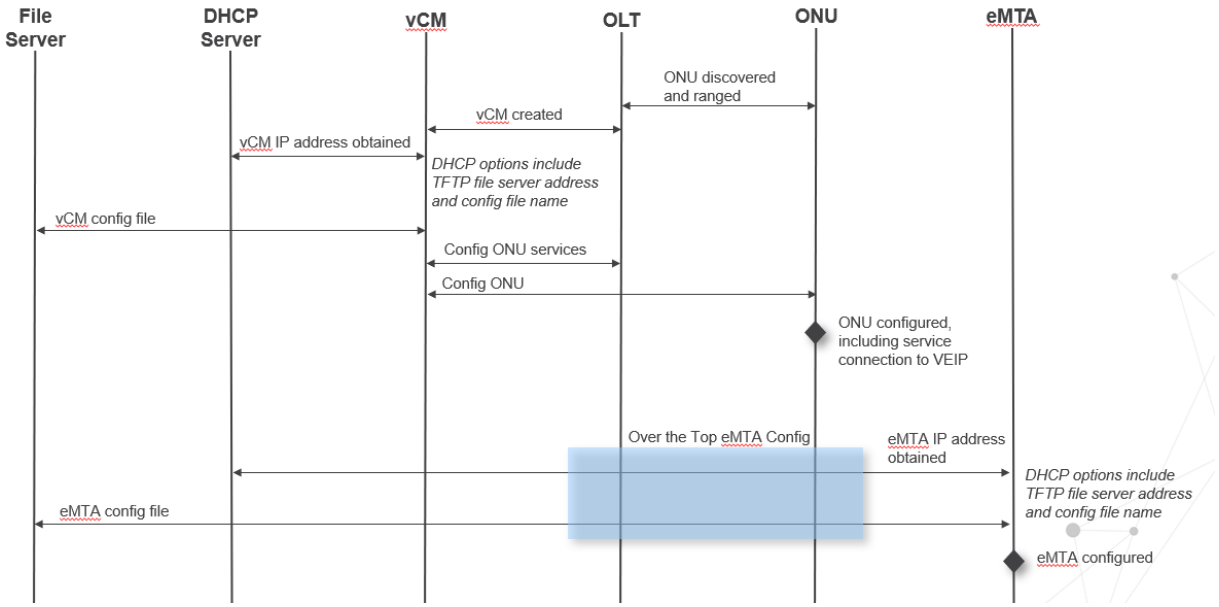


Figure 5 - Sequence Diagram for eMTA Configuration File Over-the-Top Voice Configuration

7.1.3.1 Example DOCSIS Configuration

This is an example DOCSIS vCM configuration to support the HSD and eDVA OTT voice use case. It is not exhaustive of all configuration details but merely a representation of the service flow configuration for this use case. It applies to either OTT method used to configure the voice adaptor.

The HSD services are configured much the same as in the HSD use case example with the additional CMIM classifier for UNI-1 for terminating the service flow. The VLAN is administratively configured using an unspecified manner outside the config file as VLAN 300, priority-bit 0, and TPID 0x8100.

The voice services are also configured in a similar manner as the HSD use case except that the VEIP ME is used to terminate the service flow as compared to PPTP Ethernet UNI for data. The VLAN for voice is administratively configured using an unspecified manner outside the config file as VLAN 500, priority-bit 4, and TPID 0x8100.

```
Network Access Control: on
Maximum Number of CPEs: 2
Upstream Service Flow Encodings
  Service Flow Reference: 10
  Quality of Service Parameter Set: provisioned admitted active
  Upstream Maximum Sustained Traffic Rate: 1000
  Service Flow Scheduling Type: Best effort
  Data Rate Unit Setting: Mbps
Upstream Packet Classification Encoding
  Classifier Reference: 1
  Service Flow Reference: 10
  CM Interface Mask (CMIM) Encoding: 0x40-00-00-00

Downstream Service Flow Encodings
  Service Flow Reference: 20
  Quality of Service Parameter Set: provisioned admitted active
  Downstream Maximum Sustained Traffic Rate: 1000
  Data Rate Unit Setting: Mbps
Downstream Packet Classification Encoding
```

```
  Classifier Reference: 10
  Service Flow Reference: 20
  CM Interface Mask (CMIM) Encoding: 0x40-00-00-00

Upstream Service Flow Encodings
  Service Flow Reference: 11
  Quality of Service Parameter Set: provisioned admitted active
  Upstream Maximum Sustained Traffic Rate: 1
  Minimum Reserved Traffic Rate: 1
  Service Flow Scheduling Type: Real-Time Polling Service
  Data Rate Unit Setting: Mbps
  Nominal Polling Interval: 5000
Upstream Packet Classification Encoding
  Classifier Reference: 2
  Service Flow Reference: 11
  CM Interface Mask (CMIM) Encoding: 0x00-00-80-00

Downstream Service Flow Encodings
  Service Flow Reference: 21
  Quality of Service Parameter Set: provisioned admitted active
  Downstream Maximum Sustained Traffic Rate: 1
  Data Rate Unit Setting: Mbps
Downstream Packet Classification Encoding
  Classifier Reference: 20
  Service Flow Reference: 21
  CM Interface Mask (CMIM) Encoding: 0x00-00-80-00
```

7.1.3.2 TLV-to-OMCI ME Mapping

The mapping table and any associated content will be provided in a future version.

7.1.3.3 OMCI-ME Relationship Diagram

The relationship diagram and any associated content will be provided in a future version.

7.1.4 HSD + Embedded OMCI Voice

Number of CPE MACs that are permitted to be learned by the ONU—1

Provisioning method—DOCSIS configuration file + MTA configuration at DOCSIS adaptation layer. Initialization of the SIP user agent is contingent upon the presence of a set of voice service flows with packet classification encoding CMIM sub TLVs set to 0x000080. Per [MULPIv4.0], this mask value indicates that this service flow is to be bound to the eMTA. It is the trigger to enable the eMTA and to use the MTA configuration file containing TLV11 objects for provisioning of the voice service(s). The packet classifier encodings contain no classifier rules, meaning that the embedded SIP user agent should not tag its signaling or bearer traffic and that the associated MAC-bridge port should match on untagged frames. Because the implementation of the DOCSIS adaptation layer is unspecified, it is left to the vendor to either implement a packet-cable proxy function for the OMCI-provisioned SIP user-agent (e.g., a virtual eDVA) or require that the TLV11 objects required for provisioning of the SIP user-agent be included within the cable modem configuration file. This example includes the TLV11 objects within the cable modem configuration file.

VLAN mode—N:1 with split-horizon to prevent user-to-user forwarding

VLAN ID—Administratively configured outside the config file as VLAN 300. Note that both the data and voice services are mapped to VLAN 300. It may be operationally desirable to use different VLAN IDs for the two services, but this is not a requirement.

ONU frame filtering and treatment—The extended VLAN tagging operation table is configured to filter on untagged traffic; add a tag with VID set to 300, P-bit set to 0, and TPID equal to the output TPID attribute of this ME.

OLT or BNG IP traffic management—None

Subscriber Service Interface—UNI port for HSD. The HSD services are configured with the additional CMIM classifier for UNI-1 for terminating the service flow.

7.1.4.1 Example DOCSIS Configuration

```
Network Access Control: on
Maximum Number of CPEs: 2
Upstream Service Flow Encodings
  Service Flow Reference: 10
  Service Class Name: HSD_US
  Quality of Service Parameter Set: provisioned admitted active
  Upstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 20
  Service Class Name: HSD_DS
  Quality of Service Parameter Set: provisioned admitted active
  Downstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Upstream Service Flow Encodings
  Service Flow Reference: 1
  Service Class Name: VOICE_US
  Quality of Service Parameter Set: provisioned admitted active
  Minimum Reserved Traffic Rate: 1
  Data Rate Unit Setting: Mbps
  Service Flow Scheduling Type: Real-Time Polling Service
Downstream Service Flow Encodings
  Service Flow Reference: 2
  Service Class Name: VOICE_DS
  Quality of Service Parameter Set: provisioned admitted active
  Minimum Reserved Traffic Rate: 1
  Data Rate Unit Setting: Mbps
Upstream Packet Classification Encoding
  Classifier Reference: 10
  Service Flow Reference: 10
  CM Interface Mask (CMIM) Encoding: 0x40-00-00-00
Downstream Packet Classification Encoding
  Classifier Reference: 20
  Service Flow Reference: 20
  CM Interface Mask (CMIM) Encoding: 0x40-00-00-00
Upstream Packet Classification Encoding
  Classifier Reference: 1
  Service Flow Reference: 1
  CM Interface Mask (CMIM) Encoding: 0x00-00-80-00
Downstream Packet Classification Encoding
  Classifier Reference: 2
  Service Flow Reference: 2
  CM Interface Mask (CMIM) Encoding: 0x00-00-80-00
```

```
SNMP MIB Object(portNumber.1): Gauge, 5060
SNMP MIB Object(callWaiting.1): Integer, 1
SNMP MIB Object(callerId.1): Integer, 1
SNMP MIB Object(directConnect.1): Octet String, ''
SNMP MIB Object(directConnectTimer.1): Gauge, 0
SNMP MIB Object(domain.1): Octet String, acme.com
SNMP MIB Object(msgWaitingIndicator.1): Integer, 1
SNMP MIB Object(password.1): Octet String, GAATL6783234233
SNMP MIB Object(t38FaxRelay.1): Integer, 2
SNMP MIB Object(threeWayCalling.1): Integer, 1
SNMP MIB Object(uri.1): Octet String, 6783234233
SNMP MIB Object(user.1): Octet String, 6783234233
SNMP MIB Object(countryCode.1): Gauge, 1
SNMP MIB Object(dnsPrimary.1): Octet String, ''
SNMP MIB Object(dnsSecondary.1): Octet String, ''
SNMP MIB Object(localHookFlash.1): Integer, 2
SNMP MIB Object(out-of-band-dtmf.1): Octet String, 1
SNMP MIB Object(proxyServer.1): Octet String, sip.acme.com
SNMP MIB Object(proxyServerSecondary.1): Octet String, ''
SNMP MIB Object(proxyServerPort.1): Gauge, 5060
SNMP MIB Object(proxyServerPortSecondary.1): Gauge, 0
SNMP MIB Object(registrationPeriod.1): Gauge, 3600
SNMP MIB Object(releaseTimer.1): Gauge, 10
SNMP MIB Object(rtpPort.1): Gauge, 49152
SNMP MIB Object(switchType.1): Octet String, bell
SNMP MIB Object(rtpCodecFirstOrder.1): Integer, 0
SNMP MIB Object(rtpCodecSecondOrder.1): Integer, 0
SNMP MIB Object(rtpCodecThirdOrder.1): Integer, 0
SNMP MIB Object(rtpDscp.1): Integer, 46
SNMP MIB Object(silenceSuppressionFirstOrder.1): Integer, 2
SNMP MIB Object(silenceSuppressionSecondOrder.1): Integer, 2
SNMP MIB Object(silenceSuppressionThirdOrder.1): Integer, 2
SNMP MIB Object(sipPacketRateFirstOrder.1): Gauge, 10
SNMP MIB Object(sipPacketRateSecondOrder.1): Gauge, 10
SNMP MIB Object(sipPacketRateThirdOrder.1): Gauge, 10
SNMP MIB Object(digitLongTimer.1): Gauge, 16000
SNMP MIB Object(digitShortTimer.1): Gauge, 4000
SNMP MIB Object(pattern.1): Octet String, 0T|00T|
[1-9]11|1[2-9]xxxxxxxx|[2-4]xxxxxx|[6-7]xxxxxx|9xxxxxx|80xxxxx|8[2-9]xxxxx|81[0-3]xxxx|
81[5-9]xxxx|5[0-7]xxxxx|59xxxxx|58[0-1]xxxx|58[3-9]xxxx|[2-9]xxxxxxxxx
```

7.1.4.2 TLV-to-OMCI ME Mapping

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Network Access Control (3)		On (If this value is Off, then no MEs should be configured.)
Upstream Service Flow Encodings (24)	**T-CONT (ME-ID)**	
	Managed entity ID	*0x8004*
	Alloc-ID	*0x103*
	Policy	0x1 (Strict Priority)
	Type	*4 (BE) (OLT scheduler)*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Service Flow Reference (24.1)		*10*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Upstream Max Sustained Traffic Rate (24.8)	Max Rate	*125E6 (bytes/sec) (OLT scheduler)*
Data Rate Unit Setting (24.41)		*Mbps*
	PPTP Eth UNI	
	Managed entity ID	*0x101*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x101*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	MAC Bridge Service Profile	
	Managed entity ID	*0x1*
	Spanning tree ind	0x1
	Learning ind	0x1
	Port bridging ind	0x0
	Priority	0x1
	Max age	0xbb8
	Hello time	0x12c
	Forward delay	0x514
	Unknown MAC address discard	0x0
Maximum Number of CPEs (18)	MAC learning depth	*0x2*
	Dynamic filtering ageing time	0x12c
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*20*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E6 (bytes/sec)*
Data Rate Unit Setting (25.41)		*Mbps*
	Priority Queue (US)	
	Managed entity ID	*0x8027*
Maximum Traffic Burst (24.9)	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80040007*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Maximum Traffic Burst (25.9)	**Priority Queue (DS)**	
	Managed entity ID	*0x108*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x900007 (assume slot-id is zero)*
	GEM port network CTP	
	Managed entity ID	*0x90*
	Port-ID	*0x90*
	T-CONT pointer	*0x8004*
	Direction	0x3 (bidirectional)
	Traffic management pointer for US	*0x8027*
	Traffic descriptor profile pointer for US	*0x1090*
	Priority queue pointer for DS	*0x108*
	Traffic descriptor profile pointer for DS	*0x90*
	Encryption key ring	0x0 (no encryption)
	802.1p mapper service profile	
	Managed entity ID	*0x2401*
	TP pointer	0xffff
	Interwork TP pointer for P-bit priority 0	*0x90*
	Interwork TP pointer for P-bit priority 1	0xffff
	Interwork TP pointer for P-bit priority 2	0xffff
	Interwork TP pointer for P-bit priority 3	0xffff
	Interwork TP pointer for P-bit priority 4	0xffff
	Interwork TP pointer for P-bit priority 5	0xffff
	Interwork TP pointer for P-bit priority 6	0xffff
	Interwork TP pointer for P-bit priority 7	0xffff
	Unmarked frame option	0x1 (set from Default P-bit assumption)
	DSCP to P-bit mapping	0x0
	Default P-bit assumption	0x0
	GEM interworking termination point	
	Managed entity ID	*0x90*
	GEM port network CTP connectivity pointer	*0x90*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2401
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	MAC bridge port configuration data	
	Managed entity ID	*0x101 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x101*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x2401 (PON side)*
	Bridge ID pointer	*0x1*
	Port num	*0x5*
	TP type	0x3 (802.1p mapper service profile)
	TP pointer	0x2401
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	VLAN tagging filter data	
	Managed entity ID	*0x2401*
	VLAN filter list	*0x012c0000000000000 00000000000000000000000000000000 (Admit frames tagged with VLAN 300)*
	Forward operation	0x10
	Number of entries	0x1
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x101*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600000966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x101*
	DSCP to P-bit mapping	0x0
Upstream Service Flow Encodings (24)	**T-CONT (ME-ID)**	
	Managed entity ID	*0x8003*
	Alloc-ID	*0x301*
	Policy	0x1 (Strict Priority)
Service Flow Scheduling Type (24.15)	Type	4 (rtPS) (OLT scheduler)
Service Flow Reference (24.1)		*1*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
	Fixed Rate	125E3 *(bytes/sec)* (OLT scheduler)

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*2*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E3 (bytes/sec)*
	Priority Queue (US)	
	Managed entity ID	*0x8019*
	Allocated queue size	1E3 (must account for scaling factor in ONU2-G)
	Related port	*0x80030002*
	MAC Bridge Service Profile	
	Managed entity ID	*0x61*
	Spanning tree ind	0x0
	Learning ind	0x1
	Port bridging ind	0x0
	Priority	0x1
	Max age	0xbb8
	Hello time	0x12c
	Forward delay	0x514
	Unknown MAC address discard	0x0
	MAC learning depth	*0x0*
	Dynamic filtering ageing time	0x0
	IP host config data	
	Managed entity ID	*0x1*
	IP options	0x08 (Enable DHCP, Respond to ping, Respond to traceroute, Enable IP stack)
	TCP/UDP config data	
	Managed entity ID	*0x2a*
SNMP MIB Object(proxyServerPort)	Port ID	0x13c4 (5060)
	Protocol	0x11 (UDP)
	TOS/DiffServ field	0xb8 (EF)
	IP host pointer	*0x1*
	GEM port network CTP	
	Managed entity ID	*0x8e*
	Port-ID	*0x83*
	T-CONT pointer	*0x8003*
	Direction	0x3 (bidirectional)
	Traffic management pointer for US	*0x8019*
	Priority queue pointer for DS	*0x0*
	Encryption key ring	0x0 (no encryption)
	802.1p mapper service profile	
	Managed entity ID	*0x508e*
	TP pointer	0xffff

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Interwork TP pointer for P-bit priority 0	*0x8e*
	Interwork TP pointer for P-bit priority 1	0xffff
	Interwork TP pointer for P-bit priority 2	0xffff
	Interwork TP pointer for P-bit priority 3	0xffff
	Interwork TP pointer for P-bit priority 4	0xffff
	Interwork TP pointer for P-bit priority 5	0xffff
	Interwork TP pointer for P-bit priority 6	0xffff
	Interwork TP pointer for P-bit priority 7	0xffff
	Unmarked frame option	0x1 (set from Default P-bit assumption)
	DSCP to P-bit mapping	0x0
	Default P-bit assumption	0x0
	GEM interworking termination point	
	Managed entity ID	*0x8e*
	GEM port network CTP connectivity pointer	*0x8e*
	Interworking option	0x1 (MAC bridged LAN)
	Service profile pointer	0x61
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	MAC bridge port configuration data	
	Managed entity ID	*0x508e (PON side)*
	Bridge ID pointer	*0x61*
	Port num	*0x1*
	TP type	0x5 (GEM interworking termination point)
	TP pointer	*0x8e*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC bridge port configuration data	
	Managed entity ID	*0x408e (IP Host side)*
	Bridge ID pointer	*0x61*
	Port num	*0x2*
	TP type	0x4 (IP host config data)
	TP pointer	*0x1*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	VLAN tagging filter data	
	Managed entity ID	*0x508e*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	VLAN filter list	*0x012c00000000000000 00000000000000000000000000000000 (Admit frames tagged with VLAN 300)*
	Forward operation	0x10
	Number of entries	0x1
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x408e*
	Association type	0x0 (MAC bridge port configuration data)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f000600060966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit=0)*
	Associated ME pointer	*0x408e*
	DSCP to P-bit mapping	0x0
	Large string	
	Managed entity ID	*0x3107*
	Number of parts	0x1
SNMP MIB Object(uri.1)	Part 1	*'6783234233'*
	Large string	
	Managed entity ID	*0x60a1*
	Number of parts	0x1
SNMP MIB Object(proxyServer.1)	Part 1	*'sip.acme.com'*
	Authentication security method	
	Managed entity ID	*0x1*
	Validation scheme	0x0 (disabled)
SNMP MIB Object(user.1)	Username 1	*'6783234233'*
SNMP MIB Object(password.1)	Password	*'GAATL6783234233'*
	Realm	' '
	VoIP config data	
	Managed entity ID	*0x1*
	Signaling protocol used	0x1 (SIP)
	VoIP configuration method used	0x1 (OMCI)
	VoIP configuration address pointer	0xffff
	Retrieve profile	0x1
	Network address	
	Managed entity ID	*0x60a1*
	Security pointer	0xffff
	Address pointer	*0x60a1*
	SIP agent config data	
	Managed entity ID	*0x2a*

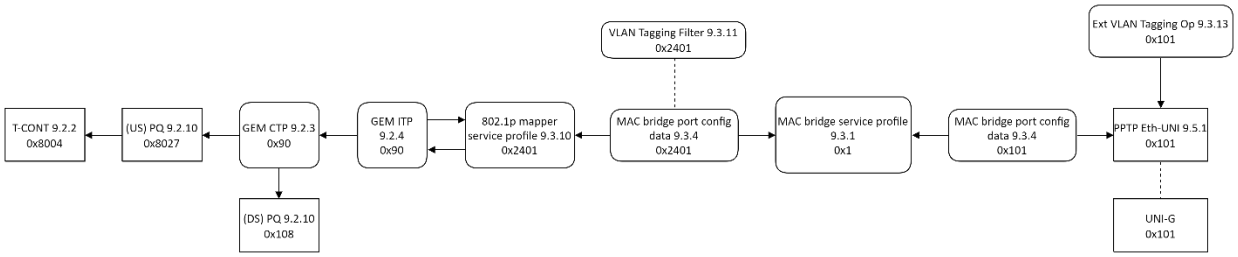
DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Proxy server address pointer	*0x60a1*
	Outbound proxy address pointer	0xffff
SNMP MIB Object(dnsPrimary.1)	Primary SIP DNS	0x0
SNMP MIB Object(dnsSecondary.1)	Secondary SIP DNS	0x0
	TCP/UDP pointer	*0x2a*
SNMP MIB Object(registrationPeriod)	SIP reg exp time	0xe10
	SIP rereg head start time	0x168
SNMP MIB Object(domain)	Host part URI	0xffff
	SIP registrar	*0x60a1*
SNMP MIB Object(switchType.1)	Softswitch	*'bell'*
	SIP option transmit control	0x0
	SIP URI format	0x0
SNMP MIB Object(proxyServerSecondary) SNMP MIB Object(proxyServerPortSecondary)	Redundant SIP agent pointer	*0xffff* [Pointer to a second SIP agent config data ME only if a set of secondary SIP server TLV11 SNMP objects are defined]
	SIP agent config data 2	
	Managed entity ID	*0x2a*
	In-Use-Options-Timer	0x3c
	Alternate-Options-Timer	0x3c
	Revertive	0x0
	SIP user data	
	Managed entity ID	*0x1*
	SIP agent pointer	*0x2a*
	User part AOR	*0x3107*
	SIP display name	0x0
	Username and password	*0x1*
	Voicemail server SIP URI	0xffff
	Voicemail subscription expiration time	0xe10
	Network dial plan pointer	*0x1*
	Application services profile pointer	*0x1*
	Feature code pointer	0xffff
	PPTP pointer	*0x301*
SNMP MIB Object(releaseTimer)	Release timer	0xa
	Network dial plan table	
	Managed entity ID	*0x1*
SNMP MIB Object(digitShortTimer)	Critical dial timeout	0xfa0
SNMP MIB Object(digitLongTimer.1)	Partial dial timeout	0x3e80
	Dial plan format	0x2 (b-PKT-SP-NCS)
	Dial plan table (row 0)	*0x 000030547C3030547C5B312D395D 31317C00000000000000000000000000*
	Dial plan table (row 1)	*0x0001315B322D395D7878787878787 8787C5B322D345D7878787878787C00*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Dial plan table (row 2)	*0x00025B362D375D7878787878787C3 97878787878787C383078787878787C*
	Dial plan table (row 3)	*0x0003385B322D395D78787878787C3 8315B302D335D787878787C00000000*
	Dial plan table (row 4)	*0x000438315B352D395D787878787C3 55B302D375D78787878787C00000000*
	Dial plan table (row 5)	*0x0005353978787878787C35385B302 D315D787878787C0000000000000000*
	Dial plan table (row 6)	*0x000635385B332D395D787878787C5 B322D395D7878787878787878780000*
	VoIP application service profile	
	Managed entity ID	*0x1*
SNMP MIB Object(callerId) [1=0x3, 2=0x0]	CID features	0x3
SNMP MIB Object(callWaiting) [1=0x3, 2=0x0]	Call waiting features	0x3
SNMP MIB Object(threeWayCalling) [2=0x0, 1=0x23]	Call progress or transfer features	0x23
SNMP MIB Object(msgWaitingIndicator) [2=0x0, 1=0x6]	Call presentation features	0x6
SNMP MIB Object(directConnect) [null=0x0, any other value = 0x1]	Direct connect feature	0x0
SNMP MIB Object(directConnect)	Direct connect URI pointer	0xffff
	Bridged line agent URI pointer	0xffff
	Conference factory URI pointer	0xffff
SNMP MIB Object(directConnectTimer)	Dial tone feature delay/warmline timer (new)	
	Voice service profile	
	Managed entity ID	*0x1*
	Announcement type	0xff
	Jitter target	0x0
	Jitter buffer max	0x28
	Echo cancel ind	0x1
SNMP MIB Object(countryCode)	PSTN protocol variant	0x1
	DTMF digit levels	0x8000
	DTMF digit duration	0x0
	Hook flash minimum time	0x0
	Hook flash maximum time	0x0
	Tone pattern table	0x00000000000000000000000000000000000000000
	Tone event table	0xe00060aa000000
	Ringing pattern table	0x0000000000
	Ringing event table	0xe00060a900ffff
	RTP profile data	
	Managed entity ID	*0x1*
SNMP MIB Object(rtpPort)	Local port min	0xc000

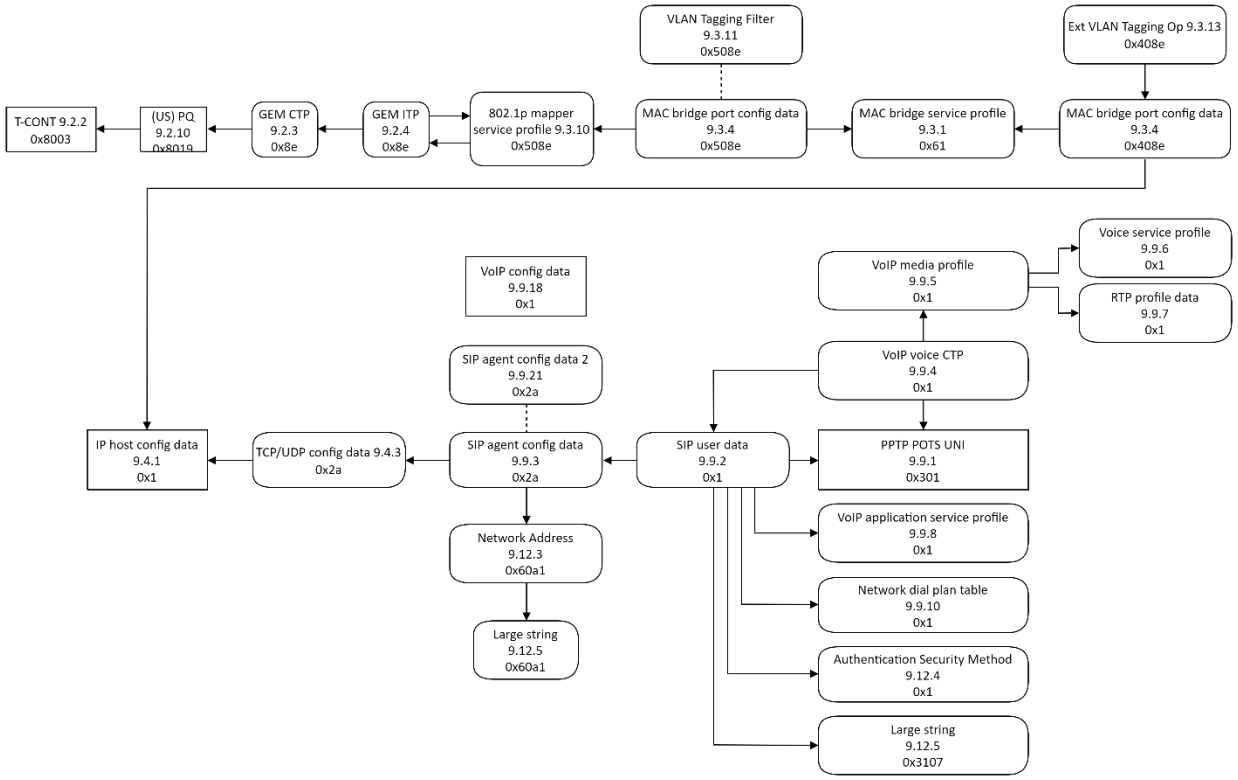
DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
SNMP MIB Object(rtpPort) [Add 0x10 to get port max]	Local port max	0xc010
SNMP MIB Object(rtpDscp)	DSCP mark	0x2e (EF)
	Piggyback events	0x0
	Tone events	0x0
	DTMF events	0x0
	CAS events	0x0
	VoIP media profile	
	Managed entity ID	*0x1*
SNMP MIB Object(t38FaxRelay) [2=0x0, 1=0x1]	Fax mode	0x0
	Voice service profile pointer	*0x1*
SNMP MIB Object(rtpCodecFirstOrder)	Codec selection (1st order)	0x0 (PCMU)
SNMP MIB Object(sipPacketRateFirstOrder)	Packet period selection (1st order)	0xa (10ms)
SNMP MIB Object(silenceSuppressionFirstOrder)	Silence suppression (1st order)	0x0 (off)
SNMP MIB Object(rtpCodecSecondOrder)	Codec selection (2nd order)	0x0 (PCMU)
SNMP MIB Object(sipPacketRateSecondOrder)	Packet period selection (2nd order)	0xa (10 ms)
SNMP MIB Object(silenceSuppressionSecondOrder)	Silence suppression (2nd order)	0x0 (off)
SNMP MIB Object(rtpCodecThirdOrder)	Codec selection (3rd order)	0x0 (PCMU)
SNMP MIB Object(sipPacketRateThirdOrder)	Packet period selection (3rd order)	0xa (10 ms)
SNMP MIB Object(silenceSuppressionThirdOrder)	Silence suppression (3rd order)	0x0 (off)
	Codec selection (4th order)	0x0 (PCMU)
	Packet period selection (4th order)	0xa (10 ms)
	Silence suppression (4th order)	0x0 (off)
SNMP MIB Object(out-of-band-dtmf.1)	OOB DTMF	0x1
	RTP profile pointer	*0x1*
	VoIP voice CTP	
	Managed entity ID	*0x1*
	User protocol pointer	*0x1*
	PPTP pointer	*0x301*
	VoIP media profile pointer	*0x1*
	Signaling code	0x1
	Physical path termination point POTS UNI	
	Managed entity ID	*0x301*
	Administrative state	0x0 (unlocked)
	Impedance	0x0 (600 ohms)
	Transmission path	0x0 (full-time on-hook)
	Rx gain	0x0 (0 dB)
	Tx gain	0x0 (0 dB)

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	POTS holdover time	0x0 (vendor specific)
	Nominal feed voltage	0x30 (48 VDC)
	Loss of softswitch	0x1 (True)

7.1.4.3 OMCI-ME Relationship Diagram (HSD)



7.1.4.4 OMCI-ME Relationship Diagram (VOICE)



7.1.5 HSD + External Voice + IP Video

Number of CPE MACs that are permitted to be learned by the ONU—1

Provisioning Method—DOCSIS configuration file + ACS/[TR-104]/[TR-181]

The voice endpoint (eDVA) is embedded in an external RG with OTT IP voice and RG configuration. The unicast IP video is delivered through the external RG to an external IP-STB. Multiple service flows and DSCP classifiers are required.

The RG and IP-STB devices behind the ONU are configured to apply DSCP markings to the service flows as depicted in Table 2. The configuration of these devices is outside the scope of this report.

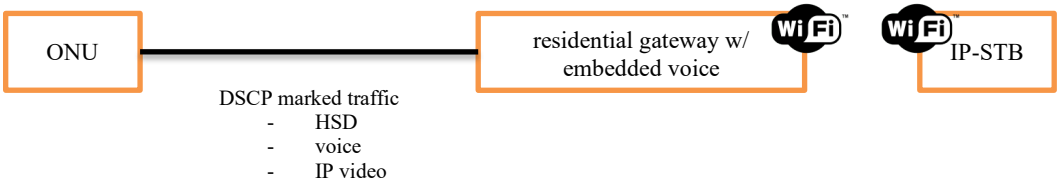


Figure 6 - HSD + External Voice + IP Video

Table 2 - DSCP Configuration for Devices behind the ONU

Application	DSCP Class	ToS Value	Mapped 802.1p Value	Upstream Service Flow	Downstream Service Flow	Scheduling Type
HSD	CS0	0x00	0	10	20	BE
Unicast IP Video	CS4	0x80	1	11	21	BE
IP Voice	EF	0xB8	2	12	22	rtPS

T-CONT scheduling type—The ONU must support four T-CONTs, one for each of the following DOCSIS service flow scheduling types: best-effort, non-real-time polling, real-time polling, and unsolicited grant service. The mapping of service flow scheduling type to T-CONT type is shown in Table 3.

Table 3 - T-CONT Service Flow Mapping

Service Flow Scheduling Type	T-CONT Type*
Best Effort	Type 4
Non-real-time polling	Type 3
Real-time polling	Type 2
Unsolicited Grant	Type 1
* Refer to [ITU-T G.984.3] amendment 1 (03.2020), table 7-1.	

Service flow mapping—Service flows are mapped to a T-CONT based on scheduling type TLV value. The absence of the scheduling type TLV implies best-effort scheduling. Service flows of the same scheduling type are mapped to the same T-CONT.

VLAN mode—N:1 with split-horizon to prevent user-to-user forwarding

HSD service VLAN ID—The VLAN for the HSD service is administratively configured using an unspecified manner outside the config file as VLAN 300, priority-bit 0, and TPID 0x8100.

ONU frame filtering and treatment—In OMCI, the extended VLAN tagging operation table is configured to filter on untagged customer traffic; add a tag with VID set to 300 and TPID set to 0x8100. The VLAN's P-bit is derived from the DSCP-to-P-bit mapping. The DSCP map is encoded in accordance with [ITU-T G.988], section 9.3.13, "DSCP to P-bit mapping," using the IP Type of Service Range and Mask (22.9.1) TLV and the associated service flow Traffic Priority (24.7) TLV.

A given 8-bit ToS value from the config file is mapped to a corresponding 6-bit DSCP value, which is mapped to a single P-bit value. All unused DSCP values (from the total range of 0 to 63) are mapped to P-bit value 0.

ONU frame classification (802.1p mapper ME) and GEM PORT/T-CONT mapping—The mapping is derived from the service flow traffic priority TLV and the service flow scheduling type TLVs. In this example frames with 802.1p

values of 0 are mapped to GEM port 0x90. Frames with 802.1p values of 1 are mapped to GEM port 0x91. Frames with 802.1p values of 2 are mapped to GEM port 0x92. Frames with 802.1p values in the range of 3–7 are dropped.

OLT or BNG IP traffic management—Upstream traffic is rate limited per T-CONT. GEM port-based rate limiting is not required in the base functional specification. Downstream traffic management is performed outside the PON domain, in either a separate BNG or the OLT's integrated traffic management subsystem The downstream traffic QoS parameters specified in the DOCSIS service flow reference TLVs are used to configure the downstream traffic management functions.

Subscriber service interface/UNI port—This example does not include a CMIM classifier TLV. When a CMIM classifier TLV is not included in the config file, the highest speed UNI port is configured for the service by default.

7.1.5.1 Example DOCSIS Configuration

```
Network Access Control: on
Maximum Number of CPEs: 1
Upstream Service Flow Encodings
  Service Flow Reference: 10
  Quality of Service Parameter Set: provisioned admitted active
  Traffic Priority: 0
  Upstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Upstream Service Flow Encodings
  Service Flow Reference: 11
  Quality of Service Parameter Set: provisioned admitted active
  Traffic Priority: 1
  Upstream Maximum Sustained Traffic Rate: 15
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Upstream Service Flow Encodings
  Service Flow Reference: 12
  Quality of Service Parameter Set: provisioned admitted active
  Traffic Priority: 2
  Upstream Maximum Sustained Traffic Rate: 1
  Maximum Traffic Burst: 750000
  Service Flow Scheduling Type: Real-Time Polling Service
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 20
  Quality of Service Parameter Set: provisioned admitted active
  Traffic Priority: 0
  Downstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 21
  Quality of Service Parameter Set: provisioned admitted active
  Traffic Priority: 1
  Downstream Maximum Sustained Traffic Rate: 150
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 22
  Quality of Service Parameter Set: provisioned admitted active
```

```
  Traffic Priority: 2
  Downstream Maximum Sustained Traffic Rate: 1
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Upstream Packet Classification Encoding
  Classifier Reference: 10
  Service Flow Reference: 10
  IP Packet Classification Encodings
    IP Type of Service Range and Mask: tos-low 0x00 tos-high 0x00 tos-mask 0xFF
Upstream Packet Classification Encoding
  Classifier Reference: 11
  Service Flow Reference: 11
  IP Packet Classification Encodings
    IP Type of Service Range and Mask: tos-low 0x80 tos-high 0x80 tos-mask 0xFF
Upstream Packet Classification Encoding
  Classifier Reference: 12
  Service Flow Reference: 12
  IP Packet Classification Encodings
    IP Type of Service Range and Mask: tos-low 0xB8 tos-high 0xB8 tos-mask 0xFF
Downstream Packet Classification Encoding
  Classifier Reference: 20
  Service Flow Reference: 20
  IP Packet Classification Encodings
    IP Type of Service Range and Mask: tos-low 0x00 tos-high 0x00 tos-mask 0xFF
Downstream Packet Classification Encoding
  Classifier Reference: 21
  Service Flow Reference: 21
  IP Packet Classification Encodings
    IP Type of Service Range and Mask: tos-low 0x80 tos-high 0x80 tos-mask 0xFF
Downstream Packet Classification Encoding
  Classifier Reference: 22
  Service Flow Reference: 22
  IP Packet Classification Encodings
    IP Type of Service Range and Mask: tos-low 0xB8 tos-high 0xB8 tos-mask 0xFF
```

7.1.5.2 TLV-to-OMCI ME Mapping

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Network Access Control (3)		On (If this value is Off, then no MEs should be configured.)
Upstream Service Flow Encodings (24)	**T-CONT (ME-ID)**	
	Managed entity ID	*0x8004*
	Alloc-ID	*0x103*
	Policy	0x1 (Strict Priority)
	Type	*4 (BE) (default)*
Service Flow Reference (24.1)		*10*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Upstream Max Sustained Traffic Rate (24.8)	Max Rate	*125E6 (bytes/sec)*
Data Rate Unit Setting (24.41)		*Mbps*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	T-CONT (ME-ID)	
	Managed entity ID	*0x8005*
	Alloc-ID	*0x104*
	Policy	0x1 (Strict Priority)
Service Flow Scheduling Type (24.15)	Type	*4 (BE) (default)*
Service Flow Reference (24.1)		*11*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Minimum Reserved Traffic Rate (24.10)	Assured rate	*0 (bytes/sec) (TLV 24.10 not present so use 0)*
Upstream Max Sustained Traffic Rate (24.8)	Max rate	*1875E3 (bytes/sec)*
Data Rate Unit Setting (24.41)		*Mbps*
Upstream Service Flow Encodings (24)	**T-CONT (ME-ID)**	
	Managed entity ID	*0x8006*
	Alloc-ID	*0x105*
	Policy	0x1 (Strict Priority)
Service Flow Scheduling Type (24.15)	Type	*2 (rtPS)*
Service Flow Reference (24.1)		*12*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Minimum Reserved Traffic Rate (24.10) + Upstream Max Sustained Traffic Rate (24.8)	Assured rate	125E3 *(bytes/sec) (TLV 24.10 not present so use 0)*
Minimum Reserved Traffic Rate (24.10) + Upstream Max Sustained Traffic Rate (24.8)	Max rate	125E3 *(bytes/sec) (TLV 24.10 not present so use 0)*
Data Rate Unit Setting (24.41)		*Mbps*
	PPTP Eth UNI	
	Managed entity ID	*0x101*
	Expected type	0x0 (autosense)
	Auto detection configuration	0x00 (Auto/Auto)
	Ethernet loopback configuration	0x0 (No loopback)
	Administrative state	0x0 (unlocked)
	Max frame size	0x2328
	DTE or DCE ind	0x0 (DCE or MDI-X)
	Bridged or IP ind	0x0 (Bridged)
	UNI-G	
	Managed entity ID	*0x101*
	Deprecated	0x0
	Administrative state	0x0 (unlock)
	Management Capability	0x0 (OMCI only)
	Non-OMCI management identifier	0x0 (OMCI management)
	MAC Bridge Service Profile	
	Managed entity ID	*0x1*
	Spanning tree ind	0x1
	Learning ind	0x1

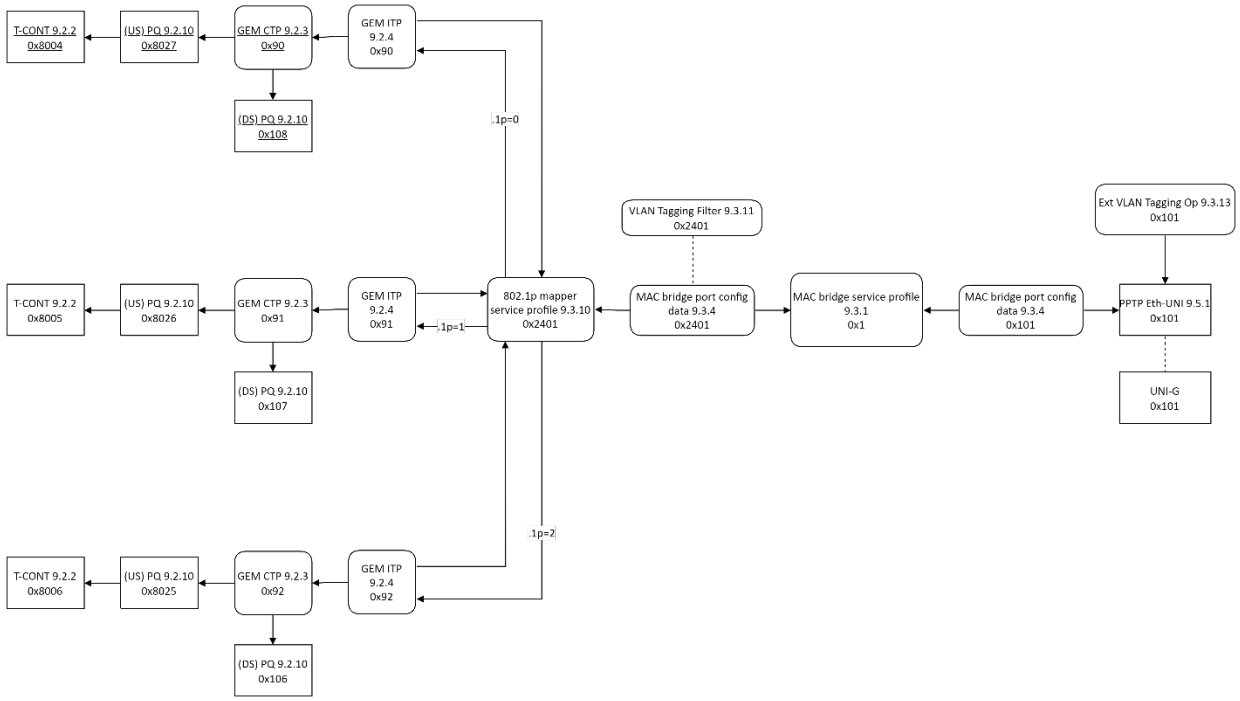
DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Port bridging ind	0x0
	Priority	0x1
	Max age	0xbb8
	Hello time	0x12c
	Forward delay	0x514
	Unknown MAC address discard	0x0
Maximum Number of CPEs (18)	MAC learning depth	*0x1*
	Dynamic filtering ageing time	0x12c
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*20*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E6 (bytes/sec)*
Maximum Traffic Burst (25.9)		*75E4*
Data Rate Unit Setting (25.41)		*Mbps*
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*21*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*1875E4 (bytes/sec)*
Maximum Traffic Burst (25.9)		*75E4*
Data Rate Unit Setting (25.41)		*Mbps*
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*22*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E3 (bytes/sec)*
Maximum Traffic Burst (25.9)		*75E4*
Data Rate Unit Setting (25.41)		*Mbps*
Maximum Traffic Burst (24.9) for SF 10	**Priority Queue (US)**	
	Managed entity ID	*0x8027*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80040007 (read)*
Maximum Traffic Burst (25.9) for SF 11	**Priority Queue (DS)**	
	Managed entity ID	*0x108*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x900007 (read)*
Maximum Traffic Burst (24.9) for SF 12	**Priority Queue (US)**	
	Managed entity ID	*0x8026*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80050006 (read)*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Maximum Traffic Burst (25.9) for SF 20	**Priority Queue (DS)**	
	Managed entity ID	*0x107*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x900006 (read)*
Maximum Traffic Burst (24.9) for SF 21	**Priority Queue (US)**	
	Managed entity ID	*0x8025*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80060005 (read)*
Maximum Traffic Burst (25.9) for SF 22	**Priority Queue (DS)**	
	Managed entity ID	*0x106*
	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x900005 (read)*
	GEM port network CTP	
	Managed entity ID	*0x90*
	Port-ID	*0x90*
	T-CONT pointer	*0x8004*
	Direction	0x3 (bidirectional)
	Priority queue pointer for DS	*0x108*
	Encryption key ring	0x0 (no encryption)
	GEM port network CTP	
	Managed entity ID	*0x91*
	Port-ID	*0x91*
	T-CONT pointer	*0x8005*
	Direction	0x3 (bidirectional)
	Priority queue pointer for DS	*0x107*
	Encryption key ring	0x0 (no encryption)
	GEM port network CTP	
	Managed entity ID	*0x92*
	Port-ID	*0x92*
	T-CONT pointer	*0x8006*
	Direction	0x3 (bidirectional)
	Priority queue pointer for DS	*0x106*
	Encryption key ring	0x0 (no encryption)
	802.1p mapper service profile	
	Managed entity ID	*0x2401*
	TP pointer	0xffff
	Interwork TP pointer for P-bit priority 0	*0x90*
	Interwork TP pointer for P-bit priority 1	0x91
	Interwork TP pointer for P-bit priority 2	0x92

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Interwork TP pointer for P-bit priority 3	0xffff
	Interwork TP pointer for P-bit priority 4	0xffff
	Interwork TP pointer for P-bit priority 5	0xffff
	Interwork TP pointer for P-bit priority 6	0xffff
	Interwork TP pointer for P-bit priority 7	0xffff
	Unmarked frame option	0x1 (Derive implied PCP field from DSCP bits of received frame)
	DSCP to P-bit mapping	0x0
	Default P-bit assumption	0x0
	GEM interworking termination point	
	Managed entity ID	*0x90*
	GEM port network CTP connectivity pointer	*0x90*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2401
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	GEM interworking termination point	
	Managed entity ID	*0x91*
	GEM port network CTP connectivity pointer	*0x91*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2401
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	GEM interworking termination point	
	Managed entity ID	*0x92*
	GEM port network CTP connectivity pointer	*0x92*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2401
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	MAC bridge port configuration data	
	Managed entity ID	*0x101 (UNI side)*
	Bridge ID pointer	*0x1*
	Port num	*0x1*
	TP type	0x1 (PPTP Ethernet UNI)
	TP pointer	*0x101*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x2401 (PON side)*
	Bridge ID pointer	*0x1*
	Port num	*0x5*
	TP type	0x3 (802.1p mapper service profile)
	TP pointer	0x2401
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	VLAN tagging filter data	
	Managed entity ID	*0x2401*
	VLAN filter list	*0x012c00000000000000 00000000000000000000000000000000 (Admit frames tagged with VLAN 300)*
	Forward operation	0x10
	Number of entries	0x1
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x101*
	Association type	0x2 (PPTP Ethernet UNI)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	*0xf8000000f8000000000f0006000a0966 (Admit only untagged frames, add inner VLAN ID 300 with P-bit derived from map)*
	Associated ME pointer	*0x101*
	DSCP to P-bit mapping	0x00000000000000000000000020000 0000010000000000000

7.1.5.3 OMCI-ME Relationship Diagram



7.1.6 HSD via Embedded RG

In this use case, all LAN ports are controlled by the RG.

- **Number of CPE MACs that are permitted to be learned by the ONU**—1
- **Provisioning method**—DOCSIS configuration file + ACS/[TR-181]
- **ONU configuration—**Gateway with multiple LAN ports
- **VLAN mode—**N:1 with split-horizon to prevent user-to-user forwarding
- **HSD service VLAN ID—**The VLAN for the HSD service is administratively configured using an unspecified manner outside the config file as VLAN 300, priority-bit 0, and TPID 0x8100.
- **Gateway configuration—**The RG WAN interface is bootstrapped to tag traffic with VLAN 2 and to use DHCP to obtain an IP address. The [TR-069] agent on the gateway is configured to "call home" to the ACS using the configuration data supplied in the "BBF TR-069 management server," "Authentication security method," and "Large String" Mes; the data for these MEs are mapped from the eRouter Configuration Encodings (202) sub-TLVs. Alternatively, the TR-069 ACS information can be supplied through other methods such as DHCP options instead of the optional OMCI MEs intended for this purpose.
- **ONU frame filtering and treatment—**The extended VLAN tagging operation table is configured to filter on VLAN 2; remove this tag; add a tag with VID set to 300, P-bit equal to that of the incoming frame that was removed (VID 2), and TPID equal to 0x8100.
- **ONU frame classification (802.1p mapper ME)**—Frames with 802.1p values in the range of 0–7 are mapped to the same GEM port.
- **OLT or BNG IP traffic management—**Upstream traffic is rate limited per T-CONT. GEM port-based rate limiting is not required in the base functional specification. Downstream traffic management is performed outside the PON domain, in either a separate BNG or the OLT's integrated traffic management subsystem. In the latter case, the downstream traffic QoS parameters specified in the DOCSIS service flow reference TLVs are used to configure the downstream traffic management functions.

- **Subscriber service interface—**The VEIP interface to the RG WAN and any RG LAN port. The absence of CMIM classifier TLVs implies that the service is bound to the ONUs default service interface, which in this case is the RG WAN interface (ONU VEIP).

7.1.6.1 Example DOCSIS Configuration

```
Network Access Control: on
Maximum Number of CPEs: 1
Upstream Service Flow Encodings
  Service Flow Reference: 10
  Quality of Service Parameter Set: provisioned admitted active
  Upstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
Downstream Service Flow Encodings
  Service Flow Reference: 20
  Quality of Service Parameter Set: provisioned admitted active
  Downstream Maximum Sustained Traffic Rate: 1000
  Maximum Traffic Burst: 750000
  Data Rate Unit Setting: Mbps
eRouter Configuration Encodings
  eRouter TR-069 Management Server
    URL:https://youracs.com:8443/
    Username: acsuser
    Password: S3cret
```

7.1.6.2 TLV-to-OMCI ME Mapping

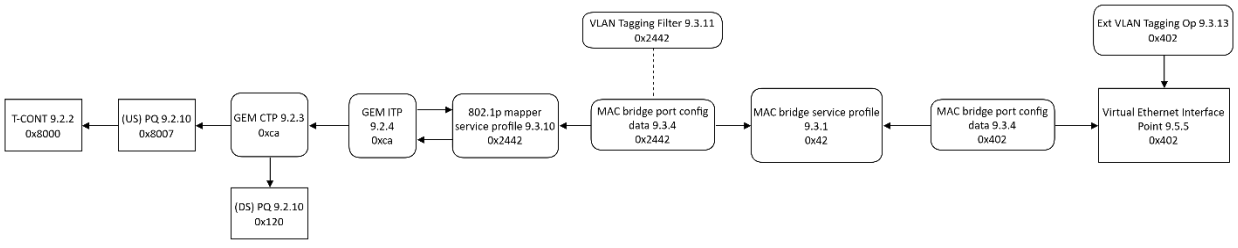
DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Network Access Control (3)		On (If this value is Off, then no MEs should be configured.)
Upstream Service Flow Encodings (24)	**T-CONT**	
	Managed entity ID	*0x8000*
	Alloc-ID	*0x148*
	Policy	0x1 (Strict Priority)
	Type	*4 (BE) (OLT scheduler)*
Service Flow Reference (24.1)		*10*
Quality of Service Parameter Set (24.6)		*provisioned admitted active*
Upstream Max Sustained Traffic Rate (24.8)	Max Rate	*125E6 (bytes/sec) (OLT scheduler)*
Data Rate Unit Setting (24.41)		*Mbps*
	Large String	
	Managed entity ID	*0x402*
	Number of Parts	*0x1*
URL (202.2.2)	Part1	*'https://youracs.com:8443/'*
	Authentication security method	
	Managed entity ID	*0x402*
	Validation scheme	*0 (disabled)*
Username (202.2.3)	Username 1	*'acsuser'*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Password (202.2.4)	Password	*'S3cret'*
	Realm	
	Username 2	
	BBF TR-069 management server	
	Managed entity ID	*0x402*
	Administrative state	*0x0*
	ACS network address	*0x402*
	Associated tag	*0x12c*
	Network Address	
	Security pointer	*0x402*
	Address pointer	*0x402*
	Virtual Ethernet interface point	
	Managed entity ID	0x402
	Administrative state	
	TCP/UDP pointer	
	IANA assigned port	
	MAC Bridge Service Profile	
	Managed entity ID	*0x42*
	Spanning tree ind	0x1
	Learning ind	0x1
	Port bridging ind	0x0
	Priority	0x1
	Max age	0xbb8
	Hello time	0x12c
	Forward delay	0x514
	Unknown MAC address discard	0x0
Maximum Number of CPEs (18)	MAC learning depth	*0x1*
	Dynamic filtering ageing time	0x12c
Downstream Service Flow Encodings (25)		
Service Flow Reference (25.1)		*20*
Quality of Service Parameter Set (25.6)		*provisioned admitted active*
Downstream Max Sustained Traffic Rate (25.8)		*125E6 (bytes/sec)*
Maximum Traffic Burst (25.9)		*75E4*
Data Rate Unit Setting (25.41)		*Mbps*
	Priority Queue (US)	
	Managed entity ID	*0x8007*
Maximum Traffic Burst (24.9)	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0x80000007*
	Priority Queue (DS)	
	Managed entity ID	*0x120*

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
Maximum Traffic Burst (25.9)	Allocated queue size	*75E4 (must account for scaling factor in ONU2-G)*
	Related port	*0xca0007 (assume slot-id is zero)*
	GEM port network CTP	
	Managed entity ID	*0xca*
	Port-ID	*0xca*
	T-CONT pointer	*0x8000*
	Direction	0x3 (bidirectional)
	Traffic management pointer for US	*0x8007*
	Traffic descriptor profile pointer for US	*0x10ca*
	Priority queue pointer for DS	*0x120*
	Traffic descriptor profile pointer for DS	*0xca*
	Encryption key ring	0x0 (no encryption)
	802.1p mapper service profile	
	Managed entity ID	*0x2442*
	TP pointer	0xffff
	Interwork TP pointer for P-bit priority 0	*0xca*
	Interwork TP pointer for P-bit priority 1	*0xca*
	Interwork TP pointer for P-bit priority 2	*0xca*
	Interwork TP pointer for P-bit priority 3	*0xca*
	Interwork TP pointer for P-bit priority 4	*0xca*
	Interwork TP pointer for P-bit priority 5	*0xca*
	Interwork TP pointer for P-bit priority 6	*0xca*
	Interwork TP pointer for P-bit priority 7	*0xca*
	Unmarked frame option	0x0 (Derive implied PCP field from DSCP bits of received frame)
	DSCP to P-bit mapping	0x0
	Default P-bit assumption	0x0
	GEM interworking termination point	
	Managed entity ID	*0xca*
	GEM port network CTP connectivity pointer	*0xca*
	Interworking option	0x5 (IEEE 802.1p mapper)
	Service profile pointer	0x2442
	Interworking termination point pointer	0x0
	GAL profile pointer	0x1 (GAL Ethernet profile)
	GAL loopback configuration	0x0 (No loopback)
	MAC bridge port configuration data	
	Managed entity ID	*0x402 (GW WAN)*
	Bridge ID pointer	*0x42*
	Port num	*0x1*
	TP type	0x11 (VEIP)

DOCSIS TLV	ITU G.988 OMCI ME and IP Traffic Management	Value (note) *Italic, right-aligned values are examples; non-italic, left-aligned values are suggested.*
	TP pointer	*0x402*
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	MAC bridge port configuration data	
	Managed entity ID	*0x2442 (PON side)*
	Bridge ID pointer	*0x42*
	Port num	*0x5*
	TP type	0x3 (802.1p mapper service profile)
	TP pointer	0x2442
	Port priority	0x1
	Port path cost	0x1
	Port spanning tree ind	0x0
	MAC learning depth	*0x0*
	VLAN tagging filter data	
	Managed entity ID	*0x2401*
	VLAN filter list	*0x012c0000000000000000000000000000000000000000000000000000*
	Forward operation	0x10
	Number of entries	0x1
	Ext VLAN tagging operation config data (ME-ID)	
	Managed entity ID	*0x402*
	Association type	0x10 (VEIP)
	Input TPID	0x8100
	Output TPID	0x8100
	Downstream mode	0x0
	Received frame VLAN tagging operation table	0xf800000080010000400f800600080966
	Associated ME pointer	*0x402*
	DSCP to P-bit mapping	0x0

7.1.6.3 OMCI-ME Relationship Diagram



8 CMIM CLASSIFIERS FOR VARIOUS INTERFACES

Based on the premise that an ONU should populate a value for the Physical path termination point Ethernet UNI [ITU-T G.988] clause 9.5.1 Managed entity ID attribute whereby higher rate-capable interfaces have a lower numerical value than lower rate-capable interfaces, Table 4 depicts examples of how CMIM classifiers could be defined to control traffic on ONUs with a variety of both quantity and type of UNI interfaces.

If the ONU is embedded in a gateway and has an active eRouter entity, then Bit 1 (0x40-00-00-00) maps to the eRouter WAN interface.

Table 4 - Example Config File CMIM Classifier Values for ONUs with Various Interfaces

Config File CMIM Classifier	ONU (Non-Pluggable) 10G Max	ONU (Pluggable) 25G Max	Physical Label
Bit 1 (0x40-00-00-00)	10G Gbase-T Ethernet (49)	25G Optical Interface (72)	10G or SFP28
Bit 5 (0x04-00-00-00)	10/100/1000 Base-T Ethernet (47)	10G Gbase-T Ethernet (49)	LAN-1
Bit 6 (0x02-00-00-00)	10/100/1000 Base-T Ethernet (47)	10/100/1000 Base-T Ethernet (47)	LAN-2
Bit 7 (0x01-00-00-00)	10/100/1000 Base-T Ethernet (47)	10/100/1000 Base-T Ethernet (47)	LAN-3
Bit 8 (0x00-80-00-00)	10/100/1000 Base-T Ethernet (47)	10/100/1000 Base-T Ethernet (47)	LAN-4
Bit 9 (0x00-40-00-00)	10/100/1000 Base-T Ethernet (47)	10/100/1000 Base-T Ethernet (47)	LAN-5
Bit 10 (0x00-20-00-00)	10/100/1000 Base-T Ethernet (47)	10/100/1000 Base-T Ethernet (47)	LAN-6
…			…
Bit 15 (0x00-01-00-00)	10/100/1000 Base-T Ethernet (47)	10/100/1000 Base-T Ethernet (47)	LAN-11
Bit 16 (0x00-00-80-00)	VEIP (eDVA)	VEIP (eDVA)	VEIP (eDVA)
…			
Bits 19-31 (0x00-00-10-00 – 0x00-00-00-01)	VEIP (vendor-specific ONU capabilities)	VEIP (vendor-specific ONU capabilities)	

9 OMCI AND THE CABLE OpenOMCI SPECIFICATION

The [ITU-T G.988] standards define ONU Management and Configuration Interface (OMCI) as the way to manage ONU equipment via the OLT. This method includes ONU configuration, fault reporting, performance monitoring, and security. OMCI defines message sets and message exchanges for all functionality within the PON. It uses managed entities (MEs) as the basic data unit for configuring and controlling a network element in the PON.

OMCI enables the management of optical distribution networks (ODNs) by providing a standardized interface for the exchange of management information between network elements. It supports a range of functions, including the following.

- Configuration management: OMCI allows for the configuration of network elements, such as setting up and managing connections and configuring network parameters.
- Fault management: OMCI enables the detection and reporting of faults in the network, facilitating rapid troubleshooting and repair.
- Performance management: OMCI provides real-time monitoring of network performance, enabling operators to identify and address potential issues before they impact service quality.

The inclusion of OMCI in [ITU-T G.988] standards offer several benefits.

- Interoperability: OMCI ensures that different network elements from various vendors can communicate effectively, promoting interoperability and reducing the risk of vendor lock-in.
- Standardization: OMCI's standardized interface simplifies network management, reducing the complexity and cost associated with managing OTNs.
- Improved network reliability: OMCI's fault management capabilities enable rapid detection and resolution of issues, minimizing network downtime and improving overall reliability.

OMCI is a critical component of [ITU-T G.988] standards, enabling the effective management and maintenance of ODNs. Its standardized interface and range of management functions make it an essential tool for network operators seeking to ensure the reliability, scalability, and efficiency of their optical transport networks. CableLabs has published the [Cable OpenOMCI] specification to organize and clarify the MEs required to support the common cable industry use cases.

Appendix I Acknowledgements

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