Cable Data Services

DOCSIS® Provisioning of EPON Specifications

DPoE™ Metro Ethernet Forum Specification

DPoE-SP-MEFv1.0-I03-120830

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Document Status Sheet

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Key to Document Status Codes

Work in Progress	An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.
Draft	A document in specification format considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.
Issued	A stable document, which has undergone rigorous member and vendor review and is suitable for product design and development, cross-vendor interoperability, and for certification testing.
Closed	A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

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1 INTRODUCTION

Comcast Corporation, Time Warner Cable, and Bright House Networks collaborated to develop the interoperability requirements to support business services products using Ethernet Passive Optical Network (EPON) as an access technology.

DOCSIS Provisioning of EPON (DPoE) is a joint effort of operators, vendors, and suppliers to support EPON technology using existing DOCSIS-based back office systems and processes.

Ethernet PON or EPON is an [802.3] standard for a passive optical network (PON). A PON is a specific type of multi-access optical network. A multi-access optical network is an optical fiber based network technology that permits more than two network elements to transmit and receive on the same fiber. Appendix I in [DPoE-SP-ARCHv1.0] has a more detailed explanation of multi-access optical networks.

This version of the DPoE specifications is focused on DOCSIS-based provisioning and operations of Internet Protocol (IP) using DOCSIS High Speed Data (HSD), or IP(HSD) for short, and Metro Ethernet Forum (MEF) services. DPoE Networks offer IP(HSD) services functionally equivalent to DOCSIS networks, where the DPoE System acts like a DOCSIS CMTS and the DPoE System and DPoE Optical Network Unit (ONU) appear to act like a DOCSIS CM.

1.1 DPoE Technology Introduction

DPoE technology was established with the following common requirements already developed by operators. Each of the participant operators had previously selected 1G-EPON and 10G-EPON as the appropriate technology for one or more applications. EPON is a widely-deployed technology with a sufficient and large supply of vendors offering a variety of products for each component of the access network. 10G-EPON technology is now becoming available and is backwards compatible with 1G-EPON. A 1G-EPON network can be incrementally upgraded to 10G-EPON, adding or replacing ONUs one at a time if required. 1G-EPON and 10G-EPON are compatible with [SCTE 174] (RFoG).

The EPON protocol [802.3ah] and the amendment for 10G-EPON [802.3av] support a centralized operator-based controller architecture (OLT), with low cost Layer 2 access devices (ONU). The basic service mapping architecture in EPON is to map Ethernet (or IP) frame header information (such as addresses, IP DiffServ Code Points, Ethernet Q tag, S-VLAN/C-VLAN ID, ISID, bridge address, or other marking) to a logical circuit called a Logical Link Identifier (LLID) in [802.3ah]. The service function is similar to that used in DOCSIS networks in many ways because it is based on a centralized scheduler and uses an LLID which functions like an SID, supports both unicast and broadcast, and has other similarities.

Existing [802.3ah] EPON systems do interoperate within the strict definitions of 1G-EPON. Experience with lab testing, field trials, and deployments has shown operators that 1G-EPON OLT and ONU systems typically only interoperate with a single port ONU. This is because [802.3ah] specifies the interfaces on the PON (the DPoE TU interface) but does not specify any of the other system interfaces. For example, an OLT from vendor A will register an ONU from vendor B, but it is not possible to construct a VLAN from the DPoE MN interface to an S interface. This is a well-recognized limitation of [802.3ah]. The challenge is that neither 1G-EPON nor 10G-EPON specify OAMP to forward traffic between NNI ports and the PON, or UNI ports and the PON. This is not different from other Ethernet standards. For example, if two Ethernet switches from two different vendors are connected, each switch must typically be configured independently. The challenge for EPON is that the remote device (the ONU) cannot be reached, and therefore cannot be configured. A solution to this problem must then be based on developing a common (standard) method of reaching the controller for the ONU, identifying the ONU capabilities, and providing that information to the OLT so that it can configure a working end to forwarding service (in both directions).

Even if EPON had solved that provisioning challenge, there are no standard management interfaces for the ongoing operations and maintenance of the network, including fault management, performance management, security, etc. Operators already have fully working and scaled-out systems that solve these challenges for DOCSIS networks. One of the primary goals for DPoE specifications is to use the existing DOCSIS back office infrastructure to scale up EPON-based business services.

1.2 Scope

This document describes the provisioning and operations required to support Metro Ethernet Forum (MEF) Ethernet Services in DPoE Networks, which use EPON as defined in [802.3ah] and [802.3av].

This document contains informative sections to provide technical background information on the following topics:

- Appendix I describes MEF Carrier Ethernet Network Reference Model and Points.
- Appendix II describes MEF Ethernet Service Framework, which is used to create MEF Ethernet services using generic Ethernet service types and service attributes.
- Appendix III provides an overview for [L2VPN] traffic forwarding and Quality of Service (QoS) support.
- Appendix IV provides brief overview of Provider Bridging.
- Appendix V provides brief overview of Provider Backbone Bridging.
- Appendix VI provides examples of the L2VPN configuration required to support Ethernet Private LINE (EPL) service in both Encapsulation and Transport Modes with and without Tag Protocol Identifier (TPID) translation.

This specification makes use of, and expands upon, current [L2VPN] provisioning to support MEF EPL service.

This document describes existing and additional DOCSIS provisioning parameters that are required to support MEF EPL attributes and parameters in a DPoE Network.

This document contains the following normative sections:

- Section 5 describes Metro Ethernet service requirements for all of the DPoE Elements in a DPoE Network.
- Section 6 describes performance and fault management requirements.
- Annex A describes new TLVs.
- Annex B defines extensions to [L2VPN] MIB to read-back L2VPN Mode, the type of encapsulation/tagging used, and its value.
- Annex C describes Link UP and Link Down event-reporting formats.
- Annex D provides summary of DOCSIS provisioning parameters to support MEF EPL service attributes.

The goal of this specification is to comply with [L2VPN] as much as possible.

Only MEF EPL is supported in this version of the specification. Metro Ethernet Service Performance Parameters and service Operations Administration and Maintenance (OAM) are not addressed in this version of the specification.

1.3 Goals

Collectively, the operators started the DPoE specification development to accomplish the following objectives:

- Identify and document the common requirements for triple play services for business customers over EPON.
- Adapt DOCSIS-based back office provisioning and operations models to EPON. This is the core objective of DPoE specifications.
- Develop consensus on additional requirements above and beyond DOCSIS specifications to take advantage of the capabilities of EPON. These are focused in the area of Ethernet services and MEF integration.
- Continue to leverage the supply chain and economic benefits of a large base of suppliers and high-volume supply chain in optics, subsystems, and network systems based on a commodity EPON technology. Doing so requires adapting operator processes and networks to the EPON system rather than making any changes to the EPON systems.
- Positioning DPoE specifications to continue to leverage those same benefits for 10G-EPON.

- Work with the established EPON vendor community to assure that these strategies can be effective to mutually develop DPoE Networks, and to create a marketplace for success for multiple vendors to provide solutions for the variety of needs within the operator environment.

1.4 Requirements

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

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

1.5 Organization of Specifications

The DPoE specifications are organized around existing DOCSIS specifications. The purpose of matching DPoE specification documents to existing CableLabs DOCSIS, IEEE, IETF, and MEF requirements is to facilitate the mapping of services from existing DOCSIS infrastructure to DPoE infrastructure, and to provide an organization that will be easy to maintain as related (referenced) standards, recommendations, or specifications undergo independent changes.

There are two types of documents in the DPoE specifications. The first includes informative and requirements documents called specifications that detail the specific requirements for products claiming compliance with the specifications. The DPoE specifications also include a new kind of document that does not fit into any of the above categories. The IP Network Elements (IP NE) Requirements [DPoE-SP-IPNEv1.0] are a set of common requirements for the management of IP network elements that operators have developed, which are above and beyond the requirements in DOCSIS specifications, but are nonetheless required in DOCSIS CMTS products today. These are not specifications because no new protocols or algorithms are provided. Most of the requirements in IP NE are existing requirements based on IEEE, IETF, or other network management standards.

The DPoE documents are detailed in Section 1.6 of this document and duplicated, for reference, in each of the DPoE specifications.

1.6 DPoE Specifications

This document is one in a series of eight (8) documents comprising the DPoE specifications. Collectively these documents represent the operators' requirements for EPON-based commercial services.

Table 1 - DPoE Specifications

Document	Document Title	Description
DPoE-SP-ARCHv1.0	DPoE Architecture Specification	DOCSIS Provisioning of EPON introduction, architecture, and narrative. Specifies fundamental architectural requirements (those that apply to more than one specification). Explains the purpose of each document below.
DPoE-SP-OAMv1.0	DPoE OAM Extensions Specification	Extensions beyond [802.3ah] and [802.3av] requirements.
DPoE-SP-PHYv1.0	DPoE Physical Layer Specification	Using the EPON PHY, the DPoE PHY specification makes mandatory some options within EPON and adds some additional requirements.
DPoE-SP-SECv1.0	DPoE Security and Certificate Specification	Specifications for support for DOCSIS network and system interfaces to provide transparent support of DOCSIS device authentication, code verification, and additional security for a DPoE implementation.
DPoE-SP-IPNEv1.0	DPoE IP Network Element Requirements	Best practices and operator requirements for IP network element management and operations. This document includes CMTS-like IP router requirements. This document recommends practices not currently covered by any existing DOCSIS specifications.
DPoE-SP-MULPIv1.0	DPoE MAC and Upper Layer Protocols Requirements	Specifications for support of a subset of DOCSIS 3.0 MULPI functionality with additional EPON requirements.
DPoE-SP-MEFv1.0	DPoE Metro Ethernet Forum Specification	Specifications for Metro Ethernet services added to DOCSIS static configuration provisioning model.
DPoE-SP-OSSIv1.0	DPoE Operations and Support System Interface Specification	Specifications for support of a subset of DOCSIS 3.0 OSSI functionality with additional EPON requirements.

1.7 Reference Architecture

The DPoE reference architecture identifies the elements that a DPoE Network minimally requires to illustrate and communicate the physical hardware and logical software interfaces between the functional subsystems of the DPoE architecture. The principal elements in the architecture are the DPoE System that resides in the operator network, and the DPoE ONU which may be an off the shelf EPON ONU, EPON SFP-ONU, or an EPON ONU with additional subsystems. The remaining elements in the architecture are existing servers and systems in the operator's network. All of the server elements have connectivity through an IP (TCP/IP) network. Transport of bearer traffic, and (in some cases) Layer 2 OAM signaling are available through either IP or Layer 2 Ethernet-based Network Interfaces.

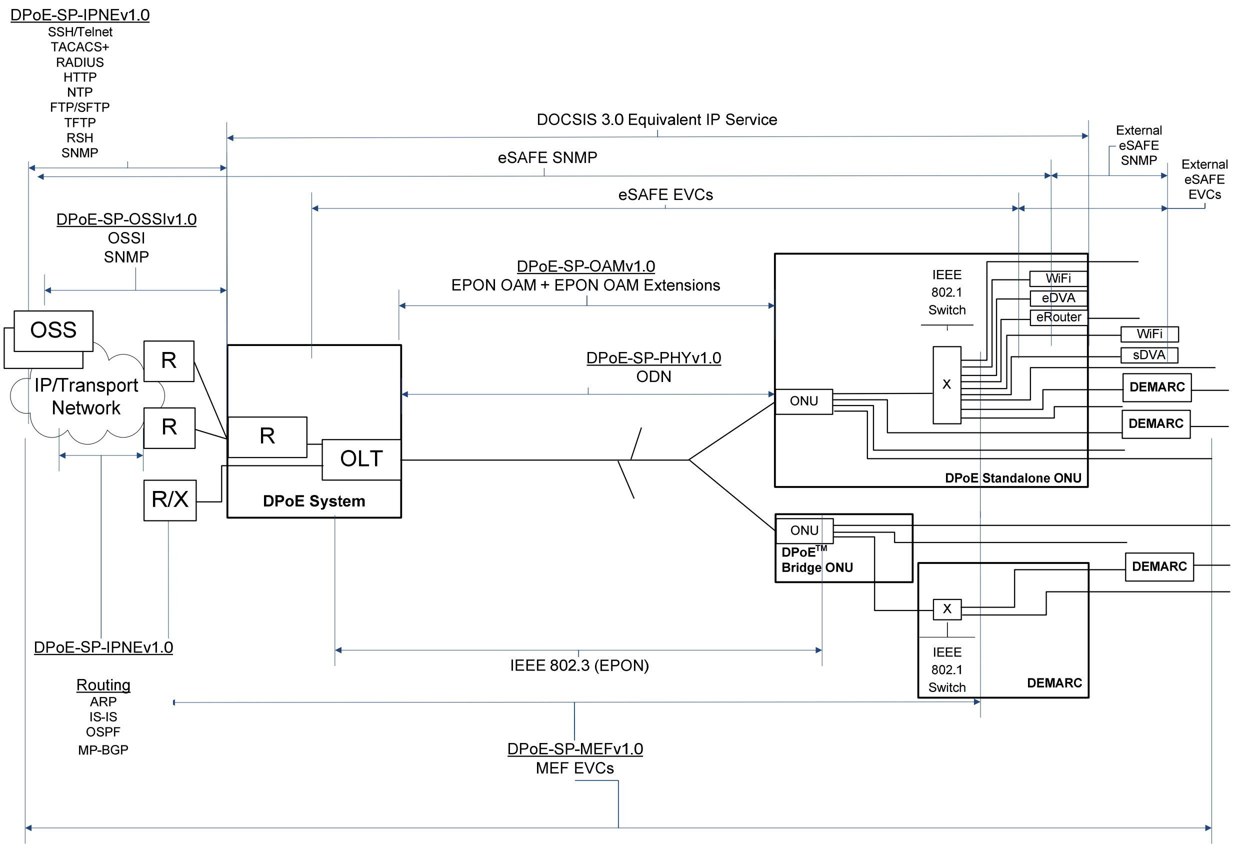

Figure 1 - DPoE Reference Architecture

1.8 DPoE Interfaces and Reference Points

The DPoE interfaces and reference points provide a basis for the description and enumeration of DPoE specifications for the DPoE architecture. Each interface or reference point indicates a point between separate sub-systems. The reference points have protocols that run across them, or have a common format of bearer traffic (with no signaling protocol). All of the interfaces are bi-directional interfaces that support two-way communications. The protocols in DPoE specifications operate within different layers based on the [802.3], [802.1], IETF, MEF, and CableLabs specifications. The C reference points are uni-directional for upstream (C_O) or downstream (C_S) classification, respectively.

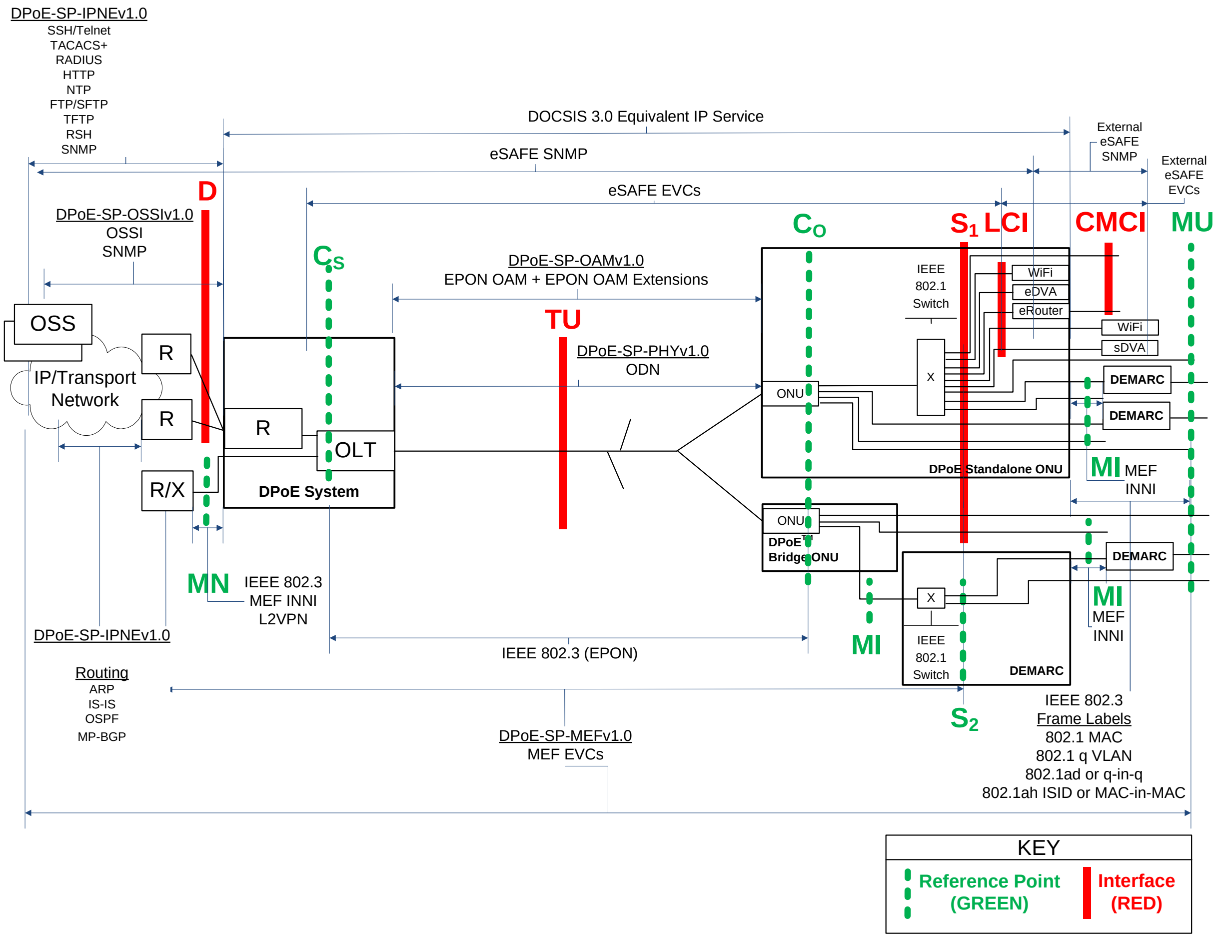

Figure 2 - DPoE Interfaces and Reference Points

Table 2 - DPoE Interface and Reference Point Descriptions

Interface or Reference Point		Interface or Reference Point Description
MN		The MN interface is an [802.3] interface for Ethernet (or MEF or L2VPN emulated) services only. It serves the role of a MEF INNI or L2VPN NSI. It is an NNI for Metro Ethernet services only.
D		The D interface is the DOCSIS IP NNI interface. It is an operator network facing interface, sometimes called a Network to Network Interface (NNI) or Network Systems Interface (NSI) in DOCSIS specifications. The D interface allows a DPoE System to communicate with an IP network. The D interface carries all IP management traffic including OSSI and IP NE traffic. The D interface carries all DOCSIS IP service traffic.
TU		The TU interface is a short form of expressing the interface between the DPoE System and the DPoE ONU.
C		The C reference point is used for explanation of traffic ingress to a DPoE classifier.
	C_O	The C_O reference point is used for explanation of traffic ingress to a DPoE ONU upstream classifier.
	C_S	The C_S reference point is used for explanation of traffic ingress to a DPoE System downstream classifier.
S		The S interface is an IEEE 802 interface. The S interface may be an internal interface (such as [802.3] across a GMII SERDES or XGMII interface in an SFP-ONU, SFP+ONU or XFP-ONU) or it may be an external Ethernet interface. S_1 is an interface for a DPoE Standalone ONU. S_2 is a reference point used for explanation of services with the DPoE Bridge ONU.
	S_1	The S_1 interfaces are the general case of all interfaces on a DPoE Standalone ONU. S_1 interfaces may be CMCI, LCI, MI, or MU interfaces.
	S_2	The S_2 reference point is used for explanation of traffic ingress to and egress from interfaces on a DEMARC device in a DPoE System. Although there are no specifications or requirements for the S_2 reference point, informative text refers to the S_2 reference point to provide the full context for the use of a DPoE Bridge ONU in a DEMARC device providing Metro Ethernet services.
LCI		The Logical CPE Interface (LCI) interface is an eDOCSIS interface as defined in [eDOCSIS]. The eDOCSIS architecture is [802.1d] MAC based according to the DOCSIS 3.0 specifications; however, DOCSIS L2VPN clearly supports [802.1q] switching. In practice, therefore, the eDOCSIS interface consists of a DOCSIS classifier and **[802.1]** switch as illustrated. The function of a DOCSIS classifier is in part replaced by forwarding (tagging and encapsulation) in MEF and in part covered by classifiers in [DPoE-SP-MULPIv1.0].
CMCI		CMCI is the DPoE interface equivalent of the DOCSIS Cable Modem CPE Interface as defined in [CMCIv3.0]. This is the service interface for DOCSIS-based IP services.
MI		MI is usually an S interface (or S reference point) that operates as a MEF INNI. A DPoE ONU that provides a MEF INNI has an MI interface. A DPoE ONU can have MU as an interface and an MI reference point on different S interfaces in a single DPoE ONU. The MI interface or reference point is an [802.3] interface (or reference point) between a DPoE ONU and a DEMARC device.
MU		MU is usually an S interface (or S reference point) that operates as a MEF UNI. A DPoE ONU that directly provides a MEF UNI (MU) interface has MU as an interface. A DPoE ONU can have MU as an interface and an MI reference point on different S interfaces in a single DPoE ONU. The MU interface or reference point is an [802.3] interface (or reference point) between a DPoE ONU or a DEMARC device and a customer's equipment.

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references. At the time of publication, the editions indicated were valid. All references are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below. References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific. For a non-specific reference, the latest version applies.

[802.1] Refers to entire suite of IEEE 802.1 standards unless otherwise specified.

[802.1ad] IEEE Std. 802.1ad-2005, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 4: Provider Bridges, May 2006.

[802.1ah] IEEE Std. 802.1ah-2008, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks – Amendment 6: Provider Backbone Bridges, January 2008.

[802.1d] IEEE Std. 802.1d-2004, IEEE Standard for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges.

[802.1q] IEEE Std. 802.1q-2009, IEEE Standard for Local and Metropolitan Area Networks-Virtual Bridged Local Area Networks, January 2010.

[802.1x] IEEE Std. 802.1X-2010 - IEEE Standard for Local and Metropolitan Area Networks - Port-Based Network Access Control.

[802.3] IEEE 802.3-2008, Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications, January 2008.

[802.3ah] IEEE 802.3ah-2004: Amendment to IEEE 802.3™-2005: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks, now part of IEEE 802.3™-2008 (subject to future revisions).

[802.3av] IEEE 802.3AV-2009, IEEE Standard for Information technology-Telecommunications and information 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 Amendment 1: Physical Layer Specifications and Management Parameters for 10Gb/s Passive Optical Networks.

[802.3x] IEEE Std. 802.3x for Local and Metropolitan Area Networks: Specification for [802.3] Full Duplex Operation.

[DPoE-SP-IPNEv1.0] DPoE-SP-IPNEv1.0, DOCSIS Provisioning of EPON, IP Network Element Requirements, Cable Television Laboratories, Inc.

[DPoE-SP-MULPIv1.0] DPoE-SP-MULPIv1.0, DOCSIS Provisioning of EPON, MAC and Upper Layer Protocols Requirements, Cable Television Laboratories, Inc.

[L2VPN] Data-Over-Cable Service Interface Specifications, Layer 2 Virtual Private Networks, CM-SP-L2VPN, Cable Television Laboratories, Inc.

[MEF 6.1] Metro Ethernet Forum, MEF 6.1 Ethernet Services Definitions, Phase 2, April 2008.

[MEF 10.2] Metro Ethernet Forum, Ethernet Services Attributes – Phase 2, October 2009.

[MEF 13] Metro Ethernet Forum User Network Interface Type 1 Implementation Agreement, November 2005.

2.2 Informative References

This specification uses the following informative references.

[802.1AB]	IEEE Std. 802.1AB-2009 - IEEE Standard for Local and Metropolitan Area Networks - Station and Media Access Control Connectivity Discovery
[802.1q-2005]	IEEE Std. 802.1q-2005, IEEE Standard for Local and Metropolitan Area Networks-Virtual Bridged Local Area Networks, January 2010.
[802.1ag]	IEEE Std. 802.1ag™-2007, IEEE Standard for Local and metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 5: Connectivity Fault Management, December 2007.
[802.1p]	IEEE 802.1p-2004, LAN Layer 2 QoS/CoS Protocol For Traffic Prioritization
[802.3ac]	IEEE Std. 802.3ac™-1995, IEEE Standard for Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Frame Extensions for Virtual Bridged Local Area Network (VLAN) Tagging on [802.3] Networks, January 1995. Now part of [802.3].
[802.3as]	IEEE Std. 802.3as-™2006, Amendment 3 to 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 Amendment 3, November 2006.
[802.3ax]	IEEE Std. 802.3ax-2008, IEEE Standard for Local and Metropolitan Area Networks-Link Aggregation, January 2008.
[802.3ad]	IEEE Std. 802.3ad-2000 - IEEE Standard for Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications-Aggregation of Multiple Link Segments
[CMCIv3.0]	Data-Over-Cable Service Interface Specifications, Cable Modem to Customer Premise Equipment Interface Specification, CM-SP-CMCIv3.0, Cable Television Laboratories, Inc.
[DOCSIS]	Refers to entire suite of DOCSIS 3.0 specifications unless otherwise specified.
[DPoE-SP-ARCHv1.0]	DPoE-SP-ARCHv1.0, DOCSIS Provisioning of EPON, DPoE Architecture Specification, Cable Television Laboratories, Inc.
[DPoE-SP-OAMv1.0]	DPoE-SP-OAMv1.0, DOCSIS Provisioning of EPON, OAM Extensions Specification, Cable Television Laboratories, Inc.
[DPoE-SP-OSSIv1.0]	DPoE-SP-OSSIv1.0, DOCSIS Provisioning of EPON, Operations and Support System Interface Specification, Cable Television Laboratories, Inc.
[DPoE-SP-PHYv1.0]	DPoE-SP-PHYv1.0, DOCSIS Provisioning of EPON, Physical Layer Specification, Cable Television Laboratories, Inc.
[DPoE-SP-SECv1.0]	DPoE-SP-SECv1.0, DOCSIS Provisioning of EPON, Security and Certificate Specification, Cable Television Laboratories, Inc.
[eDOCSIS]	Data-Over-Cable Service Interface Specifications, eDOCSIS Specification, CM-SP-eDOCSIS, Cable Television Laboratories, Inc.
[G.805]	ITU-T Recommendation G.805 (03/2000), Generic functional architecture of transport networks.
[MEF 4]	Metro Ethernet Forum, Metro Ethernet Network Architecture Framework – Part 1: generic Framework, May 2004.

[MEF 9]	Metro Ethernet Forum, Abstract Test Suite for Ethernet Services at the UNI, October 2004.
[MEF 14]	Metro Ethernet Forum, Abstract Test Suite for Traffic Management Phase 1, November 2005.
[MEF 26]	Metro Ethernet Forum, External Network to Network Interface (ENNI) – Phase 1, January 2010.
[MULPIv3.0]	Data-Over-Cable Service Interface Specifications, MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv3.0, Cable Television Laboratories, Inc.
[OSSIv3.0]	Data-Over-Cable Service Interface Specifications, Operations Support System Interface Specification, CM-SP-OSSIv3.0, Cable Television Laboratories, Inc.
[RFC 2863]	IETF RFC 2863, The Interfaces Group MIB, June 2000.
[RFC 4115]	IETF RFC 4115, A Differentiated Service Two-Rate, Three-Color Marker with Efficient Handling of in-Profile Traffic, July 2005.
[SCTE 174]	SCTE 174 2010, Radio Frequency over Glass Fiber-to-the-Home Specification.
[Y.1731]	ITU-T Recommendation Y.1731 (02/2008), OAM functions and mechanisms for Ethernet based networks.

2.3 Reference Acquisition

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  Phone +1-303-661-9100; Fax +1-303-661-9199; http://www.cablelabs.com
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- International Telecommunication Union (ITU), Place des Nations, CH-1211, Geneva 20, Switzerland; Phone +41-22-730-51-11; Fax +41-22-733-7256. Internet: http://www.itu.int
- Internet Engineering Task Force (IETF) Secretariat, 48377 Fremont Blvd., Suite 117, Fremont, California 94538, USA, Phone: +1-510-492-4080, Fax: +1-510-492-4001, http://www.ietf.org
- Metro Ethernet Forum, 6033 W. Century Blvd, Suite 830, Los Angeles, CA 90045
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- Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T), Place des Nations, CH-1211, Geneva 20, Switzerland; Phone +41-22-730-51-11; Fax +41-22-733-7256. Internet: http://www.itu.int
- SCTE, Society of Cable Telecommunications Engineers Inc., 140 Philips Road, Exton, PA 19341
  Phone: +1-800-542-5040, Fax: +1-610-363-5898, Internet: http://www.scte.org/

3 TERMS AND DEFINITIONS

3.1 DPoE Elements

DPoE Network This term means the entire network described in Figure 3 from the D or MN interface to the LCI, S, MI, or MU interface (see Figure 2 for interface and reference points), depending on the service being described. In no case does the term DPoE Network ever include a DEMARC device.

DPoE System This term means all of the collected elements that provide the DPoE function within the operator's network facilities. This includes the EPON OLT function, DOCSIS service functions required for the D interface, Metro Ethernet service functions required for the MN interface, and IP NE element management, routing and forwarding functions specified in [DPoE-SP-IPNEv1.0]. The DPoE System is depicted in Figure 3.

DPoE ONU This term means a DPoE-capable ONU that complies with all of the DPoE specifications. There are two types of DPoE ONUs. These are the DPoE Standalone ONU and the DPoE Bridge ONU.

DPoE Standalone ONU This term means a DPoE ONU that is a standalone ONU capable of providing IP or Ethernet services directly to customer premise equipment or transport of traffic to an external DEMARC device.

DPoE Bridge ONU This term means a DPoE ONU that is capable of [802.1] forwarding but cannot do all of the encapsulation functions required to be a DPoE Standalone ONU. Examples include an SFP-ONU and some simple EPON chipset-only based ONUs.

DEMARC Short form of "Demarcation Device." This term means the device, owned and operated by the operator that provides the demarcation (sometimes called the UNI interface) to the customer. Some architectures describe this device as the CPE (as in DOCSIS, DSL, or Broadband Forum Models) or the NID (as in the MEF model).

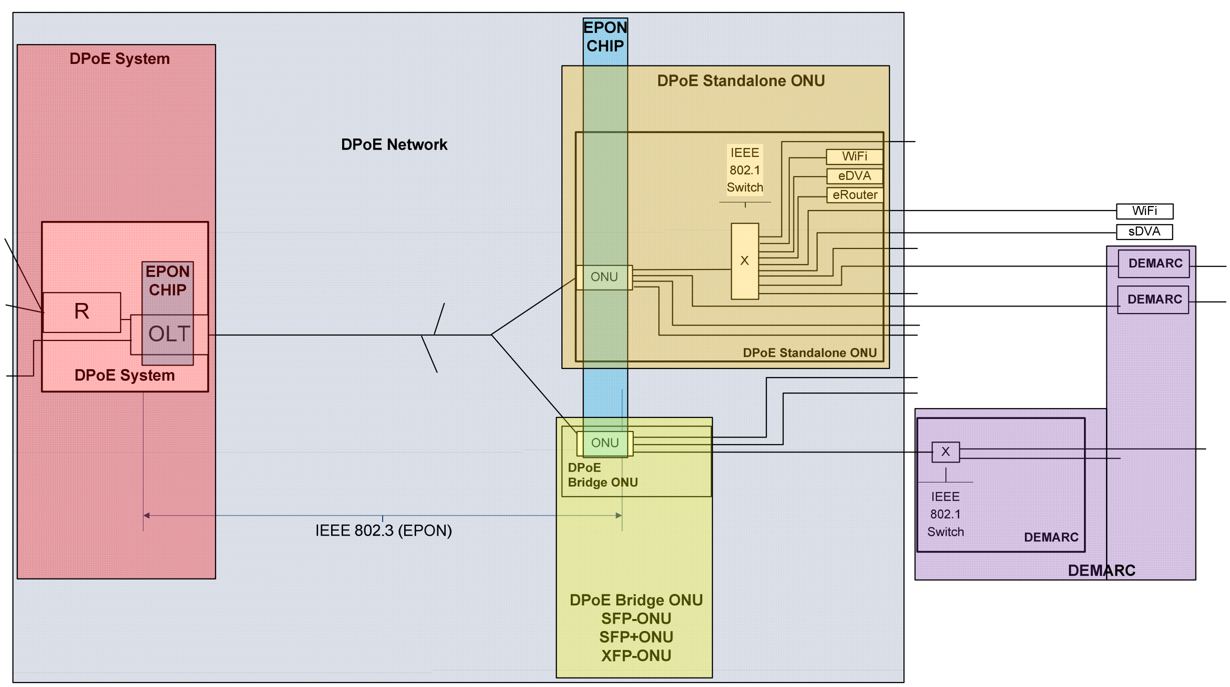

Figure 3 - DPoE Elements

3.2 Other Terms

10G-EPON	EPON as defined in [802.3ah] and amended in [802.3av]
1G-EPON	EPON as defined in [802.3ah]
B-BEB	B-type BEB – contains a B-component. It supports bridging in the provider backbone based on B-MAC and B-TAG information.
Customer Premise Equipment (CPE)	Customer Premise Equipment as defined in [DOCSIS]
DOCSIS Service Flow	A unidirectional flow of packets from the upper layer service entity to the RF with pre-defined QoS traffic parameters.
EPON Operations Administration and Maintenance	EPON Operations Administration and Maintenance (OAM) messaging as defined in [802.3ah] and [DPoE-SP-OAMv1.0]; Ethernet OAM is not the same as EPON OAM. Ethernet OAM is [802.1ag].
eRouter	An eSAFE device that is implemented in conjunction with the DOCSIS"
Ethernet Passive Optical Network (EPON)	Refers to both 1G-EPON and 10G-EPON collectively
Ethernet Virtual Connection	An association of two or more UNIs. Ingress Traffic that map to the EVC can only be sent to one of more UNIs in the EVC, except the ingress UNI.
ETH-trail	An ETH-layer entity responsible for the transfer of information from the input of a trail termination source to the output of a trail termination sink.
I-BEB	I type BEB – contains an I-component for bridging in the customer space based on customer MAC and service VLAN ID.
IB-BEB	Combination of I-BEB and B-BEB containing both I-component and B-component.
L2VPN ID	An octet string that uniquely identifies an L2VPN within a cable operator administrative domain corresponding to a single subscriber enterprise.
Layer 2 Virtual Private Network (L2VPN)	L2 Virtual Private Network is a set of LANs and the L2 Forwarders between them that enable hosts attached to the LANs to communicate with Layer 2 Protocol Data Units (L2PDUs). A single L2VPN forwards L2PDUs based only on the Destination MAC (DMAC) address of the L2PDU, transparent to any IP or other Layer 3 address. A cable operator administrative domain supports multiple L2VPNs, one for each subscriber enterprise to which Transparent LAN Service is offered.
Logical CPE Interface	LCI as defined in [eDOCSIS]
Network Interface Device (NID)	A DEMARC device in DPoE specifications
Service Provider	The organization providing Ethernet Services
Subscriber	The organization purchasing and/or using Ethernet services.
TRAN-Trail	A TRAN-trail (see ITU-T Recommendation [G.805]) is a "transport entity" responsible for the transfer of information from the input of a trail termination source to the output of a trail termination sink.

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations:

B-DA	BEB Destination MAC address
B-SA	BEB Source MAC address
B-VLAN Tag	Provider Backbone VLAN Tag
BCB	Backbone Core Bridge
BEB	Backbone Edge Bridge
CAC	Call Admission Control
CE	Customer Edge
CBS	Committed Burst Size
CE-VLAN CoS	Customer Edge CoS
CE-VLAN ID	Customer Edge VLAN ID. It is the same as C-VLAN ID.
CE-VLAN Tag	Customer Edge VLAN Tag. This is the same as C-VLAN Tag.
CF	Coupling Flag
CIR	Committed Information Rate
CM	Cable Modem
CMCI	Cable Modem CPE Interface as defined in [MULPIv3.0]
CMIM	Cable Modem Interface Mask
CMTS	Cable Modem Termination System
CoS	Class of Service
CPE	Customer Premise Equipment
C-VLAN ID	Customer VLAN ID
C-VLAN Tag	Customer VLAN Tag
DPoE	DOCSIS Provisioning of EPON
DSCP	Differentiated Services Code Point
EBS	Excess Burst Size
eCM	embedded Cable Modem
eDVA	embedded Digital Voice Adapter
E-NNI	External Network to Network Interface
EPL	Ethernet Private Line
EPON	Ethernet Passive Optical Network
eRouter	Embedded Router
ETH	Ethernet MAC layer network
EVC	Ethernet Virtual Connection
E-VPL	Ethernet Virtual Private Line.
Gbps	Gigabits per second (as used in the industry)

HSD	High Speed Data (Broadband Internet Access using DOCSIS)
I-NNI	Internal Network to Network Interface
IP	Internet Protocol
I-SID	[802.1ah] I-Component Service IDentifier
L2VPN	L2 Virtual Private Network
L2PDU	Layer 2 Protocol Data Unit
LCI	Logical CPE Interface as defined in [eDOCSIS]
MEF	Metro Ethernet Forum
MEN	Metro Ethernet Network
MI	MEF I-NNI
MRR	Minimum Reserved Traffic Rate
MSR	Maximum Sustained Traffic Rate
MTU	Maximum Transmission Unit
MU	MEF UNI
NID	Network Interface Device (a DEMARC device in DPoE)
NNI	Network to Network Interface
nrtPS	Non-Real-Time Polling Service
NSI	CMTS Network System Interface
OAM	Operations Administration and Maintenance
ODN	Optical distribution network
OLT	Optical Line Termination
ONU	Optical Network Unit
OSC	Optical Splitter Combiner
PB	Provider Bridging [802.1ad]
PBB	Provider Backbone Bridging [802.3ah]
PBBN	Provider Backbone Bridged Network
PBN	Provider Bridged Network
PEB	Provider Edge Bridge
PHY	PHYsical Layer
PON	Passive Optical Network
QoS	Quality of Service
R	IP Router
rtPS	Real-Time Polling Service
SF	DOCSIS Service Flow
SFP	Small Form-factor Pluggable
SNMP	Simple Network Management Protocol
S-VLAN ID	Service Provider VLAN ID

S-VLAN Tag	Service Provider VLAN Tag
TLS	Transparent LAN Service
TOS	Type of Service byte in the IPv4 header
TPID	Tag Protocol Identifier
UGS	Unsolicited Grant Service
UGS-AD	Unsolicited Grant Service with Activity Detection
UNI	User Network Interface
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
VPNID	VPN Identifier
X	IEEE Ethernet Switch (Generic)
XFP	X Form-factor Pluggable

5 METRO ETHERNET SERVICE REQUIREMENTS (NORMATIVE)[1]

In DPoE Reference Architecture depicted in Figure 1 above, DPoE ONU S_1 interface can be a MEF UNI (MU) or MEF I-NNI (MI) in the Carrier Ethernet Network Architecture depicted in Figure 5 in Appendix I. DPoE ONUs MUST support MEF UNI Type 1.1, which is specified in [MEF 13]. UNI type 1.1 provides bare minimum data-plane connectivity without any control plane or management plane capabilities.

This version of the DPoE MEF specification only supports MEF EPL service. A DPoE ONU MUST associate all the customer frames received from or transmitted on a single MU interface with exactly one EPL service instance. A DPoE ONU MUST associate all the frames received from or transmitted on MI interface to one or more EPL service instance.

This specification does not support configuring EPL service between two MEF UNIs attached to DPoE ONUs connected to the same DPoE System. On a DPoE ONU with multiple MU interfaces, each of the MU interfaces is associated with one and only one EPL service instance that is different from the service instance associated with any other MU in the same DPoE ONU.

MN and D interfaces are logical interfaces that exist on the physical Network System Interface (NSI). The MN interface performs the functions of MEF Internal Network to Network Interface (I-NNI); it is not required in this version of the specification to support MEF External Network to Network Interface (E-NNI) functionality. The D interface is not used as MEF I-NNI to carry traffic of MEF Ethernet Service Instances; it is used to allow DPoE System to communicate with IP Networks.

When an Ethernet Virtual Connection (EVC) is implemented for EPL service with a DPoE Network, the part of the EVC in the DPoE Network is called TRAN-Trail in MEF. Other TRAN-Trails for a Metro Ethernet service can include the operator's transport network or Metro Ethernet Network (MEN) and another TRAN-Trail for the other end of the service. Throughout this document, when EVC attributes or requirements are identified or explained, those attributes and requirements apply to the TRAN-Trail in the DPoE Network.

A DPoE ONU S_1 interface can operate in one of two modes: Encapsulation Mode and Transport Mode.

This version of the specification only supports [802.1ad] S-VLAN tagging and [802.1ah] encapsulation.

In the upstream direction, a DPoE System MAY support the translation of the TPID of the outermost tag of the frame before it is sent on the DPoE System egress MN interface. In the downstream direction, DPoE System MAY support the translation of the TPID of the outermost tag of the frame before it is sent on the TU interface.

Annex A defines new TLVs to extend [L2VPN] provisioning to support Transport and Encapsulation Mode. Additionally, Annex A defines new TLVs to extend [L2VPN] provisioning to support [802.1ad] S-VLAN tagging and [802.1ah] encapsulation in the Encapsulation Mode. The new TLVs also support TPID translation in the upstream direction and/or downstream direction for both Encapsulation Mode and Transport Mode. Section 5.6 and Section 5.7 describe how these new TLVs are used to support provisioning of EPL service instances.

Throughout the normative sections of this document, requirements for the MN and C_S interface and reference points apply to the DPoE System as illustrated in Figure 1. Requirements for the MI, MU, S, S_1, C_O interfaces, and reference points apply to the DPoE ONU (which includes the DPoE Standalone ONU and DPoE Bridge ONU) as illustrated in Figure 1.

5.1 Encapsulation Mode

DPoE ONUs MUST support encapsulation mode on both MU and MI interfaces. A DPoE ONU provisioned to use encapsulation mode on an S interface MUST add configured [802.1ad] tags or [802.1ah] encapsulation to the frames received from the S_1 interface before transmitting them on the egress TU interface. This tagging or encapsulation is used to identify the EPL service instance to which these frames belong. DPoE ONUs MUST remove the [802.1ad] tag or [802.1ah] encapsulation from the frames received on the TU interface before transmitting them (downstream) on the egress S_1 interface. DPoE Systems MUST drop and count all frames received on MN interfaces that do not belong to an EPL service instance. DPoE Systems MUST use classifiers specified in [DPoE-SP-MULPIv1.0] to

[1] Revised per MEFv1.0-N-12-0041-1 on 8/1/12 by JB.

identify frames that belong to a particular EPL service instance based on the tagging or encapsulation used by the service instance. For the upstream frames, a DPoE ONU MUST add all required tagging or encapsulation before or at the C_O Reference point. For the downstream frames, a DPoE ONU MUST remove all required tags and encapsulation at or after the C_O Reference point.

5.2 Transport Mode

A DPoE ONU MUST support the transport mode on the MI interface. A DPoE ONU MUST NOT support the transport mode on the MU interface. A DPoE ONU MUST NOT add or remove any tagging or encapsulation from the upstream frames that belong to an EPL service instance and are received on an MI interface before forwarding them on the TU interface. A DPoE ONU MUST NOT add or remove any tagging or encapsulation from the downstream frames that belong to an EPL service instance and are received on the TU interface before forwarding them on the MI interface. A DPoE ONU MUST use the classifiers specified in [DPoE-SP-MULPIv1.0] to identify frames that belong to a particular EPL service instance. DPoE Systems MUST use the classifiers specified in [DPoE-SP-MULPIv1.0] to identify frames that belong to a particular EPL service instance. DPoE ONUs MUST drop and count the frames received from MI interface if the frames do not belong to any EPL service instance. DPoE Systems MUST drop and count the frames received from MN interface if the frames do not belong to any EPL service instance.

5.3 Provider Bridging

Appendix IV provides a brief overview of Provider Bridging. [802.1ad] is the IEEE standard for Provider Bridging.

This section describes Provider Bridging requirements that are supported by this version of the specification.

5.3.1 Provider Bridging Encapsulation Requirements[2]

In this version of the specification, a DPoE ONU MUST NOT add C-VLAN Tag to customer-untagged and priority-tagged frames received from MU interface operating in Encapsulation Mode.

A DPoE ONU MUST support the addition of the configured [802.1ad] S-VLAN tag (which uses TPID 0x88a8) to untagged, priority-tagged, and tagged customer frames received from MU interface operating in Encapsulation Mode. A DPoE ONU MUST add the S-VLAN tag prior to or at the C_O Reference point. A DPoE ONU MUST set the Class of Service (CoS) of the S-VLAN tag to ZERO.

Legacy implementations of Provider Bridges use different TPIDs for S-VLAN Tag. Examples of such TPIDs include 0x8100, 0x9100, and 0x9200. Legacy and [802.1ad] Provider Bridges can be connected to MI or MN interfaces.

A DPoE ONU MUST support, in the upstream direction, the transportation of Provider Bridge (PB) S-VLAN tagged traffic received from MI interface, operating in Transport Mode to the egress TU interface, without adding or removing any tagging or encapsulation. A DPoE System MUST support, in the upstream direction, the transportation of PB S-VLAN tagged traffic received from TU interface to the egress MN interface. PB S-VLAN tagged traffic may use [802.1ad] TPID 0x88a8 or legacy TPID, including 0x8100.

A DPoE ONU MUST forward PB S-VLAN tagged traffic received from an MI interface without adding or removing any tagging or encapsulation. DPoE ONUs MAY use [802.1ad] TPID 0x88a8 or legacy TPID, including 0x8100 for PB forwarding from an MI interface.

A DPoE ONU that is plugged into a DEMARC MUST support, in the upstream direction, the transportation of PB S-VLAN tagged traffic received from the DEMARC to the egress TU interface, without adding or removing any tagging or encapsulation.

A DPoE System MUST support, in the downstream direction, the transportation of PB S-VLAN tagged traffic received from MN interface to TU interface. A DPoE ONU MUST support, in the downstream direction, the transportation of PB S-VLAN tagged traffic received from TU interface to MI interface, operating in Transport

[2] Revised per MEFv1.0-N-12-0041-1 on 8/1/12 by JB.

Mode, without adding or removing any tagging or encapsulation. PB S-VLAN tagged traffic may use [802.1ad] TPID 0x88a8 or legacy TPID, including 0x8100.

A DPoE System MAY support TPID Translation in the upstream direction to translate, whenever required, legacy TPID to [802.1ad] TPID (or vice versa) before the frame is transmitted on the DPoE System egress MN interface. TLV 43.5.14.1 is used to configure the new TPID value.

A DPoE System MAY support TPID Translation in the downstream direction to translate, whenever required, legacy TPID to [802.1ad] TPID (or vice versa) before the frame is transmitted on the TU interface. TLV 43.5.14.2 is used to configure the new TPID value.

5.3.2 Provider Bridging Classification Requirements

At the C_O Reference point when [802.1ad] Provider Bridge S-VLAN tagging is used, a DPoE ONU MUST support the following parameters for the classification of traffic received from MU interface into upstream service flows:

- C-VLAN ID (if the customer frame is tagged),
- S-VLAN ID,
- TPID of the outermost S-VLAN tag.

At the C_O Reference point, a DPoE ONU MUST support the following parameters for the classification of upstream Provider Bridge traffic received from an MI interface operating in the Transport Mode or from DEMARC device into which DPoE Bridge ONU is plugged:

- C-VLAN ID (if customer frame is tagged),
- S-VLAN ID,
- TPID of the outermost S-VLAN tag.

A DPoE ONU MUST classify the PB traffic that belongs to an EPL service instance into one upstream service flow.

At the C_S Reference point, a DPoE System MUST support the following parameters for the classification of downstream service flows of Provider Bridge traffic received from MN interface:

- C-VLAN ID (if present in the received frame),
- S-VLAN ID,
- TPID of the outermost S-VLAN tag.

A DPoE System MUST classify the PB traffic that belongs to an EPL service instance into one downstream service flow.

5.3.3 Provider Bridging Forwarding Requirements

DPoE Systems MUST support L2VPN Point-to-Point Forwarding Mode to forward in the downstream direction Provider Bridge frames received from MN interface using S-VLAN ID.

In the upstream direction, DPoE Systems MUST forward Provider Bridge traffic based on S-VLAN ID.

This specification does not allow a DPoE Network to use the same S-VLAN ID with more than one S-VLAN Tag TPID.

5.4 Provider Backbone Bridging

Appendix V provides a brief overview of Provider Backbone Bridging. [802.1ah] is the IEEE standard for Provider Backbone Bridging.

This section describes Provider Backbone Bridging requirements that are supported by this version of the specification.

5.4.1 Provider Backbone Bridging Encapsulation Requirements[3]

DPoE ONUs MAY support the [802.1ah] I-Component encapsulation of Provider Backbone Edge Bridge.

B-Component of Provider Backbone Edge Bridge is not supported in this version of the specification, therefore IB-BEB and B-BEB functionalities are not supported in this version of the specification.

Since only I-BEB functionality is supported, DPoE ONUs MUST NOT add B-Tag to frames received with I-Tag.

Since only EPL service is supported in this version of the specification, I-Component is not required to learn the MAC address of the destination BEB, which is responsible for forwarding the frame to a given destination customer MAC address. Instead, the DPoE ONU is configured with the destination BEB MAC address (B-DA). A DPoE ONU that supports the optional PBB encapsulation MUST use the configured address in the B-DA field in the [802.1ah] encapsulation for each S interface configured for PBB.

In this version of the specification, DPoE ONU MAY support [802.1ah] I-Component encapsulation on both MU and MI interfaces operating in Encapsulation Mode. I-Component encapsulation contains the following components:

- [802.1ah] 48-bit I-Tag, which uses TPID 0x88e7. I-Tag includes 24-bit I-SID (I-Backbone Service Identifier). A DPoE ONU that supports the optional PBB encapsulation MUST use a default value of zero for the CoS part of the I-Tag field. I-Tag is configured using TLV 43.5.2.6.1.
- MAC-in-MAC (M-in-M) Encapsulation, which encapsulates the I-tagged frame into Provider Backbone MAC frame with the source MAC Address B-SA and destination MAC address B-DA are set as follows:
  - B-SA is the MAC address of the source Backbone Edge Bridge. A DPoE ONU that supports the optional PBB encapsulation MUST use the MAC address of the egress MN interface that is configured using [DPoE-SP-IPNEv1.0] to populate the B-SA field in the [802.1ah] frame.
- A DPoE ONU that supports the optional PBB encapsulation MUST populate the B-DA field with the MAC address of the destination Backbone Edge Bridge, which is responsible for forwarding the frame to a given destination customer MAC address. B-DA is configured using TLV 43.5.2.6.2.

The size of [802.1ah] encapsulation described above is 18 bytes. The maximum frame size on 1G-EPON is 1600 bytes. As a consequence, in 1G-EPON a DPoE ONU that supports the optional PBB encapsulation MUST support receiving of up to 1582 bytes frame on MU and MI interface. This will allow a DPoE ONU that supports the optional PBB encapsulation enough room to add 18 bytes of [802.1ah] I-Component encapsulation before forwarding the frame on the TU interface. A DPoE ONU with 1G-EPON or 10/1G EPON SHOULD drop 1583 bytes or larger frames received on the MI or MU interface. The maximum frame size on 10G-EPON is 2000 Bytes. As a consequence, in 10G-EPON a DPoE ONU that supports the optional PBB encapsulation MUST support receiving of up to 1982 bytes frame on MU and MI interface. This will allow a DPoE ONU that support the optional PBB encapsulation enough room to add 18 bytes of [802.1ah] I-Component encapsulation before forwarding the frame on the TU interface. A DPoE ONU with 10G-EPON SHOULD drop 1983 bytes or larger frames received on the MI or MU interface operating in encapsulation mode.

DPoE ONUs MAY support the addition of the configured [802.1ah] I-Component encapsulation to untagged, priority-tagged, and tagged customer frames received from MU interface operating in Encapsulation Mode.

DPoE ONUs MAY support the addition of the configured [802.1ah] I-Component encapsulation to PB frames received from MI interface operating in Encapsulation Mode. A DPoE ONU MUST match the S-VLAN tag in the received PB frames with the S-VLAN tag in the configured classifier to associate the frames with the correct upstream service flow. A DPoE ONU is not required to support the PB frames containing S-VLAN tag with a value of zero. The S-VLAN tag can use [802.1ad] TPID or legacy TPID, including 0x8100.

This version of the specification does not support mapping more than one S-VLAN ID into the same I-SID on a DPoE ONU.

If [802.1ah] I-Component encapsulation functionality is supported, DPoE ONU MUST add [802.1ah] I-Component encapsulation prior to or at the C_O Reference Point.

[3] Revised per MEFv1.0-N-12.0013-1 on 3/23/12 and per MEFv1.0-N-12-0041-1 on 8/1/12 by JB.

DPoE ONUs MUST support, in the upstream direction, the transportation of Provider Backbone Bridging (PBB) I-Tagged traffic, received from MI interface operating in Transport Mode to the egress TU interface without adding or removing any tagging or encapsulation. DPoE Systems MUST support, in the upstream direction, the transportation of PBB I-Tagged traffic, received from TU interface to the egress MN interface without adding or removing any tagging or encapsulation. I-Tag can use [802.1ah] TPID 0x88e7 or legacy TPID.

DPoE ONUs MUST support, in the upstream direction, the transportation of Provider Backbone Bridging (PBB) B-Tagged traffic, received from MI interface operating in Transport Mode to the egress TU interface without adding or removing any tagging or encapsulation. DPoE Systems MUST support, in the upstream direction, the transportation of PBB B-Tagged traffic, received from TU interface to the egress MN interface without adding or removing any tagging or encapsulation.

A DPoE System MUST support, in the downstream direction, the transportation of PBB I-Tagged traffic received from MN interface to TU interface without adding or removing any tagging or encapsulation. A DPoE ONU MUST support, in the downstream direction, the transportation of PBB I-Tagged traffic received from TU interface to MI interface operating in Transport Mode without adding or removing any tagging or encapsulation. I-Tag can use [802.1ah] TPID 0x88e7 or legacy TPID.

A DPoE System MUST support, in the downstream direction, the transportation of PBB B-Tagged traffic received from MN interface to TU interface without adding or removing any tagging or encapsulation. A DPoE ONU MUST support, in the downstream direction, the transportation of PBB B-Tagged traffic received from TU interface to MI interface operating in Transport Mode without adding or removing any tagging or encapsulation.

A DPoE Bridge ONU MUST support, in the downstream direction, the transportation of PBB I-Tagged traffic received from TU interface to DEMARC device to which the DPoE Bridge ONU is plugged without adding or removing any tagging or encapsulation. I-Tag can use [802.1ah] TPID 0x88e7 or legacy TPID.

A DPoE Bridge ONU MUST support, in the downstream direction, the transportation of PBB B-Tagged traffic received from TU interface to DEMARC device to which the DPoE Bridge ONU is plugged without adding or removing any tagging or encapsulation.

A DPoE System MAY support TPID Translation in the upstream direction to translate, whenever required, legacy I-Tag TPID to [802.1ah] TPID (or vice versa) before the frame is transmitted on the DPoE System egress MN interface. TLV 43.5.14.1 is used to configure the new TPID value.

A DPoE System MAY support TPID Translation in the downstream direction to translate, whenever required, legacy I-Tag TPID to [802.1ah] TPID (or vice versa), before the frame is transmitted on the TU interface. TLV 43.5.14.2 is used to configure the new TPID value.

In the DPoE architecture, the DPoE Network implements the [802.1ah] I-Component function across both the DPoE System and the DPoE ONU. Figure 4 below describes an example of Provider Backbone Bridged Network (PBBN) with five [802.1ah] networking scenarios, of which DPoE Network can support the first three of the following scenarios:

Scenario #1. The Customer Edge (CE) is connected to IB-BEB over customer LAN (C LAN). Customer traffic on C LAN is associated with a single I-SID. In this version of the specification, only I-BEB functionality of the IB-BEB is supported. DPoE ONU MU interface is connected to Customer Equipment (CE). [802.1ah] I-Component encapsulation is added to customer frames received from MU interface. I-Component encapsulation includes I-Tag, B-DA, and B-SA as described above. B-SA is the MAC address of the DPoE System MN interface connected to the I-BEB device in the figure.

Scenario #2. In this scenario, S-VLAN Bridge (SB) (i.e., [802.1ad] Provider Bridge) is connected to IB-BEB over Service Provider LAN (S LAN). In this version of the specification, only I-BEB functionality of the IB-BEB Bridge is supported. DPoE ONU is connected to the [802.1ad] Provider Bridge on MI interface operating in Encapsulation Mode. [802.1ah] I-Component encapsulation is added to [802.1ad] frames received from MI interface. S-VLAN ID in the frame received from PB maps to I-SID in the [802.1ah] I-Tag. As mentioned earlier in this version of the specification, only one S-VLAN ID maps to a given I-SID.

Scenario #3. In this scenario, I-BEB is connected to PBs and Provider Edge Bridge (PEB). DPoE ONU is connected to PB and PEB using MI interface operating in Encapsulation Mode. [802.1ah] encapsulation is added to [802.1ad] frames received from PB and PEB. S-VLAN ID in the frame received from PB or PEB maps to I-SID in the [802.1ah] I-Tag. DPoE System MN interface is connected to B-BEB over MN interface. B-BEB adds B-VLAN Tag to the [802.1ah] I-tagged frames it receives from DPoE System before delivering them to BCB in the core of the PBBN.

Scenarios #4 and #5. Require E-NNI as described in Appendix V. These two scenarios are not supported because E-NNI is not supported in this version of the specification. In addition, scenario #5 requires B-BEB functionality, which is not supported in this version of the specification.

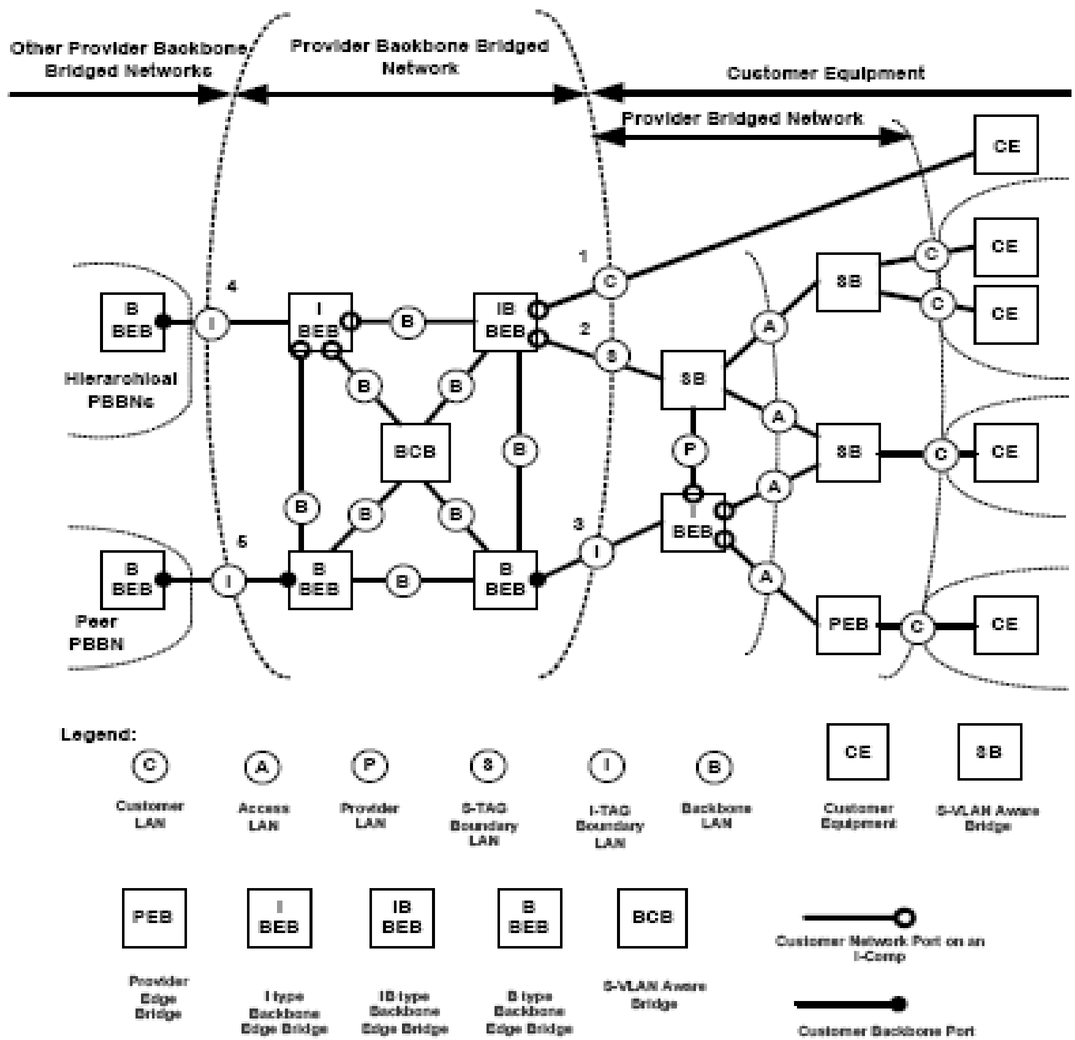

Figure 4 - [802.1ah] Networking Scenarios

5.4.2 Provider Backbone Bridging Classification Requirements

At the C_O Reference point, when [802.1ah] encapsulation is used, a DPoE ONU MUST support the following parameters for the classification of upstream traffic received from MU interface into a Service Flow (SF):

- C-VLAN ID (if the customer frame is tagged),
- I-SID,

- B-DA,
- TPID of I-Tag.

At the C_O Reference point, when [802.1ah] encapsulation is used, a DPoE ONU MUST support the following parameters for the classification of upstream traffic received from MI operating in Encapsulation Mode into a SF:

- C-VLAN (if present in the received frame),
- S-VLAN ID,
- I-SID,
- B-DA,
- TPID of I-Tag.

DPoE ONUs MUST be able to classify upstream service flows based on the follow parameters at the C_O Reference point. DPoE ONUs MUST support these parameters for classification of PBB traffic received from an MI interface operating in Transport Mode or from a DEMARC device:

- C-VLAN (if present in the received frame),
- S-VLAN ID (if present in the received frame),
- I-SID,
- B-DA,
- TPID of I-Tag

DPoE ONUs MUST classify the PBB traffic that belongs to an EPL service instance one upstream service flow.

At the C_S Reference point, a DPoE System MUST support the following parameters for the classification of downstream PBB traffic received from MN interface into a service flow:

- C-VLAN (if present in the received frame),
- S-VLAN ID (if present in the received frame),
- I-SID,
- B-DA,
- TPID of I-tag of the received frame.

A DPoE System MUST classify the PBB traffic that belongs to an EPL service instance into one downstream service flow.

5.4.3 Provider Backbone Bridging Forwarding Requirements

DPoE Systems MUST forward the PBB traffic received from the MN interface in the downstream direction based on I-SID and B-DA. In the upstream direction, DPoE Systems MUST forward the PBB frames using the I-Component on the MN interface configured using [DPoE-SP-IPNEv1.0].

This specification does not allow a DPoE Network to use the same I-SID ID with more than one I-Tag TPID.

5.5 Frame Formats

This section describes the supported frame formats for interfaces and reference points, including MN, MI, MU, and TU.

5.5.1 Valid Frames Formats on MU Interface

Only customer-tagged, priority-tagged, and untagged customer frames are accepted on MU interface. DPoE ONUs MUST drop and count all other types of frames received at the MU interface.

5.5.2 Valid Frame Formats on MI Interface in Encapsulation Mode

DPoE ONUs MUST only accept PB S-VLAN tagged frames that belong to a configured EPL service instance and use a configured TPID from an MI interface operating in the Encapsulation Mode. The S-VLAN tag can use standard [802.1ad] TPID or legacy ones, which include 0x8100.

DPoE ONUs MUST match the S-VLAN ID of the S-VLAN tag in the received PB frame with configured classifiers values to determine the EPL service instance to which the frame belongs. DPoE ONUs MUST support the configuration of this value using the L2VPN upstream service flow classifiers specified in [DPoE-SP-MULPIv1.0].

DPoE ONUs MUST drop and count the PB S-VLAN tagged frames that do not belong to any configured service instance.

DPoE ONUs MUST drop and count the PB S-VLAN tagged frames that use S-VLAN TPID that does not match a configured classifier value. Classification based on S-VLAN TPID is specified in [DPoE-SP-MULPIv1.0].

DPoE ONUs MUST drop and count the frames that are not PB S-VLAN tagged. Examples of such frames include:

- [802.1ah] frames that have I-Tag that uses standard TPID 0x88e7,
- Frames generated by legacy implementation of Provider Backbone Bridges that use proprietary TPID for the I-Tag,
- [802.1ah] frames with B-Tag,
- [802.1d] frames.

5.5.3 Valid Frame Formats on MN and MI Interfaces in Transport Mode[4]

A DPoE System on its MN interfaces MUST support the following frames:

- PB S-VLAN tagged frames that belong to a configured EPL service instance and use a configured TPID.
- PBB frames that use I-Component encapsulation with a configured I-Tag TPID, and belong to a configured EPL service instance.

A DPoE ONU on its MI interfaces working in the Transport Mode MUST support the following frames:

- PB S-VLAN tagged frames that belong to a configured EPL service instance and use a configured TPID.
- PBB frames that use I-Component encapsulation with a configured I-Tag TPID, and belong to a configured EPL service instance.
- PBB frames that include both I-Tag and B-Tag encapsulation, and belong to a configured EPL service instance.

For PB frames, a DPoE ONU MUST match the S-VLAN ID in the S-VLAN Tag with configured classifiers to identify the EPL service instance to which the ingress frames belong. Similarly for PB frames, a DPoE System MUST match the S-VLAN ID in the S-VLAN Tag with configured classifiers to identify the EPL service instance to which the ingress frames belong. A DPoE ONU MUST allow configuration of the S-VLAN ID using L2VPN upstream service flow classifier. A DPoE System MUST allow configuration of the S-VLAN ID using L2VPN downstream service flow classifier. These classifiers are specified in [DPoE-SP-MULPIv1.0].

For PBB frames, DPoE ONUs MUST compare the I-SID value in the I-Tag with configured classifiers to identify the EPL service instance to which the ingress frames belong. Similarly for PBB frames, DPoE Systems MUST match the I-SID value in the I-Tag with configured classifiers to identify the EPL service instance to which the frame belongs. DPoE ONUs MUST allow configuration of the I-SID value using L2VPN upstream service flow classifier. DPoE Systems MUST allow configuration of the I-SID value using L2VPN downstream service flow classifier. These classifiers are specified in [DPoE-SP-MULPIv1.0].

[4] Revised per MEFv1.0-N-12.0013-1 on 3/23/12 by JB.

DPoE ONUs MUST drop and count any PB S-VLAN tagged frames that do not belong to any configured EPL service instance. DPoE Systems MUST drop and count any PB S-VLAN tagged frames that do not belong to any configured EPL service instance.

DPoE ONUs MUST drop and count any PB S-VLAN tagged frames that use S-VLAN TPID that does not match a configured upstream classifier value. DPoE Systems MUST drop and count any PB S-VLAN tagged frames that use S-VLAN TPID that does not match a configured downstream classifier value. Classification based on S-VLAN TPID is specified in [DPoE-SP-MULPIv1.0].

DPoE ONUs MUST drop and count any PBB frames that use I-Component encapsulation and do not belong to any configured EPL service instance. DPoE Systems MUST drop and count any PBB frames that use I-Component encapsulation and do not belong to any configured EPL service instance.

DPoE ONUs MUST drop and count all PBB frames that use I-Tag TPID that does not match a configured classifier value. DPoE Systems MUST drop and count all PBB frames that use I-Tag TPID that does not match a configured classifier value.

Classification based on I-Tag TPID is specified in [DPoE-SP-MULPIv1.0].

DPoE ONUs MUST drop and count all frames that use formats different from the formats listed above. Examples of such frames include:

- [802.1d] frames.

5.5.4 Valid Frame Formats from DEMARC into DPoE Bridge ONU

The rules that determine the frames that a DPoE Bridge ONU or DPoE Standalone ONU operating with an S interface configured as MI MUST accept from the DEMARC device, are the same rules used for frames received from MI interface in Transport Mode. These rules are defined in Section 5.5.3 above.

5.5.5 Valid Frame Formats on TU Interface

Frames associated with EPL Metro Ethernet services can only have one of the following formats on the TU interface:

- Frame that contains S-VLAN tag immediately following the source MAC address field. The S-VLAN tag may use [802.1ad] TPID or a legacy TPID. The frame may or may not have a C-VLAN tag that uses TPID 0x8100. The C-VLAN ID may be 0. The source MAC address of the frame is the customer source MAC address, and the destination MAC address of the frame is the customer destination MAC address.
- Frame that contains I-Component encapsulation that includes I-Tag that uses [802.1ah] TPID or a legacy TPID, B-SA, and B-DA. The source MAC address of the frame is B-SA, and the destination MAC address of the frame is B-DA. I-Tag immediately follows B-SA. The frame does not have an S-VLAN tag and may or may not have a customer C-VLAN Tag that uses TPID 0x8100. The C-VLAN ID may be ZERO.
- Frame that contains I-Component encapsulation that includes I-Tag that uses [802.1ah] TPID or a legacy TPID, B-SA, and B-DA. The source MAC address of the frame is B-SA, and the destination MAC address of the frame is B-DA. I-Tag immediately follows B-SA. The frame has S-VLAN tag. S-VLAN ID cannot be ZERO. The frame may or may not have a customer C-VLAN tag that uses TPID 0x8100.

5.6 Configuring Frame Tagging and Encapsulation[5]

[L2VPN] TLV 43.5 is extended in this version of the specification to specify the required new TLVs.

Annex A defines the following new TLVs to support the new [802.1ah] encapsulations:

- DPoE ONUs MUST allow the use of TLV 43.5.2.6.1 to add [802.1ah] I-Tag when [802.1ah] encapsulation is supported.

[5] Revised per MEFv1.0-N-12-0041-1 on 8/1/12 by JB.

- DPoE ONUs MUST allow the use of TLV 43.5.2.6.2 to add [802.1ah] B-DA when [802.1ah] encapsulation is supported.

Current [L2VPN] TLV 43.5.2.3 is used to add two tags: the outermost [802.1ad] S-VLAN tag and the inner C-VLAN tag. The outermost S-VLAN tag uses TPID 0x88a8, and the inner C-VLAN tag uses TPID 0x8100. DPoE ONUs MUST add the inner C-VLAN tag if it is not set to NULL. Since this specification does not require adding the C-VLAN tag, the C-VLAN tag is always set to NULL. DPoE ONUs MUST reject the configuration if the C-VLAN is configured with a non-zero value.

DPoE Systems MAY support the translation of the TPID of the outermost tag of the frame in both the upstream direction and downstream direction. The new TPID is specified using the following two new TLVs:

- DPoE Systems MAY allow the use of TLV 43.5.14.1 to translate the TPID value of the outermost tag of the frame before the frame is transmitted on MN interface.
- DPoE Systems MAY allow the use of TLV 43.5.14.2 to translate the TPID value of the outermost tag of the frame before the frame is transmitted on TU interface.

DPoE Systems MUST support the setting of the L2VPN attributes described in Table 3 below based on the new TLVs described in Annex A.

Table 3 - New TLV Attributes

Attribute Name	Type	Value Range	Default Value
L2VPN Mode (TLV 43.5.13) (Refer to Section 5.7 for details.)	Int (8-Bits)	0 .. 255	0 (Encapsulation Mode)
I-Tag TCI (TLV 43.5.2.6.1) I-Tag consists of 16-bit TPID and 32-bit TCI which contains 24-bit I-SID. TPID is always 0x88e7.	Int (32-Bits)	0x00 00 00 00 – 0x00 FF FF FF	NA
B-DA (TLV 43.5.2.6.2)	MAC Address (48-Bits)	NA	NA
Upstream TPID Translation (TLV 43.5.14.1)	Int (16-Bits)	NA	NA
Downstream TPID Translation (TLV 43.5.14.2)	Int (16-bits)	NA	NA

5.7 L2VPN Modes Introduced in DPoE

DPoE Systems MUST allow the use of new TLV 43.5.13, defined in Annex A, to define the L2VPN Mode. DPoE ONUs MUST allow the use of new TLV 43.5.13, defined in Annex A, to define the L2VPN Mode. Currently, L2VPN has two modes: Encapsulation Mode and Transport Mode. Encapsulation Mode is the default L2VPN Mode.

In the L2VPN Encapsulation Mode, DPoE ONUs MUST allow the use of TLV 43.5.2.3 to add [802.1ad] S-VLAN tag to the customer frames received from MU interface. Customer traffic received from MU interface belongs to one EPL service instance, which is identified by the S-VLAN ID in the [802.1ad] S-VLAN tag.

In the L2VPN Encapsulation Mode, DPoE ONUs MUST allow the use of TLV 43.5.2.6.1 and TLV 43.5.2.6.2 to add [802.1ah] I-Component encapsulation to the customer frames received from MU interface. Customer traffic received from MU interface belongs to one EPL service instance, which is identified by the I-SID in [802.1ah] I-Component encapsulation.

In the L2VPN Encapsulation Mode, DPoE ONUs MUST allow the use of TLV 43.5.2.6.1 and TLV 43.5.2.6.2 to add [802.1ah] I-Component encapsulation to the PB frames received from MI interface. DPoE ONUs MUST match the S-VLAN ID in the S-VLAN tag of the received PB frame with the configured classifiers to identify the EPL service instance of the frame. DPoE ONUs MUST allow configuration of this value using L2VPN upstream service-flow classifiers that are specified in [DPoE-SP-MULPIv1.0]. The I-SID in [802.1ah] I-Component encapsulation is the one that corresponds to S-VLAN ID and is used to identify the service instance to which the frame belongs in the PBBN.

In L2VPN Encapsulation Mode, DPoE Systems MUST use the classifiers specified in [DPoE-SP-MULPIv1.0] to classify L2VPN downstream service flows of a particular EPL service instance based on the S-VLAN ID of the S-VLAN tagging or I-SID of the [802.1ah] I-Component encapsulation.

DPoE ONUs MUST use L2VPN Transport Mode to forward traffic that belongs to a particular EPL service instance from the ingress MI interface or DEMARC device to which DPoE Bridge ONU is plugged to the egress MN interface in the upstream direction without adding extra tagging or encapsulations or removing existing ones.

DPoE Systems MUST use L2VPN Transport Mode to forward traffic that belongs to a particular EPL service instance from the ingress MN interface to the egress MI interface or the DEMARC to which the destination DPoE Bridge ONU is plugged without adding extra tagging or encapsulations or removing existing ones.

In L2VPN Transport Mode, DPoE ONUs MUST use classifiers specified in [DPoE-SP-MULPIv1.0] to classify L2VPN upstream service flows of a particular EPL service instance based on the S-VLAN ID of the S-VLAN tagging or I-SID of the [802.1ah] I-Component encapsulation.

In L2VPN Transport Mode, DPoE System MUST use classifiers specified in [DPoE-SP-MULPIv1.0] to classify L2VPN downstream service flows of a particular EPL service instance based on the S-VLAN ID of the S-VLAN tagging or I-SID of the [802.1ah] I-Component encapsulation.

In L2VPN Transport Mode, TLV 43.5.2.3, TLV 43.5.2.6.1, and TLV 43.5.2.6.2 TLVs MUST NOT be used.

DPoE ONUs MUST support L2VPN Transport Mode for frames that use Provider Bridge tagging and frames that use Provider Backbone Bridge encapsulation.

TPID translation must be supported in both L2VPN Encapsulation Mode and L2VPN Transport Mode.

In this version of the specification, there is no configurable attribute for a given interface to define its mode of operation. The mode of operation for a given interface is implicitly defined by the L2VPN Mode. Thus, DPoE ONUs MUST consider an MI interface to be configured in Transport Mode if all the L2VPNs on the MI interface are configured in the Transport Mode.

5.8 MEF EPL Service Attributes

[MEF 10.2] EPL service uses point-to-point EVC that has exactly two MEF UNIs. All ingress service frames from any one of these two UNIs are mapped to the point-to-point EVC and are delivered by the Carrier Ethernet network unconditionally to the other UNI, while preserving the C-VLAN tag if one exists in the ingress frame.

EPL service can also be used to provide an Ethernet service between a MEF UNI on the management CPU of the DEMARC device and a management station. This connection carries only management traffic and allows the operator to manage DEMARC devices remotely.

This version of the specification supports all applicable EPL service attributes defined in section 7.1 of [MEF 6.1]. DPoE ONUs MUST support all applicable MEF UNI EPL service attributes, MEF EVC service attributes, and EVC per UNI EPL service attributes.

Since provisioning is associated with one EPL EVC, this specification requires that EVC Identifier to be the same as the L2VPN identifier L2VPN ID, which is configured using TLV 43.5.1.

[L2VPN] supports EPL EVC unconditional delivery service attributes because it forwards traffic unconditionally between MU and MN interfaces without changing a C-VLAN tag, if one exists in the received frame.

Section 5.8.1 describes existing MIB objects that must be used to support UNI service attributes.

Section 5.8.2 describes existing TLVs required to support EVC and UNI service attributes.

Section 5.8.3 describes L2 Control Protocol Processing.

Section 5.9 describes provisioning of EPL QoS attributes.

EVC Performance attributes defined in [MEF 10.2] are not supported in this version of the specification**.**

Annex D provides a summary of MEF EPL service attributes, parameters, and values and, wherever applicable, it describes how they are supported using this specification's provisioning model.

Appendix VI provides examples of using implementation of this specification's provisioning model to support EPL services using Provider Bridge tagging and Provider Backbone Bridging encapsulation for both Transport Mode and Encapsulation Mode with and without TPID Translation.

5.8.1 Interface MIB Objects

The DPoE System, on behalf of the vCM used to provide Simple Network Management Protocol (SNMP) management for the DPoE ONU, MUST support the following MIB objects in the ifTable of the IF-MIB for each DPoE ONU S interface:

- ifAlias. This writeable object is used to provision the MU Identifier or MI Identifier. As an example, the Service Provider might use "SC-DPoE-System-DPoE-ONU1-Port1" as a UNI Identifier to signify Port 1 on 'DPoE ONU1' on the 'Santa Clara DPoE System'. TLV-11 should be used to set ifAlias.
- ifType. This read-only object stores the MEF UNI Physical Medium and Mac Layer.
- ifSpeed. This read-only object stores the Speed of the MEF UNI.
- ifMtu. This read-only object stores the Maximum Transmission Unit (MTU) size of the MEF UNI, which must not exceed 1600 bytes for 1G -EPON and 2000 bytes for 10G-EPON, as specified in [DPoE-SP-MULPIv1.0].

The DPoE System, on behalf of the virtual CM, MUST support the dot3StatsDuplexStatus MIB object in the dot3StatsTable of the EtherLike-MIB. This object stores the Mode of the MEF UNI.

DPoE Systems MAY support other IETF-approved MIB objects defined by IEEE or MEF.

5.8.2 DOCSIS L2VPN TLVs

DPoE Systems MUST support the following TLVs:

- Cable Modem Interface Mask (CMIM) Sub-type (43.5.4). This TLV is described in section B.3.4 of [L2VPN]. The TLV is used to map tagged, untagged, and priority-tagged customer traffic of the MU interface to the EPL EVC (L2VPN).
- VPN Identifier (VPNID) (43.5.1). This TLV is described in section B.3.1 of [L2VPN]. The TLV is used to provision the [L2VPN] Identifier, which is also used as the EVC Identifier. As an example, the Service Provider might use "EVC-0001898-MEGAMART" to represent the 1898th EVC in the MEN, and the customer for the EVC is MegaMart.

5.8.3 EPL L2CP Processing

DPoE ONUs MUST support OPTION 2 in section 8.1, Table 31 of [MEF 6.1] as the default and only option to handle L2CP. In OPTION 2, all L2CP service frames, except PAUSE frames, will be mapped to the EVC like all other MEF UNI ingress service frames. PAUSE frames must be discarded at the MEF UNI.

5.9 QoS for Metro Ethernet Services[6]

DPoE Systems support RTPS scheduling for all MEF upstream service flows.

5.9.1 Provisioning Bandwidth Profile Service Attributes[7]

The Minimum Reserved Traffic Rate (TLV 24/25.10) and Maximum Sustained Traffic Rate (TLV 24/25.8) for each service flow should be configured with the value of Committed Information Rate (CIR) as defined in [MEF 10.2]. Maximum Traffic Burst (TLV 24/25.9) should be configured with Committed Burst Size (CBS) as defined in [MEF 10.2]. The minimum value and default values of Maximum Traffic Burst are defined in [DPoE-SP-MULPIv1.0].

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[6] Revised per MEFv1.0-N-12.0032-1 on 5/21/12 by JB.
[7] Revised per MEFv1.0-N-12.0032-1 on 5/21/12 by JB.

DPoE Systems use the Nominal Polling Interval (TLV 24.17) as specified in [DPoE-SP-MULPIv1.0].

5.10 Ethernet Service OAM

This version of the specification does not support Ethernet Service OAM specified in [Y.1731] and [802.1ag] for EPL Services.

6 PERFORMANCE AND FAULT MANAGEMENT (NORMATIVE)

This version of the specification does not support performance management as specified by [MEF 10.2]. DPoE Systems MUST support the 32-bit counters provided by the docsL2vpnVpnCmStatsTable table of the L2VPN MIB. These counters are:

docsL2vpnVpnCmStatsUpstreamPkts

docsL2vpnVpnCmStatsUpstreamBytes

docsL2vpnVpnCmStatsUpstreamDiscards

docsL2vpnVpnCmStatsDownstreamPkts

docsL2vpnVpnCmStatsDownstreamBytes

docsL2vpnVpnCmStatsDownstreamDiscards

The two counters docsL2vpnVpnCmStatsUpstreamDiscards and docsL2vpnVpnCmStatsDownstreamDiscards do not include the counters for packets that are dropped at the MI, MU, and MN interfaces. These interface counters are maintained in the ifInDiscards and ifOutDiscards in ifTable of the IF-MIB.

DPoE Systems MUST support ifInDiscards that includes frames dropped due to any of the reasons described in Section 5 of this specification.

Fault Management in this version of the specification is supported using ifOperStatus MIB object from the ifTable, and the associated linkUp and linkDown traps (enabled via ifLinkUpDownTrapEnable object). All those objects and notifications are defined in IF-MIB [RFC 2863].

DPoE System SHOULD report these events via SYSLOG using the rules defined in section 8.1 of [OSSIv3.0].

DPoE Systems MUST support the Link Up and Link Down events as defined in Annex C.

Vendor-specific text must include MI or MU Identifier in ifAlias if it is available in the DOCSIS configuration file.

For example, the syslog message for DPoE ONU MU link up event may follow this format:

> "<134>CABLEMODEM[DPoE]: <80000102> Ethernet Interface link up ifIndex=2; ifAdminStatus=up; ifAlias=EPL Santa Clara UNI"

Annex A Parameter Encodings (Normative)

A.1 L2VPN Mode

This parameter is used to configure L2VPN Mode. L2VPN has two modes: Encapsulation Mode and Transport Mode. If this parameter is omitted or is 0, then L2VPN Encapsulation Mode is used. In this mode, the L2VPN NSI service multiplexing value, configured using the NSI Encapsulation Subtype (TLV 43.5.2), must be used to add the service tag or encapsulation to the frames received from MU or MI interfaces before they are transmitted on the selected MN interface.

If this parameter is set to "1", then L2VPN Transport Mode is used. The behavior of DPoE ONU and DPoE System is described in the Section 5 of this specification.

SubType	Length	Value
43.5.13	1	L2VPN Mode 0 = L2VPN Encapsulation Mode (default) 1 = L2VPN Transport Mode. 2-255 = Reserved

A.2 [802.1ah] Encapsulation

This parameter defines the parameters associated with [802.1ah] tagging and encapsulation.

SubType	Length	Value
43.5.2.6	n	

A.2.1 [802.1ah] Backbone Service Instance Tag (I-Tag)

This parameter defines [802.1ah] I-Tag, which consists of TPID 0x88e7 and 32-bit I-TAG TCI. The value of this parameter is the 32-bit [802.1ah] I-Tag TCI (most significant byte 1st), which contains in its least significant 24-bits the Backbone Service Instance Identifier (I-SID). The most significant byte of I-Tag TCI must be zero.

SubType	Length	Value
43.5.2.6.1	4	32-bit value of [802.1ah] I-Tag TCI

A.2.2 MAC Address of the Destination Backbone Edge Bridge (B-DA)

This parameter defines for a given Backbone Service Instance the MAC address of the destination BEB, which should deliver [802.1ah] frames of this instance to the destination customer systems. The value of this parameter is 6-bytes individual MAC address.

SubType	Length	Value
43.5.2.6.2	6	48-bit BEB MAC Address

A.3 TPID Translation

This field defines the L2VPN top-level parameters associated with the translation of the TPID of the frame outermost tag (e.g., S-VLAN tag or I-Tag).

SubType	Length	Value
43.5.14	n	

A.3.1 Upstream TPID Translation

This parameter defines the new TPID value to be used for the outermost Tag of the frame before it is transmitted on the MN interface. For example, this parameter can be used to replace the standard [802.1ad] TPID value 0x88a8 with a value that is expected by the upstream device that supports legacy Provider Bridge tagging, which uses legacy TPIDs like 0x9100 and 0x9200.

SubType	Length	Value
43.5.14.1	2	2-Byte TPID value

Value	Informative Example Use
0x8100	[802.1q]
0x9100	q-in-q or [802.1ad]
0x9200	q-in-q or [802.1ad]
0x88a8	[802.1ad]

A.3.2 Downstream TPID Translation

This parameter defines the new TPID value to be used for the outermost Tag of the frame before it is transmitted on the TU interface. For example, this parameter can be used to replace a legacy TPID value of Provider Bridge S-VLAN tagging (e.g., 0x9100) with a value that is expected by the downstream device that supports standard [802.1ad] tagging, which uses TPID 0x88a8.

SubType	Length	Value
43.5.14.2	2	2-Byte TPID value

Value	Informative Example Use
0x8100	[802.1q]
0x9100	q-in-q or [802.1ad]
0x9200	q-in-q or [802.1ad]
0x88a8	[802.1ad]

Annex B DPoE MEF MIB Requirements (Normative)

This section describes the new MIB objects that are required to support DPoE MEF EPL service.

The following modifications to the DOCS-L2VPN-MIB, which is described in [L2VPN] Annex A, must be supported by the DPoE System to read back the encapsulation and tagging used by L2VPN, and whether L2VPN is configured to support Encapsulation Mode (i.e., [802.1ad] S-VLAN tagging or [802.1ah] encapsulation is added to the frame at or before the C_O reference point) or Transport Mode, where no additional encapsulation or tagging is required.

The new subtype `DocsNsiModeSubtype` will be defined to describe L2VPN Mode as shown below. A 'none' enumeration is used to handle implementations that support the DOCS-L2VPN-MIB but are not DPoE-based.

```
DocsNsiModeSubtype ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
            "An enumerated integer that defines L2VPN Mode. Two modes
            are supported: Encapsulation Mode and Transport Mode."
    SYNTAX      INTEGER {
                none(1),
                encapsulation(2),
                transport(3)
                }
```

The new objects `docsL2vpnCmNsiMode, docsL2vpnCmNsiTpidTransUS,` and `docsL2vpnCmNsiTpidTransDS` will be added to `DocsL2vpnCmNsiEntry` as shown below to describe L2VPN Mode and TPID Translation value.

```
DocsL2vpnCmNsiEntry ::= SEQUENCE {
        docsL2vpnCmNsiEncapSubtype DocsNsiEncapSubtype,
        docsL2vpnCmNsiEncapValue DocsNsiEncapValue,
        docsL2vpnCmNsiAGI OCTET STRING,
        docsL2vpnCmNsiSAII OCTET STRING,
        docsL2vpnCmNsiTAII OCTET STRING,
        docsL2vpnCmNsiMode DocsNsiModeSubtype,
        docsL2vpnCmNsiTpidTransUS Integer32,
        docsL2vpnCmNsiTpidTransDS Integer32
        }

docsL2vpnCmNsiMode OBJECT-TYPE
    SYNTAX      DocsNsiModeSubtype
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object indicates L2VPN Mode, which can be Encapsulation Mode
            or Transport Mode.
            This Mode is configured using TLV 43.5.13.
            In the L2VPN Encapsulation, Mode IEEE 802.1ad S-VLAN tagging
            or IEEE 802.1ah encapsulation
            is added to frames received from MI and MU interfaces
            at or before the Co reference point
            to transport these frames over the MN interface.
            L2VPN Transport Mode is used to forward traffic that belongs
            to a particular EPL service instance to the egress MN interface
            in the upstream direction
            or egress MI interface in the downstream direction without
            adding extra encapsulations or
            tagging or removing existing ones."
    REFERENCE
            "TLV 43.5.13 is described in Annex A of DPoE-SP-MEF specification.
            Section 5 of DPoE-SP-MEF specification describes
            IEEE 802.1ad S-VLAN tagging
```

```
            and IEEE 802.1ah encapsulation when L2VPN Encapsulation Mode is used."
    ::= { docsL2vpnCmNsiEntry 6 }

docsL2vpnCmNsiTpidTransUS OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object is the configuration of the TPID used
            in the Upstream Direction (US) by DPoE System to translate
            the TPID of the frame before it is transmitted on the MN interface.
            Value of 0 indicates that no TPID translation is required in the
            Upstream Direction."
    REFERENCE
            "TLV 43.5.14.1 is described in Annex A of DPoE-SP-MEF specification."
    ::= { docsL2vpnCmNsiEntry 7 }

docsL2vpnCmNsiTpidTransDS OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object is the configuration of the TPID used
            in the Downstream Direction (DS) by DPoE System to translate
            the TPID of the frame before it is transmitted on the TU interface.
            Value of 0 indicates that no TPID translation is required in the
            Downstream Direction."
    REFERENCE
            "TLV 43.5.14.2 is described in Annex A of DPoE-SP-MEF specification."
    ::= { docsL2vpnCmNsiEntry 8 }
```

The definition of `DocsNsiEncapSubtype` will be extended to support [802.1ah] encapsulation as described below.

```
DocsNsiEncapSubtype ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
            "An enumerated integer that defines the default
            encapsulation on NSI ports of an L2VPN-forwarded packet.
            A CMTS implementation MUST support ieee8021q(2).
            A CMTS MAY omit support for all NSI encapsulations
            other than ieee8021q(2).
            ieee8021q(2) encapsulation is not explicitly supported in the
            DPoE Network, so the value will not be reported by the DPoE System.
            Support for the ieee8021ah encapsulation is optional in the
            DPoE Network and MAY be reported by the DPoE System.
            DPoE System MUST NOT support mpls(4) and l2tpv3(5)."
    SYNTAX      INTEGER {
                other(1),
                ieee8021q(2),
                ieee8021ad(3),
                mpls(4),
                l2tpv3(5),
                ieee8021ah(6)
                }
```

The description of `DocsNsiEncap`Value will be extended to support IEEE 802.1ah encapsulation as described below.

```
DocsNsiEncapValue ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
            "The encapsulation value for L2VPN forwarded packets on NSI
```

```
        ports. The value of an object of this type depends on the
        value of an associated object of type DocsEncapSubtype:
        other(1): vendor specific,
        ieee8021q(2): 802.1Q tag with VLAN ID in lower 12 bits,
        ieee8021ad(3): pair of 16-bit values with service provider
        in lower 12 bits of the first 16-bit value and customer
        VLAN ID in the lower 12 bits of the second 16-bit value,
        mpls(4): must be zero length string,
        l2tpv3(5): must be zero length string.
        ieee8021ah(6): IEEE 802.1ah encapsulation which consists of B-SA,
        B-DA and 48-bit I-Tag"
SYNTAX      OCTET STRING
```

Annex C Format and Content for DPoE Events Extensions (normative)

To facilitate DPoE MEF fault management, the DPoE System, on behalf of the DPoE ONU, MUST support the DOCSIS Event extensions defined in this section. This section is an extension of the Format and Content for Event, SYSLOG, and SNMP Notification Annex D of [OSSIv3.0].

Table 4 - DPoE Events Extensions

Process	Sub-Process	DPoE ONU Priority	DPoE System Priority	Event Message	Message Notes and Detail	Error Code Set	Event ID	Notification Name
Interface Status	Ethernet Interface	Critical	Critical	Ethernet Interface link down	For Local Log & Syslog, append: ifIndex: <P1>; ifAdminStatus: <P2>; ifAlias: <P3> P1 = ifIndex from ifTable for Ethernet Interface P2 = ifAdminStatus from ifTable for Ethernet Interface P3 =ifAlias from ifTable for Ethernet Interface	P001.1	80000101	linkDown [RFC 2863]
Interface Status	Ethernet Interface	Notice	Notice	Ethernet Interface link up	For Local Log & Syslog, append: ifIndex: <P1>; ifAdminStatus: <P2>; ifAlias: <P3> P1 = ifIndex from ifTable for Ethernet Interface P2 = ifAdminStatus from ifTable for Ethernet Interface P3 =ifAlias from ifTable for Ethernet Interface	P001.2	80000102	linkUp [RFC 2863]

Annex D MEF EPL Service Attributes (Informative)

This annex summarizes MEF EPL service attributes, parameters, and values as defined in section 7.1 of [MEF 6.1], and describes existing or additional DOCSIS provisioning parameters that are used to implement EPL service using [L2VPN]. Three tables are provided to cover service attributes of the MU, EVC, and EVC per UNI.

Table 5 below describes the MEF UNI service attributes, parameters, and values for MEF EPL service as defined by Table 10 in section 7.1 of [MEF 6.1]. A new column is added to describe how DOCSIS parameters (new or existing) are used to implement EPL service in DPoE Networks.

Table 5 - MEF UNI (MU) Service Attributes for EPL Service

MEF UNI Service Attribute	Metro Ethernet Service Attribute Parameters and Values	DOCSIS Provisioning Parameters
UNI Identifier	Arbitrary Text String to Identify the UNI	This parameter is provisioned using ifAlias MIB object in the ifXTable of the IF-MIB.
Physical Medium	UNI Type 1 Physical Interfaces defined in [802.3] except EPON Interfaces	This parameter is accessible using the read-only ifType MIB object in the ifTable of the IF-MIB.
Speed	10 Mbps, 100Mbps, 10/100Mbps Auto-negotiation, 10/100/1000 Mbps Auto-negotiation, 1Gpbs or 10Gbps.	This parameter is accessible using the read-only ifSpeed MIB object in the ifTable of the IF-MIB.
Mode	Must be Full Duplex	This parameter is media-specific. For Ethernet, this parameter is accessible using the dot3StatsDuplexStatus MIB object in the dot3StatsTable table of the Ethernet Interface MIB (EtherLike-MIB).
MAC Layer	[802.3]	This parameter is accessible using the read-only ifType MIB object in the ifTable of the IF-MIB.[8]
UNI MTU Size	Must be >= 1522	This parameter is accessible using the read-only ifMTU MIB object in the ifTable of the IF-MIB.
Service Multiplexing	Must be NO	Not applicable in this version of the specification which only supports EPL service, which does not require service multiplexing.
Bundling	Must be NO	Not applicable in this version of the specification which ONLY supports EPL service, which does not require Bundling.
All to One Bundling	Must be Yes.	CMIM sub-type defined by TLV [43.5.4] is used to map UNI ingress traffic to one EVC (L2VPN).
CE-VLAN ID for untagged and priority tagged Service Frames	All untagged and priority-tagged Service Frames at the UNI must map to the same EVC as is used for all other Service Frames.	CMIM sub-type defined by TLV [43.5.4] is used to map UNI ingress traffic including untagged and priority-tagged frames to one EVC (L2VPN).
Maximum Number of EVCs	Must be 1	Not applicable in this version of the specification because no UNI can support more than ONE EVC.
Ingress Bandwidth Profile per UNI	Must not Specify	No DOCSIS parameters should be provisioned in this case.
Egress bandwidth Profile per UNI	Must not Specify	No DOCSIS parameters should be provisioned in this case.
Layer 2 Control Protocol Processing	Must Specify in accordance with Table 8.1 of [MEF 6.1].	DPoE ONUs must support OPTION 2 in section 8.1, Table 31 of [MEF 6.1] as the default and only option to handle L2CP. In OPTION 2, all L2CP service frames, except PAUSE frames, will be mapped to the EVC like all other UNI ingress service frames. DPoE ONUs must discard the PAUSE frames at the UNI.

[8] Please note that the value of the ifType MIB object actually reflects a "combination" of Physical Medium and MAC Layer parameters.

Table 6 below describes EVC per UNI service attributes, parameters, and values for the EPL service as defined by Table 11 in section 7.1 of [MEF 6.1]. A new column is added to describe how DOCSIS parameters (new or existing) are used to implement EPL service.

Table 6 - EVC per UNI Service Attributes for EPL Service

MEF EVC per UNI Service Attribute	Metro Ethernet Service Attribute Parameters and Values	DOCSIS Provisioning Parameters
UNI EVC Identifier	A string formed by the concatenation of UNI ID and the EVC ID.	No new DOCSIS provisioning parameter is required.
CE-VLAN/EVC Map	All Service Frames at the UNI must map to a single Point-to-Point EVC.	CMIM sub-type defined by TLV [43.5.4] is used to map UNI ingress traffic to one EVC (L2VPN).
Ingress Bandwidth Profile Per EVC	OPTIONAL. If supported, must specify <CIR, CBS, EIR, EBS, CM, CF>. Must not be combined with any other type of ingress bandwidth profile.	Must specify in accordance with Section 5.9 of this specification.
Ingress Bandwidth Profile Per CoS ID	OPTIONAL. If supported, must specify CoS ID, and must specify <CIR, CBS, EIR, EBS, CM, CF> for each CoS. Must not be combined with any other type of ingress bandwidth profile.	Ingress Bandwidth Profile per CoS is not supported in this version of the specification.
Egress Bandwidth Profile per EVC	Must not Specify	No DOCSIS parameters should be provisioned in this case.
Egress bandwidth Profile per CoS ID.	Must not Specify	No DOCSIS parameters should be provisioned in this case.

Table 7 below describes the EVC service attributes, parameters, and values for the EPL service as defined in Table 12 of section 7.1 of [MEF 6.1]. A new column is added to describe how DOCSIS parameters (new or existing) are used to implement EPL service.

Table 7 - EVC Service Attributes for EPL Service

EVC Service Attribute	Service Attribute Parameters and Values	DOCSIS Provisioning Parameters
EVC Type	Must be Point-to-Point.	No new DOCSIS provisioning parameter is required because only Point-to-Point EVC is supported in this version of the specification.
EVC ID	An arbitrary string, unique across Carrier Ethernet Network, for the EVC supporting the service instance.	No new DOCSIS provisioning parameter is required. EVC ID is the same as L2VPN ID, which is defined in [L2VPN] TLV 43.5.1.
UNI List	Must list the two UNIs associated with the EVC. The UNI type must be Root for Each UNI.	No new DOCSIS provisioning parameter is required because this version of the specification only supports Point-to-Point EVC, which only has two UNIs.
Maximum Number of UNIs.	Must be 2.	No new DOCSIS provisioning parameter is required because this version of the specification only supports Point-to-Point EVC, which only has two UNIs.
EVC MTU Size	Must be >= 1522.	EVC MTU size must not exceed 1600 bytes for 1G-EPON and 2000 bytes for 10G-EPON.
CE-VLAN ID Preservation	Must be Yes.	[L2VPN] preserves CE-VLAN ID. Therefore, no new DOCSIS provisioning parameters are required.
CE-VLAN CoS Preservation	Must be Yes.	[L2VPN] preserves CoS. Therefore, no additional provisioning parameters are required.
Unicast Service Frame Delivery	Must deliver unconditionally.	Unconditional delivery of unicast traffic is currently supported by [L2VPN]. Therefore, no new DOCSIS provisioning parameters are required.
Multicast Service Frame Delivery	Must Deliver unconditionally.	Unconditional delivery of multicast traffic is currently supported by [L2VPN]. Therefore, no new DOCSIS provisioning parameters are required.

EVC Service Attribute	Service Attribute Parameters and Values	DOCSIS Provisioning Parameters
Broadcast Service Frame Delivery	Must deliver unconditionally.	Unconditional delivery of broadcast traffic is currently supported by [L2VPN]. Therefore, no new provisioning parameters are required.
Layer 2 Control Protocol Processing (only applies for L2CP passed to the EVC).	Must specify in accordance with Table 8.1 of [MEF 6.1].	DPoE ONUs must support OPTION 2 in section 8.1, Table 31 of [MEF 6.1] as the default and only option to handle L2CP. In OPTION 2 all L2CP service frames, except PAUSE frames, will be mapped to the EVC like all other UNI ingress service frames. PAUSE frames must be discarded at the UNI.
EVC Performance	At least one CoS is REQUIRED. Must specify CoS ID, per section 6.8 of [MEF 10.2]. Must list values for each of the following attributes {Frame Delay, Frame Delay Variation, Frame Loss Ratio, and availability} for each CoS, where Not Specified (N/S) is an acceptable value.	Not Applicable because EVC Performance Service Parameters are not supported in this version of the specification.

Appendix I MEF Carrier Ethernet Reference Model (Informative)

This is an informative section. The information in this section is based on MEF specifications. Any *"MUST"* or *"SHOULD"* requirements in this section are MEF requirements, NOT DPoE requirements.

Figure 5 below shows MEF Carrier Ethernet Network architecture[9]. Two major functional components are involved in the architecture:

- The Customer Edge (CE) equipment in the Subscriber Network. The CE may be implemented by an (Ethernet) Switch, (IP/MPLS) Router, or a Host System.
- The Provider Edge (PE) equipment in the Service Provider Carrier Ethernet Network.

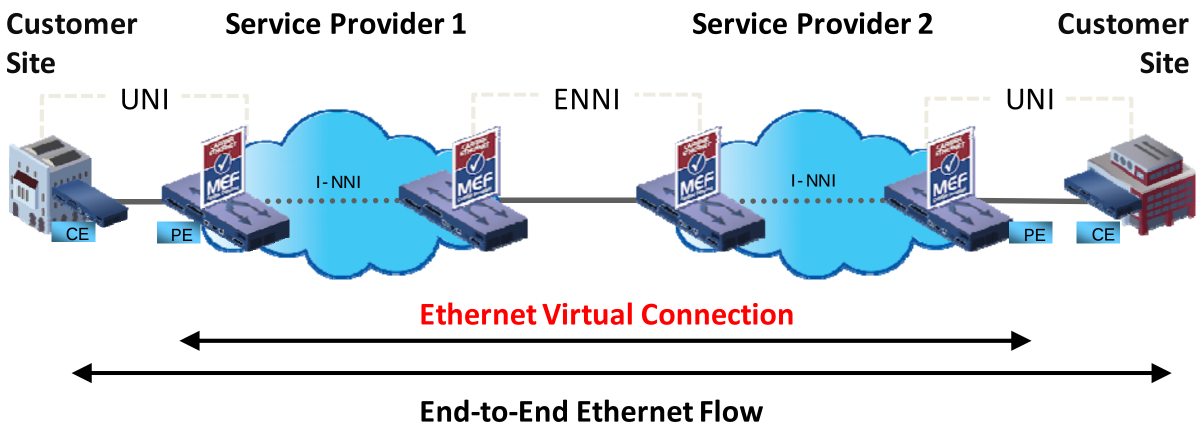

Figure 5 - MEF Carrier Ethernet Reference Architecture [MEF-Pres-2008]

The architecture identifies the following main reference points:

- The User Network Interface (UNI), which describes different aspects of the interface between the Public Service Provider Network and the Private Subscriber/Customer Network. The UNI is physically implemented over a bi-directional Ethernet MAC layer network (ETH) link and *MUST* be dedicated to a single Subscriber.
- E-NNI. This is the open interface between two service providers. [MEF 26] defines E-NNI.
- I-NNI. This is the open interface between two network elements in the same service provider network.

The connectivity between UNIs is specified using EVC, which is defined by [MEF 4] as:

> *"the architecture construct that supports the association of UNI reference points for the purpose of delivering an Ethernet flow between subscriber sites across Carrier Ethernet Network."*

EVC prevents data transfer between sites that are not part of the same EVC. A MEF UNI can be associated with one or more EVCs. PE applies classification rules to ingress service frames (i.e., subscriber frames transmitted across the UNI toward the Service Provider) to map subscriber flows to EVCs. There may be one or more subscriber flows mapped to a particular EVC.

[9] Figure 5 is a slightly modified version of the one in slide 18 of the MEF presentation, which provides an overview for MEF 10.2 and MEF 6.1. This presentation can be obtained from the MEF web site on the technical specification page. The URL for this page is http://metroethernetforum.org/page_loader.php?p_id=29.

[MEF 10.2] supports the following three types of Ethernet Virtual Connections, which are illustrated in Figure 6 below:

- Point-to-point EVC. An EVC with exactly two MEF UNIs.
- Multipoint-to-multipoint EVC. An EVC with at least two MEF UNIs.
- Rooted multipoint EVC. An EVC in which a MEF UNI is either a Root or a Leaf. A Root MEF UNI can deliver ingress frames to any one of the Leaf MEF UNIs. A Leaf MEF UNI can only send frames to Root MEF UNI(s).

EVC is built of ETH-trails in the Ethernet Services Layer (ETH Layer). An ETH-trail is responsible for transferring Ethernet MAC frames between two MEF UNIs. An Ethernet Line service EVC is built of a single ETH-trail, while an Ethernet LAN service EVC is built of a number of ETH-trails.

Ethernet Services Layer uses Transport Services Layer (TRANS Layer), which carries Ethernet frames over various transports. The Trans layer is built of layered TRAN-trails, so there can actually be layering of transports (e.g., Ethernet over MPLS over SONET).

Appendix II Overview of MEF Ethernet Service Framework and MEF OAM (Informative)

This is an informative section. The information in this section is based on MEF specifications. Any *"MUST"* or *"SHOULD"* requirements in this section are MEF requirements, NOT DPoE requirements.

The Ethernet service framework provides the definition of and relationship between MEF UNI and EVC service attributes and their associated parameters.

An Ethernet service can be created using this framework by going through the following steps:

- Selecting one of the MEF generic Ethernet service types based on which service is created. Service types are described in Appendix II.1 below.
- Selecting one or more Ethernet service attributes that define the characteristics of the MEF UNI at which the service is offered and the EVC of the service type. Appendix II.1.1 describes EVC service attributes, and Appendix II.1.2 describes MEF UNI service attributes, which fall into two types:
  - Service attributes that are independent of the EVCs at the MEF UNI, and
  - Service attributes that are associated with the EVC at the MEF UNI. It is worth noting that for a given Ethernet service, different MEF UNIs in the same EVC may be assigned different parameter values for the same service attribute. For example, UNIs in the same EVC may have different physical media, speed, or bandwidth profiles.
- Deciding upon one or more parameter values associated with each one of the Ethernet Service Attribute that has been selected.

II.1 Overview of MEF Ethernet Service Types and Attributes

[MEF 6.1] defines three *generic* Ethernet service types:

- Ethernet Line (E-Line) service type (uses point-to-point EVC)
- Ethernet LAN (E-LAN) service type (uses multipoint-to-multipoint EVC)
- Ethernet Tree (E-Tree) service type (uses rooted multipoint EVC)

Figure 6 below describes MEF generic Ethernet service types. [MEF 6.1] added Ethernet E-Tree service type. This version of the specification only uses E-Line service type.

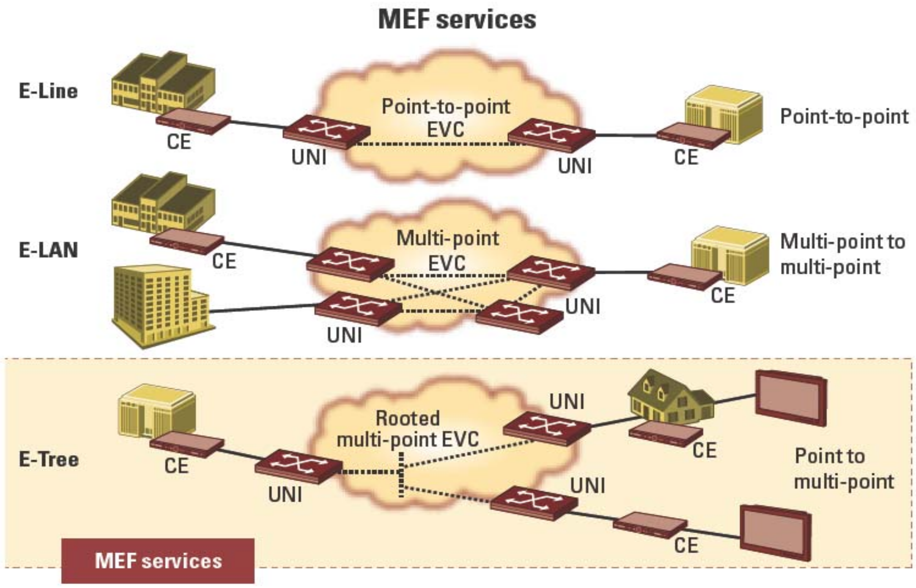

Figure 6 - MEF Carrier Ethernet Generic Service Types [LW-OCT-2008]

II.1.1 EVC Service Attributes

EVC Service Attributes are described in detail in section 6 of [MEF 10.2]. They are summarized below:

- **EVC Type.** This EVC Service attribute describes the type of connectivity that an Ethernet service provides. See section 6.1 of [MEF 10.2] for details.
- **EVC ID.** Alphanumeric string assigned by the service provider to uniquely identify an EVC in the Carrier Ethernet Network. As an example, the Acme Service Provider might use "EVC-0001898-ACME-MEGAMART" to represent the 1898th EVC in the MEN, and the customer for the EVC is MegaMart.
- **UNI List.** List of MEF UNIs in the EVC. Each MEF UNI is described using 2-tuple, which contains a MEF UNI identifier and a UNI type, which *MUST* be *Root* for point-to-point and multipoint-to-multipoint EVC types, and can be either *Root* or *Leaf* for rooted multipoint EVC.
- **Maximum Number of UNIs (MNU).** This should be at least 2 for multipoint EVCs and exactly 2 for point-to-point EVCs.
- **EVC MTU Size.** MTU *MUST* be >= 1522 and <= UNI MTU.
- **Service Frame Delivery Service Attribute.** Refer to Appendix II.1.1.1 for more details. This attribute describes, for each type of service frame, whether the service frame should be discarded, delivered unconditionally, or only delivered when certain conditions are met. There are three types of service frames:
  - Unicast service frame
  - Multicast service frame
  - Broadcast service frame
- **CE-VLAN Tag Preservation Service Attributes.** (See Appendix II.1.1.2 for details.)
  - CE-VLAN ID Preservation Service Attribute
  - CE-VLAN CoS Preservation Service Attribute

- **L2 Control Protocol (L2CP) Processing.** (See Appendix II.1.1.3 for details.)
- **Class of Service Identifier (CoS ID).** This attribute identifies the CoS instance for a given service frame, including L2 Control Protocols service frames (refer to Appendix II.1.1.3). Service frames in different EVCs *MUST* have different CoS IDs. This attribute is derived from one of the following:
  - The EVC to which the service frame is mapped.
  - The frame EVC and CoS value in the CE-VLAN TAG of the ingress tagged or priority-tagged frames. If the ingress frame is untagged, it's CoS value is assumed to be zero.
  - The frame EVC and IP Differentiated Services Code Point (DSCP) for service frames carrying IPv4/IPv6 packets. All Service frames not carrying IP packets will be assigned a value for the Class of Service Identifier that is agreed upon between the subscriber and service provider.
- **EVC Performance Service Attributes.** These attributes specify frame delivery performance. Four performance attributes are described in section 6.9 of [MEF 10.2]:
  - Frame Delay Performance,
  - Inter-Frame Delay Variation Performance,
  - Frame Loss Ratio Performance,
  - Availability Performance.

II.1.1.1 Service Frame Delivery

Service frames are divided into two groups: Data Service Frames and Layer 2 Control Protocol Frames. Data Service Frames can be unicast, multicast, or broadcast service frames.

This attribute is related to service frame disposition and transparency.

Section 6.5.2 of [MEF 10.2] describes the disposition of ingress service frames by one of the following:

- Discard: The service frame is discarded. Examples include a service frame containing a particular Layer 2 Control protocol (e.g., [802.3x]) that is always discarded at the MEF UNI, ingress service frames with an invalid FCS that *MUST* be discarded by the MEN, and ingress service frames with certain CoS value(s).
- Deliver Unconditionally: The service frame should be delivered across egress MEF UNIs regardless of its contents, assuming correct FCS.
- Deliver Conditionally: The service frame is delivered across an egress MEF UNI if certain specified conditions are met. These conditions can be verified at ingress or egress, or both. An example of conditional delivery of service frames includes delivering a service frame across a destination MEF UNI if the destination MAC address of the frame is known by MEN to be at the destination MEF UNI. Another example is delivering broadcast traffic only when the amount of such traffic does not exceed certain limits.
- Tunnel: This applies only to Layer 2 Control Protocol Service Frames as described below.

EVC Service Frame Transparency requires that all fields of each egress service frame be identical to the same fields of the corresponding ingress service frame except as follows:

- Egress service frame is tagged while the corresponding ingress service frame is untagged.
- Egress service frame is untagged while the corresponding ingress service frame is tagged.
- Both egress and ingress frames are tagged, but the contents of the tag are different.

II.1.1.2 CE-VLAN Tag Preservation Service Attributes

The Customer Edge VLAN Tag (CE-VLAN Tag) has two components, and each has an associated service attribute.

- Customer Edge VLAN Identifier (CE-VLAN ID)
- Customer Edge Priority Code Points (CE-VLAN CoS)

II.1.1.2.1 CE-VLAN ID Preservation Service Attribute

An EVC with CE-VLAN ID Preservation Service attribute *MUST* preserve the CE-VLAN ID for service frames so that the VLAN ID of an ingress service frame is identical to the VLAN ID of the corresponding egress service frame.

This attribute means that untagged service frames should also be delivered untagged across the egress MEF UNI.

If CE-VLAN ID is configured for an untagged or priority-tagged service frame, the CE-VLAN ID Preservation Service Attribute does not mandate that the configured CE-VLAN ID be preserved at egress, except when the All to One Bundling service attribute of the MEF UNI is TRUE (see Appendix II.1.2 below). When the CE-VLAN ID Preservation Service Attribute is not in force, the egress service frame *MUST* be untagged.

The EVC *MUST* have the CE-VLAN Preservation Service Attribute if it includes a MEF UNI at which more than one CE-VLAN is mapped to the EVC.

II.1.1.2.2 CE-VLAN CoS Preservation Service Attributes

In an EVC with CE-VLAN CoS Preservation Attributes, both the ingress and corresponding egress service frame *MUST* have identical CoS values.

II.1.1.3 EVC Layer 2 Control Protocol Processing Service Attribute

Layer 2 Control protocols use service frames whose destination MAC address is one of the addresses specified below:

- Bridge Block of Protocols: 01-80-C2-00-00-00 through 01-80-C3-00-00-0F
- GARP Block of Protocols: 01-80-C2-00-00-20 through 01-80-C2-00-00-2F

The All Bridges Group Address 01-80-C2-00-00-10 has been officially deprecated in [802.1q-2005]. Frames that use this MAC DA are treated as normal service frames.

Table 8 - L2CP and Corresponding MAC DA

L2 Control Protocol	MAC DA
STP/RSTP/MSTP	01-80-C2-00-00-00
Pause ([802.3x])	01-80-C2-00-00-01
LACP/LAMP ([802.3ad])	01-80-C2-00-00-02
Link OAM ([802.3ah] Clause 57)	01-80-C2-00-00-02
Port Authentication ([802.1x])	01-80-C2-00-00-03
E-LMI	01-80-C2-00-00-07
LLDP ([802.1AB])	01-80-C2-00-00-0E
GARP/MRP Block	01-80-C2-00-00-20 through 01-80-C2-00-00-2F

Table 8 above summarizes the standard L2 Control Protocols and the MAC DA they use. Service frames that use different MAC DA will be treated as normal data.

Section 8 of [MEF 6.1] defines how each Ethernet service should handle each one of the protocols specified in this table. Section 8 of [MEF 6.1] does not currently specify how to handle a bridge block protocol that uses a MAC DA other than that specified in this table.

L2 Control Protocols that use the same destination MAC address are identified using additional fields, such as Ethertype and a protocol identifier.

For a given EVC at a given UNI, the service provider defines which L2 Control protocol will be discarded and which will be tunneled via EVC across the service provider network and delivered intact at the egress UNI without any processing. Classification of L2 Control Protocols frames to be tunneled is based only on MAC DA. If L2 Control protocol tunneling is supported in a given EVC, then all UNIs of this EVC should be configured to pass the protocol service frames to the EVC.

Tunneled L2 Control Protocols may be assigned different CoS IDs based, for example, on the destination MAC address.

II.1.2 MEF UNI Service Attributes

MEF UNI service attributes are described in detail in [MEF 10.2]. The following attributes are independent of any EVC that is configured at the MEF UNI:

- **MEF UNI Identifier.** This is an arbitrary alphanumeric string assigned by the service provider that uniquely identifies a MEF UNI in the MEN. As an example, the Service Provider might use "SCPOP1-Node3-Slot2-Port1" as a UNI Identifier, and this could signify Port 1 in Slot 2 of Node 3 in Santa Clara POP1.
- Physical Layer Service Attributes, which include:
  - **Physical Medium**. Includes all Ethernet physical media (except EPON) that are specified in [802.3] and compatible with Speed and Mode described below.
  - **Speed.** 10Mbps, 100Mbps, 10/100Mbps with auto-negotiation, 1Gbps, and 10Gbps.
  - **Mode.** Full Duplex.
  - **MAC Layer Service Attribute.** Ethernet Frame format as specified in [802.3] *MUST* be supported.
- **MEF UNI MTU Size**. The MTU size *MUST* not be less than 1522.
- **Service Multiplexing Service Attribute.** This attribute allows multiple combinations of EVC types to be multiplexed at a MEF UNI.
- **Maximum Number of EVCs Service Attribute.** This attribute defines the maximum number (>=1) of EVCs that can be supported at the MEF UNI.
- **Bundling.** (See Appendix II.1.2.1.)
- **All to One Bundling.** (See Appendix II.1.2.1.)
- **CE-VLAN ID** for untagged and priority-tagged service frames. *MUST* specify CE-VLAN ID (in the range of 1-4094) for untagged and priority-tagged service frames
- **Ingress and Egress Bandwidth Profile** per MEF UNI. (See Appendix II.1.2.3.)
- **Layer 2 Control Protocols (L2CP) Processing.** (See Appendix II.1.2.2.)

The following MEF UNI attributes are associated with an EVC at the UNI:

- **MEF UNI EVC ID.** This attribute is associated with each EVC at the MEF UNI. It is an alphanumeric string that is formed by the concatenation of MEF UNI ID and EVC ID.
- **CE-VLANID/EVC Map.** This service attribute provides one or more mappings, where each mapping associates one or more CE-VLAN IDs with an EVC, and each CE-VLAN ID is mapped to at most one EVC. When Bundling and All to One bundling attributes are not invoked, exactly one CE-VLAN ID *MUST* be mapped to at most one EVC. UNI Ingress service frames with CE-VLAN ID that is not associated in the map with any EVC *MUST* be discarded by the Carrier Ethernet Network. Also, this CE-VLAN ID *MUST* not be used at the egress of that UNI.
- **Ingress/Egress Bandwidth Profile** per EVC and CoS ID (See Appendix II.1.2.3.)

II.1.2.1 Bundling and All to One Bundling Service Attributes

These two key MEF UNI service attributes are related to the method used to identify a service instance at the UNI. There are two methods for service identification:

- **Port-based.** In this method, all MEF UNI traffic belongs to one Ethernet service instance and one EVC, which *MUST* have the CE-VLAN ID Preservation Service Attribute. The type of MEF UNI used in this method is called the All to One Bundling UNI, which belongs to one EVC. All MEF UNIs in this EVC *MUST* have an All to One Bundling Service Attribute.

- **CE-VLAN-based.** In this method, CE-VLAN ID is used to identify an Ethernet service instance and its associated EVC. The type of UNI used in this method is called the Service Multiplexed UNI, which allows mapping only one CE-VLAN ID to at most one EVC, or Bundling more than one CE-VLAN ID into one EVC. In the case of bundling, the set of CE-VLAN IDs that map to this EVC should be the same at each MEF UNI in the EVC. In addition, the EVC *MUST* have the CE-VLAN ID Preservation Service Attribute.

Port-based method is used by Private Ethernet Services, while VLAN-based method is used by Virtual Private Ethernet services.

II.1.2.2 MEF UNI Layer 2 Control Protocol Processing Service Attribute

There are four alternatives for processing a given Layer 2 Control Protocol at a MEF UNI:

- **Discard.** The L2 Control Protocol service frames are discarded at the MEF UNI.
- **Peer.** The Carrier Ethernet Networks PE exchange protocol frames with CE that is running the Layer 2 Control Protocol.
- **Pass to EVC.** The Layer 2 Control protocol service frame handling is based on the L2 Control Protocol Processing Service Attribute of the EVC to which the frame belongs. This EVC is determined by the CE-VLAN ID of the service frame and the CE-VLAN ID/EVC Map of the MEF UNI.
- **Peer and Pass to EVC.** Each service must determine which L2 Control Protocol service frames should be processed by PE as peer, and which service frames should be passed to the EVC.

Classification of L2 Control Protocol frames is based on both MAC DA and protocol identifier (e.g., Ethertype, Slow-protocol sub-type).

II.1.2.3 MEF Standard Bandwidth Profile Parameters and Algorithm

[MEF 10.2] standardized Bandwidth Profile algorithm and parameters for Ethernet services. MEF specification does not define a particular implementation of this algorithm; however, the algorithm can be implemented using two token buckets: the first one is replenished at the CIR, and the second one is replenished at the EIR. CIR and EIR *MUST* be >= 0. Peak Information Rate is the sum of CIR and EIR. All rates are expressed as bits/sec.

Initially, the size of the first token bucket is CBS, and the size of the second token bucket is Excess Burst Size (EBS). When CIR > 0, CBS *MUST* be greater than or equal to the largest MTU size among all of the EVCs to which the bandwidth profile applies. Similarly, when EIR > 0, EBS *MUST* be greater than or equal to the largest MTU size among all of the EVCs to which the bandwidth profile applies.

The algorithm has a parameter named Coupling Flag (CF). When CF is set, unused tokens from the first token bucket can be added to the second token bucket.

The algorithm can work in either Color Blind or Color Aware mode. The mode is selected using the Color Mode parameter.

The algorithm can be applied at ingress and/or egress to all the service frames of a particular UNI, the UNI service frames of a given instance of an EVC at the UNI, or UNI service frames with specific CoS ID.

In Color Blind mode, when a service frame arrives, it is tested against the 1^{st} token bucket; if it is in profile, it is declared GREEN; otherwise, it is tested against the 2^{nd} token bucket, and declared YELLOW if it is in-profile and RED if it is out-of-profile.

In Color Aware mode, incoming RED service frame is not tested against any token buckets and remains RED. Incoming YELLOW service frame is tested only against the 2^{nd} token bucket; if it is in-profile, it remains YELLOW; otherwise, it is declared RED. Incoming GREEN service frame is tested against the 1^{st} token bucket; if it is in-profile it remains GREEN; otherwise, it is tested against the 2^{nd} token bucket and declared YELLOW if it is in-profile and RED if it is out-of-profile.

RED Frames *MUST* be discarded.

MEF algorithm is also described in [RFC 4115], which describes a Differentiated Service Two-Rate, Three-Color Marker (trTCM) with Efficient Handling of in-Profile Traffic. This marker has been used in data services like Frame Relay services.

II.2 MEF Basic Ethernet Services

Section 7 of [MEF 6.1] defined six basic Ethernet services based on the three Ethernet generic service types mentioned above.

Services that use All to One Bundling UNIs are referred to as Private Ethernet Services, while services that use service multiplexed UNIs are referred to as Virtual Private Ethernet services. Table 9 below lists MEF basic services. For each service, the table shows the associated Ethernet service type and EVC type.

Table 9 - MEF Basic Services

Service Type	Port-Based (All-to-One Bundling)	VLAN-Based (Service Multiplexed)
E-Line (Point-to-Point EVC)	Ethernet Private Line (EPL)	Ethernet Virtual Private Line (EVPL)
E-LAN (multipoint-to-multipoint EVC)	Ethernet Private LAN (EP-LAN)	Ethernet Virtual Private LAN (EVP-LAN)
E-Tree (rooted multipoint EVC)	Ethernet Private Tree (EP-Tree)	Ethernet Virtual Private Tree (EVP-Tree)

Figure 7 below shows examples of EPL, EVPL, EP-LAN, and EVP-LAN services. Only EPL service is addressed in this version of the specification.

This figure shows the type of EVC used by each service. It also shows that in EVPL, EVP-Tree, and EVP-LAN services multiplexing is supported in one or more UNIs in the EVC.

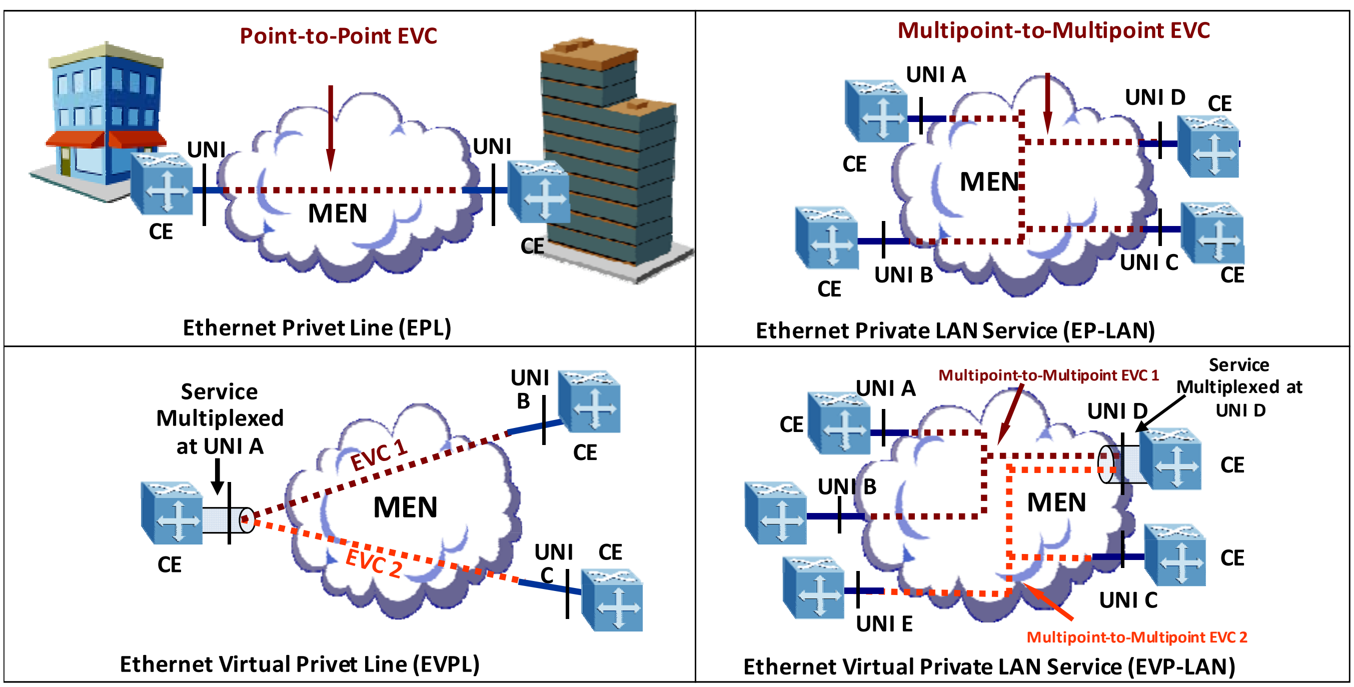

Figure 7 - MEF Ethernet Basic Services and Corresponding EVC [MEF]

II.3 Ethernet Service OAM

Ethernet Service OAM enables fault and performance management of Ethernet services from end to end. Ethernet service OAM protocols are standardized in [Y.1731] and [802.1ag].

The [Y.1731] scope is Ethernet OAM Fault and Performance Management in Carrier Ethernet Networks. The [802.1ag] scope is Connectivity Fault Management in Carrier Ethernet Networks, which includes proactive connectivity monitoring, fault verification, and fault isolation.

Appendix III Overview of DOCSIS L2VPN (Informative)

This is an informative section. The information in this section is based on [L2VPN] specifications. Any *"MUST"* or *"SHOULD"* requirements in this section are DOCSIS L2VPN requirements, NOT DPoE requirements.

[L2VPN] allows cable operators to offer Layer 2 Transparent LAN Service (TLS) to business and commercial enterprises, Multiple ISP L2VPNs, and Management L2VPNs that are used solely for the provisioning and management of the eCM and eSAFEs devices to isolate these devices from the Internet and from the subscriber, thus enhancing security.

[L2VPN] specifies the configuration of L2VPN forwarding within a single CMTS between CM or Service Flow and the NSI interface. The [L2VPN] specification does not fully specify the layer 2 forwarding of Ethernet frames between CMTSs.

Although [L2VPN] describes more than one type of encapsulation that CMTS can use to encapsulate customer L2VPN traffic on a single selected NSI port, it only requires implementing NSI Encapsulation format that uses [802.1q] tagging.

CM can use upstream classifiers to classify traffic into L2VPN upstream service flows. For example, the CM may classify upstream CPE packets to a particular service flow, based on the priority bits of the CPE-applied tag.

Downstream traffic classification is performed according to section 6.8 of [L2VPN]:

> *"In the downstream direction, the IEEE 802.1p/Q Packet Classification Encoding criteria of [DOCSIS RFI], apply only to any inner, non-service delimiting tag in the packet as it appears on the RF interface. Note that CMTSs are not required to implement these layer 2 criteria in the downstream direction. What is usually desired, however, is to classify downstream traffic according to the priority or VLAN ID of the outer, service delimiting tag as the packet appeared on the NSI interface. This specification defines Downstream Classifier L2VPN Encodings to permit classification based on the packet's VPNID and user priority as signaled in its NSI encapsulation."*

CMTS can select one of two modes to forward L2VPN traffic between NSI and CM or Service Flow:

- Point-to-Point Forwarding Mode
- Multipoint Forwarding Mode

In Point-to-Point L2VPN Forwarding Mode, each CM or Service Flow has a different NSI Encapsulation value. For example, when NSI encapsulation format uses [802.1q] tagging, each CM or Service Flow is configured with a different [802.1q] VLAN ID. In Point-to-Point mode, CMTS simply forwards upstream and downstream data between one NSI port and a CM or Service Flow using NSI Encapsulation value without learning the MAC addresses of the CPEs attached to the CM.

Figure 8 below, taken from [L2VPN], shows point-to-point forwarding mode for two L2VPNs that use [802.1q] NSI encapsulation with two different VLAN tags. In this example, L2VPN A uses VLANID 17 and 18, and L2VPN B uses VLANID 19 and 20. CMTS uses the VLANID in the L2VPN downstream traffic to forward it to the correct CM.

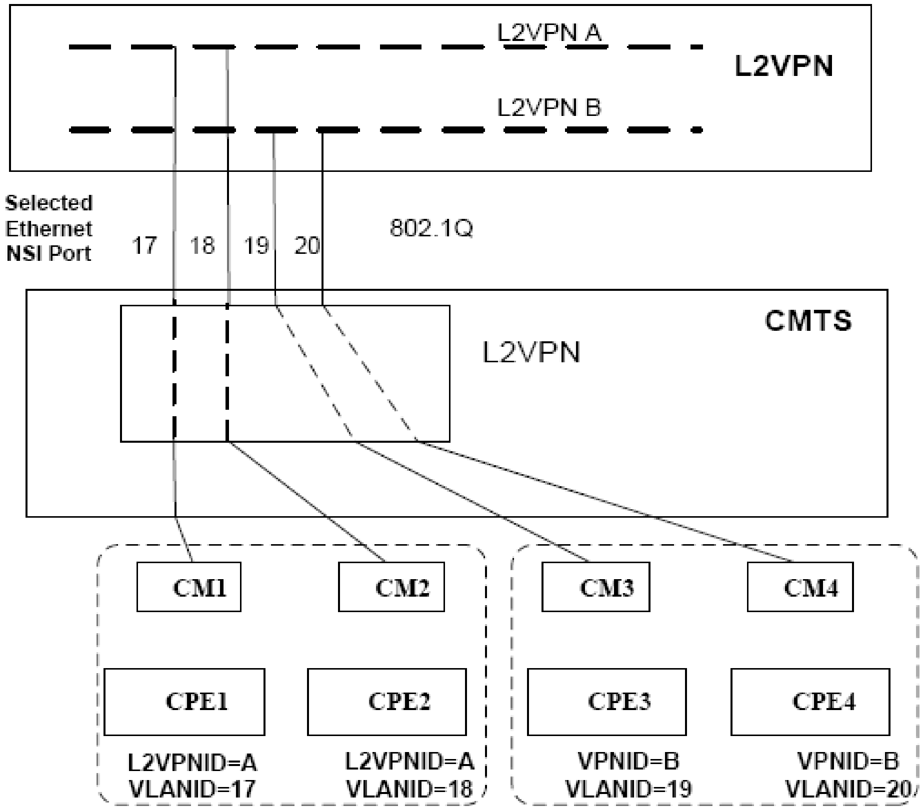

Figure 8 - Point-to-Point Forwarding [L2VPN]

In Multipoint Forwarding Mode, CMTS learns the MAC addresses of the CPEs attached to the CM from the L2VPN upstream flows, and when a L2VPN downstream unicast packet arrives at the CMTS, it looks up the Destination MAC (DMAC) in its learning database and forwards the packet to the correct CM or Service Flow.

Figure 9 below, taken from [L2VPN], shows an example of two DOCSIS-based commercial TLS services that are offered to two different customers. These services are deployed across multiple CMTSs. The first TLS service uses L2VPN 17 and the second TLS service uses L2VPN 18. The cable operator's backbone implements [802.1q] tagging encapsulation format on NSI, and uses a different Service Provider VLAN (S-VLAN) for each L2VPN. In this example, L2VPN 17 uses S-VLAN 17, and L2VPN 18 uses S-VLAN 18.

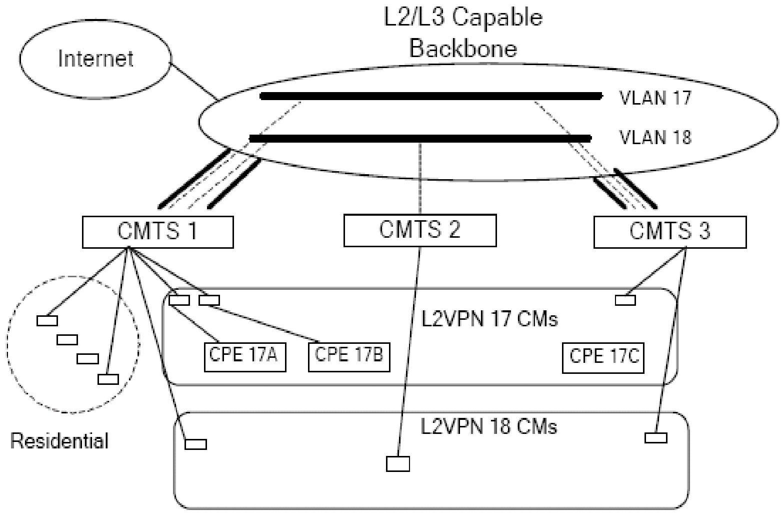

Figure 9 - Point-to-Point and Multipoint for the Same Layer 2 VPN [L2VPN]

In this example, L2VPN 17 is used to provide Multipoint-to-Multipoint TLS service to one of the commercial customers where CMTS 1 implements Point-to-Multipoint L2 Forwarding and CMTS 3 implements Point-to-Point L2 Forwarding.

CMTS may select one forwarding mode for all L2VPNs, or it may implement different forwarding modes for different sets of L2VPNs.

In Point-to-Point forwarding mode, CMTS does not learn CPE MAC address. If CPE MAC address learning is enabled in the Point-to-Point topology, L2VPN will use Multipoint forwarding mode.

In both forwarding modes, CMTS does not change C-VLAN Tag (i.e., Customer VLAN ID or [802.1p] priority) in the L2VPN upstream or downstream flows. In addition, [L2VPN] does not allow overwriting IP TOS in upstream forwarded traffic.

III.1 DOCSIS L2VPN QoS

[L2VPN] allows configuration of the [802.1p] priority of S-VLAN tag of the upstream flows (default [802.1p] priority of S-VLAN tag is 0).

[MULPIv3.0] defines rate limiting (shaping) algorithm for both upstream and downstream service flows. Two token buckets can be used. The first token bucket has fill rate of Maximum Sustained Traffic Rate (MSR) R, and token bucket size B equal to Maximum Traffic Burst. B cannot be less than 1522, and its default value is 3044 bytes. The 2^{nd} token bucket has fill rate of Peak Traffic Rate (PR) P and token bucket size of 1522 bytes. P in general should be >= R, but it can be less than R based on specific vendor operation.

Configuring this peak rate parameter permits an operator to define a Maximum Traffic Burst value for the Maximum Sustained Traffic Rate much larger than a maximum packet size.

If the upstream traffic burst is larger than the Maximum Burst Size of the token bucket being used, the CM will buffer out-of-profile frames to "rate shape" them. Buffer size depends on vendor implementation.

CMTSs also "rate shape" out-of-profile traffic for downstream service flows. If both token buckets are configured, CMTS limits the bytes forwarded in any interval T to the lesser of Max(T) and Peak(T) where:

$$Max(T) = T*(R/8) + B \text{ and } Peak(T) <= T*(P/8) + 1522.$$

DOCSIS single-rate or two-rate traffic shaping algorithm is color blind and does not change the color of the output frames.

The specific algorithm to enforce MSR, with or without concurrently enforcing PR, is not mandated by the [MULPIv3.0] specification. CMTS may enforce Peak Rate by any one of the following methods:

- Discarding over-limit requests.
- Deferring the grant until conforming to the allowed limit, or
- Discarding over-limit data packets.

DOCSIS allows the configuration of Minimum Reserved Traffic Rate (MRR). DOCSIS does not define a token bucket to enforce Minimum Reserved Traffic Rate, nor does it preclude using one either. The default value for MRR is 0. The aggregate Minimum Reserved Traffic Rate of all Service Flows could exceed the amount of available bandwidth to support oversubscription. If the requested bandwidth of a service flow is less than the configured MRR, CMTS MAY allocate the excess bandwidth to other service flows.

How MRR is used in CMTS Call Admission Control (CAC) algorithm is vendor-specific and is not mandated by [MULPIv3.0].

Upstream flows have scheduling type parameter, defined in TLV 24.15, which can be Best Effort, Non-Real-Time Polling Service (nrtPS), Real-time polling service (rtPS), Unsolicited Grant Service with Activity Detection (UGS-AD), or Unsolicited Grant Service (UGS). Downstream flows are not configured with scheduling type, but they can be configured with Maximum Downstream Latency, which specifies the maximum desired latency in microseconds across the DOCSIS network. This parameter is configured using TLV 25.14.

It is worth noting that Minimum Reserved Traffic Rate is used by DOCSIS CIR service with either best effort or nrtPS scheduling type.

Each service flow has Traffic Priority that *SHOULD* be used by CMTS to provide differentiated services to serve flows.

Appendix IV Provider Bridging (Informative)

As shown in Figure 10 below in Provider Bridged Network (PBN), S-VLAN Tag is added to customer frames by Provider Bridges connected to customer equipment. S-VLAN ID in the S-VLAN tag is used to identify the carrier Ethernet service instance of the frame in the PBN.

Although this figure shows an example where customer frames have C-VLAN Tag, PB can add S-VLAN tag to untagged or priority-tagged customer frames.

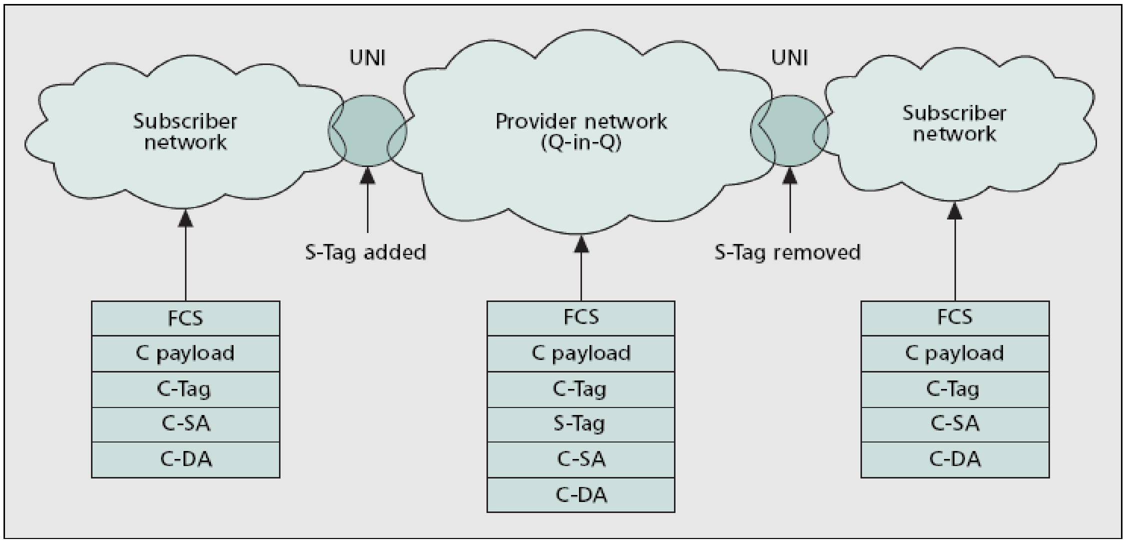

Figure 10 - Provider Bridge S-VLAN Tagging Support in Provider Bridged Network [IEEE-Comm-CE-Dev]

As shown in Figure 11 below, [802.1ad] PB has S-VLAN Component, which supports [802.1q] - Clause 5. S-VLAN Component can add S-VLAN Tag with TPID 0x88a8 and switch traffic based on S-VLAN and destination customer MAC address.

[802.1ad] PEB in Figure 11 is a PB that has one or more C-VLAN Components, which optionally can add C-VLAN Tag to the received untagged and priority tagged customer frames. C-VLAN Tag is a standard [802.1q] tag, which uses TPID 0x8100. [802.1ad] PEB provides a Registration Table that maps C-VLAN ID to S-VLAN ID.

As shown in Figure 11, PB can exist in the core of the Provider Bridged Network, in which case PB switches traffic without adding or removing any S-VLAN tags.

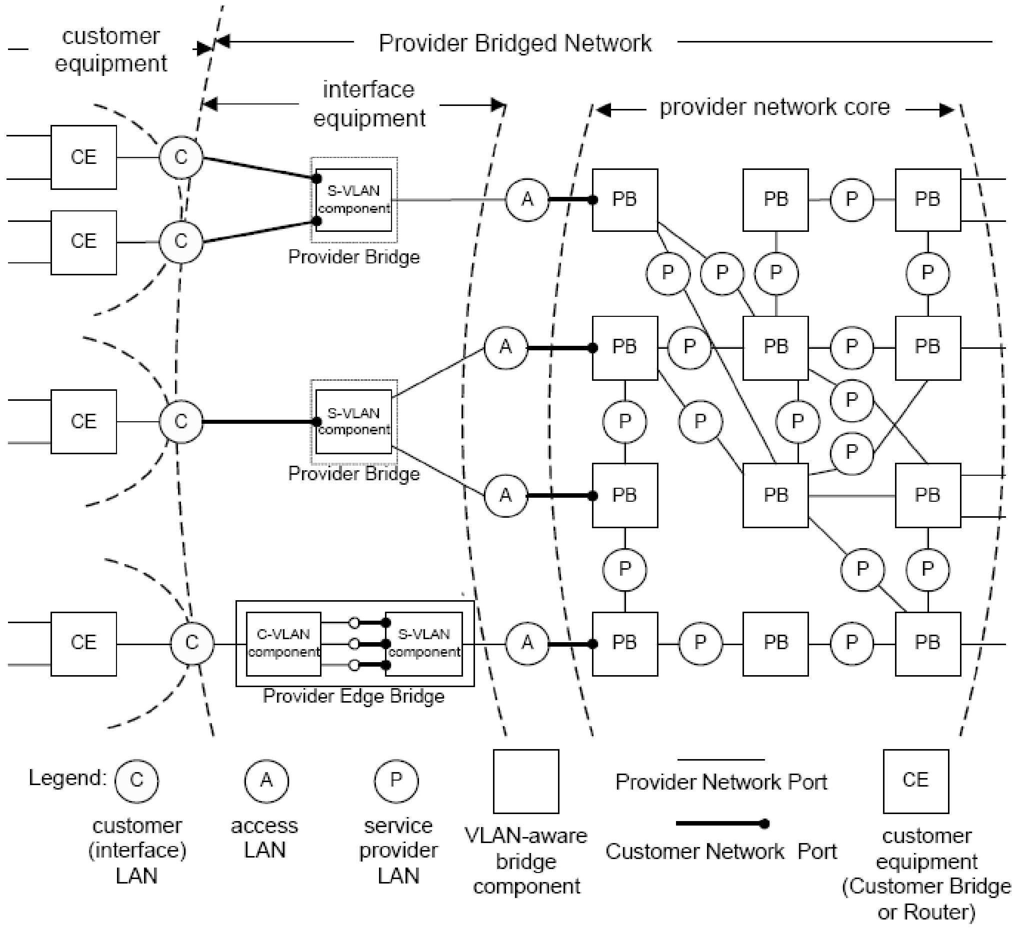

Figure 11 - Provider Bridged Network with Interface Examples - Figure 16-1 in [802.1ad]

Appendix V Provider Backbone Bridging (Informative)

PBBNs are built using PBBs, which are specified in [802.1ah]. Each PBBN may connect many PBNs, creating a hierarchy of provider networks where PBNs are the access networks to the core PBBN. The core PBBN can be connected to a Peer PBBN or serve as access network to other PBBNs to further extend the hierarchy.

[802.1ah] provides scalability in two areas:

- Support large number of service instances by interconnecting many PBNs.
- Hide Customer MAC addresses so that bridges in the PBBN core do not need to learn customer MAC addresses.

PBBs can be a BEB or BCB. BEB exists at the edge of the PBBN and can be connected to customer systems or Provider Bridges.

[802.1ah] classifies BEB into three types: I-BEB, B-BEB, or IB-BEB, which combines the functions of I-BEB and B-BEB. I-BEB has one or more I-Component. I-Component adds the following [802.1ah] encapsulation:

- [802.1ah] 48-bit I-Tag, which includes 24-bit I-SID (Backbone Service Identifier) that identifies the service instance of the frame in the PBBN. I-Tag uses TPID 0x88e7. I-Tag format as described in Figure 9-3 of Clause 9.8 of [802.1ah].
- MAC-in-MAC (M-in-M) Encapsulation, which encapsulates the I-tagged frame into Provider Backbone MAC frame with the source MAC Address B-SA and destination MAC address B-DA, are set as follows:
  - B-SA is the MAC address of the source BEB.
  - B-DA is the MAC address of the destination BEB, which should forward the frame to the UNI of the destination customer. I-BEB can learn B-DA for a given destination customer MAC address.

The B-BEB has B-Component that adds the B-VLAN Tag (B-Tag) to [802.1ah] frame with I-Tag and M-in-M encapsulation before sending the frame to the core of PBBN. B-Tag uses the same TPID as [802.1ad] Tag (i.e., it uses TPID 0x88a8).

Figure 12 below describes the frame format as different tagging and encapsulation are added to the frame by the same device or different devices. Although this figure shows the case where S-VLAN tag is added to [802.1q] tagged frame, S-VLAN tag can also be added to untagged [802.1d] customer frames. Similarly, [802.1ah] encapsulation may be added to customer-tagged or untagged frames, in which case [802.1ah] frame will not have S-VLAN tag.

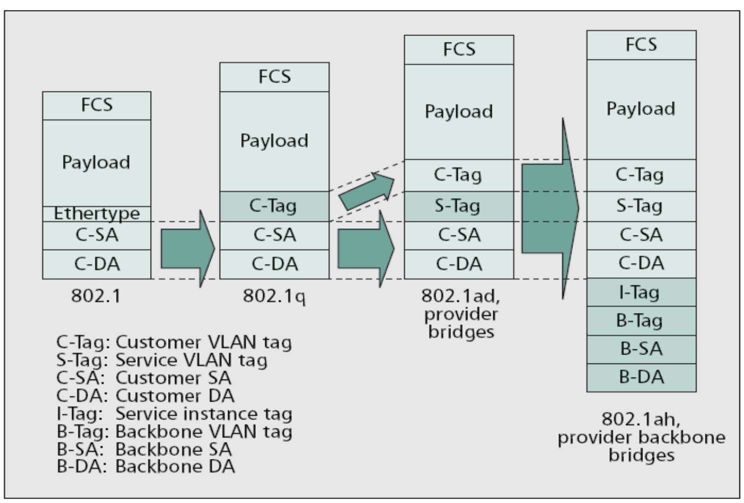

Figure 12 - [802.1ad] Provider Bridge Frame Formats [IEEE-Comm-CE-Dev]

Figure 13 below describes the bridge model of [802.1ah] IB-BEB and the format of the frame generated by each component of the bridge. Although this figure shows an example where the I-Component ingress frame has S-VLAN Tag, I-Component can be connected directly to customer systems, in which case it adds [802.1ah] encapsulation described above to customer-tagged, priority-tagged, or untagged customer frames.

In [802.1ah] one or more S-VLAN ID can map to the same I-SID.

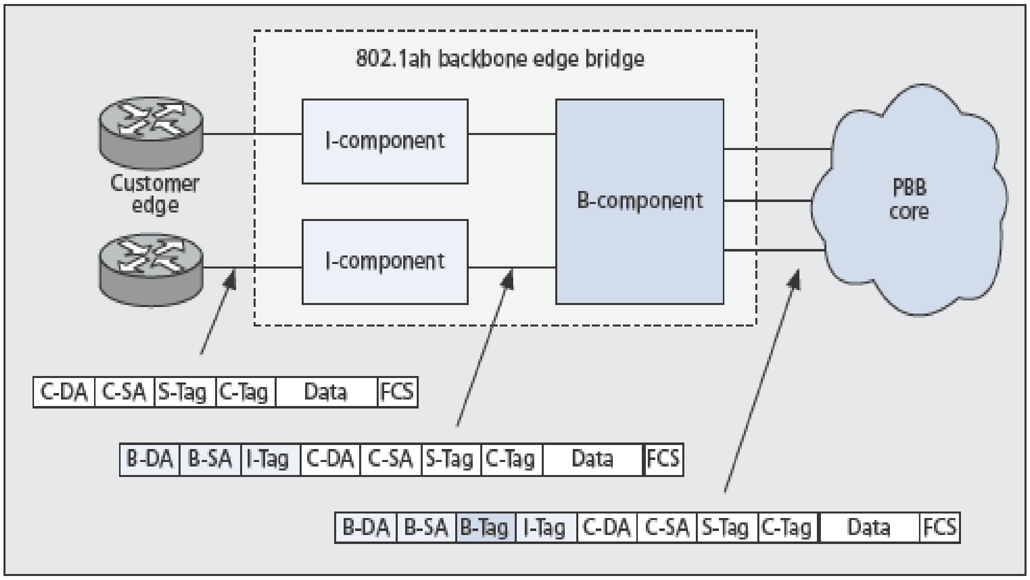

Figure 13 - [802.1ah] Provider Backbone Bridge Model [IEEE-Comm-PBB-MPLS]

BCB does not add any encapsulation. It bridges frames based on B-Tag and B-DA.

Figure 14 summarizes the functions of different types of PBBs and the tags and encapsulation they use.

BEB	Backbone edge bridge — encapsulates customer frames for transmission across a PBBN.
BCB	Backbone core bridge — bridges frames based on B-TAG and B-MAC information, similar to an 802.1ad bridge, in the PBBN core.
B-BEB	B type BEB — contains a B-component. It supports bridging in the provider backbone based on B-MAC and B-TAG information.
I-BEB	I type BEB — contains an I-component for bridging in the customer space based on customer MAC and service VLAN ID.
B-TAG	Backbone VLAN tag — has a similar format to an 802.1ad S-TAG.
I-TAG	Service Instance tag — encapsulates customer addresses and contains the Service iInstance identifier (I-SID).
I-SID	Service Instance identifier — A field of the Service Instance tag which identifies the service instance of the frame.
S-TAG	A field defined in the 802.1ad Q-in-Q encapsulation which identifies the Service VLAN (S-VLAN).

Figure 14 - PBB Tag Descriptions [IEEE-Comm-Evol]

PBBNs can be interconnected over MEF E-NNI interfaces as described in [802.1ah] clause 26.5. The interconnection of PBBNs can be classified into two types: hierarchal interconnect and peer interconnect.

V.1 Hierarchical PBBN Model

In this model, scaling the number of services is done by using Leveled Hierarchy, where PBBN at level N provides carrier Ethernet service to PBBN at level N-1. This is achieved by using PBBN at level N, the required encapsulation for frames in PBBN at level N-1, the same way PBBN at level 1 performs [802.1ah] encapsulation for PBN. Figure 15 describes an example of hierarchical PBBNs that support MAC-in-MAC-in-MAC.

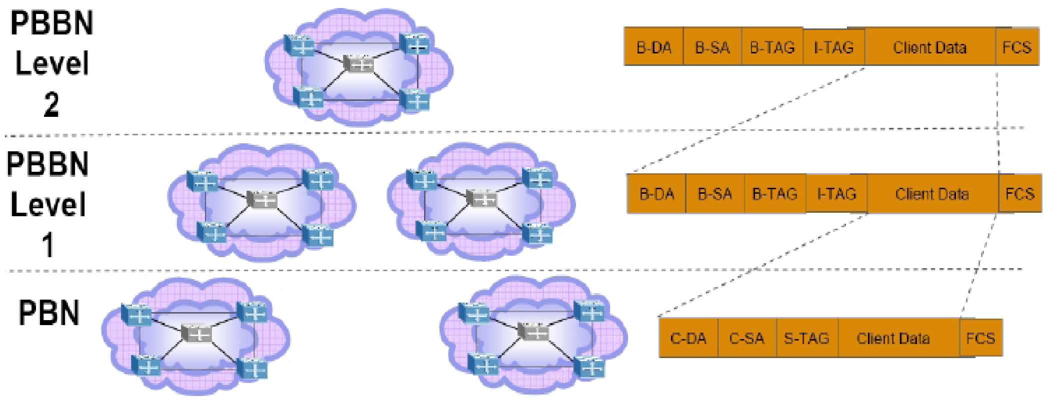

Figure 15 - Hierarchical PBB Model [IEEE-802.1-PBB-Models]

V.2 Peer PBBN Model

In this model, scaling the number of services is accomplished using Service Localization, and I-SID translation and filtering. Figure 16 describes Peer PBBNs.

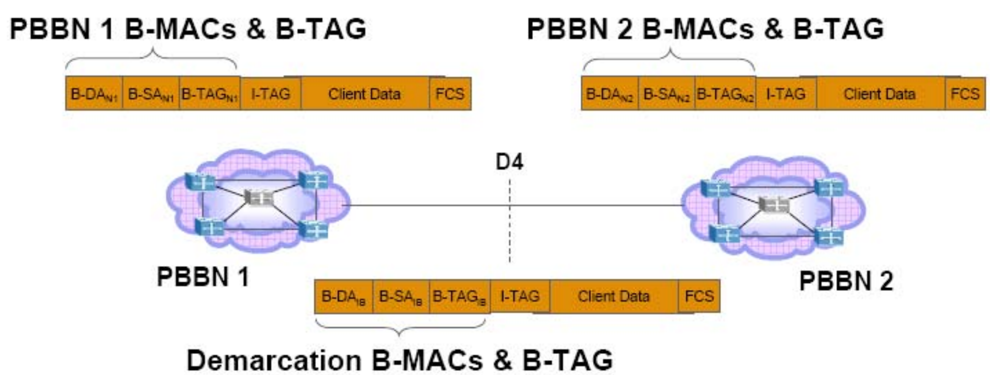

Figure 16 - Peer PBBNs [IEEE-802.1-PBB-Models]

Appendix VI Examples of EPL Service (Informative)[10]

This appendix provides four examples of EPL service configuration for configuration files based on [L2VPN] with extensions. These examples are informative and do not represent all of the possible Metro Ethernet service configurations that can be provisioned. The four examples are:

- EPL with DPoE Standalone ONU with [802.1ad] tagging
- EPL with DPoE Standalone ONU with [802.1ah] encapsulation
- EPL with DPoE Bridge ONU with transport mode
- EPL with DPoE Bridge ONU with [802.1ad] tagging and TPID translation

Each example includes a diagram and table with the values that would be configured to provide the service with the parameters required by the example. Some parameters are specific to the scenario, while other parameters are specific to the service configuration.

In all these examples, RTPS scheduling type is used for the upstream service flow of the EPL service instance. The Minimum Reserved Traffic Rate (TLV 24/25.10) and Maximum Sustained Traffic Rate (TLV 24/25.8) for each EPL service flow are configured with the value of CIR, which in these examples is 10Mbps. These examples use default Maximum Traffic Burst (TLV 24/25.9), which is 3200 bytes (these are the default values for 1G-EPON, which is used in these examples). A 5 msec Nominal Polling Interval (TLV 24.17) is used in these examples for upstream service flows.

VI.1 Example 1: EPL with DPoE Standalone ONU with [802.1ad] tagging

In this example, one EPL service EPL1 is provisioned to provide Ethernet Private Line service between subscribers connected to MEF UNI ONU1-MU1 and subscribers connected to MEF UNI ONU2-MU1. ONU1-MU1 is attached to DPoE Standalone ONU-1, and ONU2-MU1 is attached to DPoE Standalone ONU-2. Each DPoE Standalone ONU is connected to a different DPoE System. The DPoE Systems implemented for MEF are connected over MEN. Figure 17 below describes the network configuration for this example.

[10] Revised per MEFv1.0-N-12.0032-1 on 5/21/12 by JB.

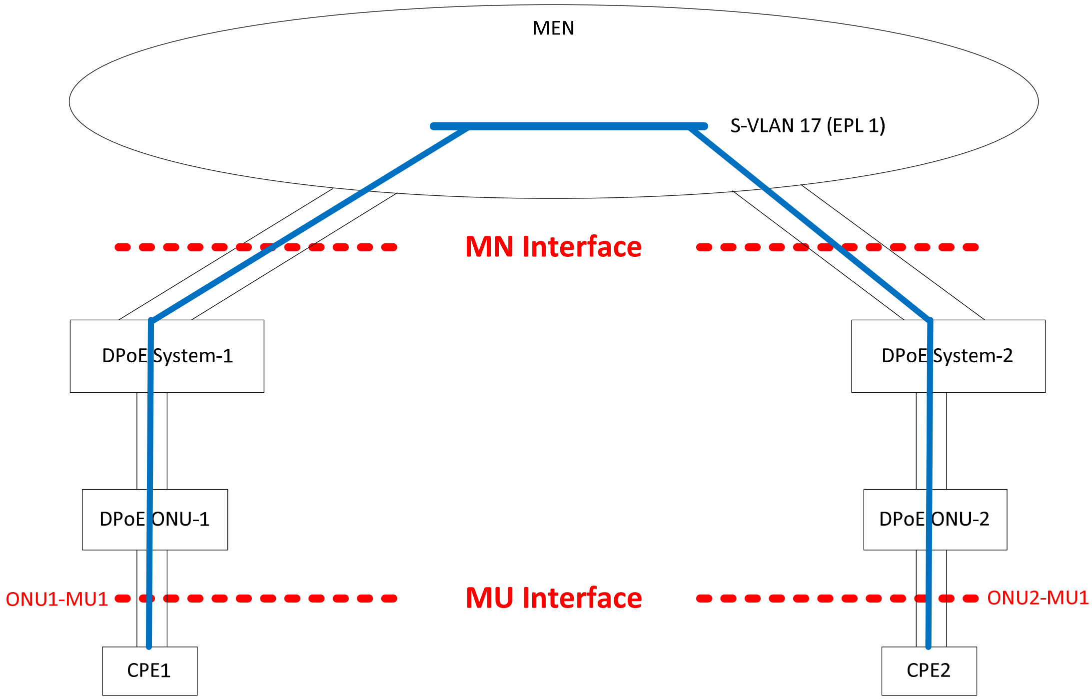

Figure 17 - Example 1 Network

Table 10 shows a subset of the DPoE Standalone ONU-1 configuration file that describes the [L2VPN] configuration for this example.

In this example, [802.1ad] S-VLAN tag is added to customer-tagged, untagged, and priority-tagged traffic received from ONU1-MU1, at or before the C_O Reference point. The TPID of the S-VLAN tag is 0x88a8, and the S-VLAN ID of the S-VLAN tag is 17. S-VLAN tag is provisioned using TLV 43.5.2.3, which uses NULL C-VLAN ID so that only [802.1ad] S-VLAN tag is added to customer frames.

DPoE System-1 classifies traffic received from MN interface with TPID 0x88a8 and S-VLAN ID 17 into EPL1 downstream Service Flow. DPoE System-1 uses S-VLAN ID 17 to forward traffic of the downstream service flow to DPoE Standalone ONU-1 using [L2VPN] Point-to-Point Forwarding Mode. S-VLAN tag is removed at or after C_O Reference point.

Table 10 - Example 1 Configuration File

EPL with DPoE Standalone ONU with [802.1ad] tagging				
43				Per-CM L2VPN Encoding
28				Overall length
	08 03 FFFFFF			Vendor ID : 0xFFFFFF for GEI
	05			GEI 43.5 for L2VPN Encoding
	21			Length of GEI.5 Subtype
		01 05 EPL1		VPNID Subtype
		04 04 0x40		CMIM
		02		NSI Encapsulation subtype
		06		Length of GE1.5 Subtype
			03	[802.1ad]
			4	Length
			0x0011	Vlan -1
			0x0000	Vlan-2

EPL with DPoE Standalone ONU with [802.1ad] tagging				
24				Upstream Service Flow Encoding
44				Length
	06 01 07			QOS Param Set Type Subtype
	10 04 10000000			Min Reserved rate
	08 04 10000000			Max Rate Sustained
	15 01 04			Scheduling Type
	17 04 5000			Nominal Polling interval
	01 02 0001			Service Flow Reference 0001
	43			Vendor-Specific Subtype:
	14			Overall length
		08 03 FFFFFF		Vendor ID for GEI
		05		GEI 43.5 for L2VPN Encoding
		7		Length of GEI.5 Subtype
			01 05 EPL1	VPNID Subtype
25				Downstream Service Flow Encoding
19				Length
	06 01 07			QOS Param set
	01 02 0001			Service Flow Reference 001
	10 04 10000000			Min Reserved rate
	08 04 10000000			Maximum Sustained Rate
23				Downstream Classifier
13				Length
	03 02 0001			Service Reference number
	01 01 01			Classifier Reference
	14			[802.1ad] Packet Classification
	4			Length
		2 2 0x0011		SVLAN

VI.2 Example 2: EPL with DPoE Standalone ONU with [802.1ah] encapsulation

This example is similar to example 1, except that [802.1ah] encapsulation instead of [802.1ad] tagging is used to transport customer frames over MN interface to the PBBN. Figure 18 below describes the network configuration for this example.

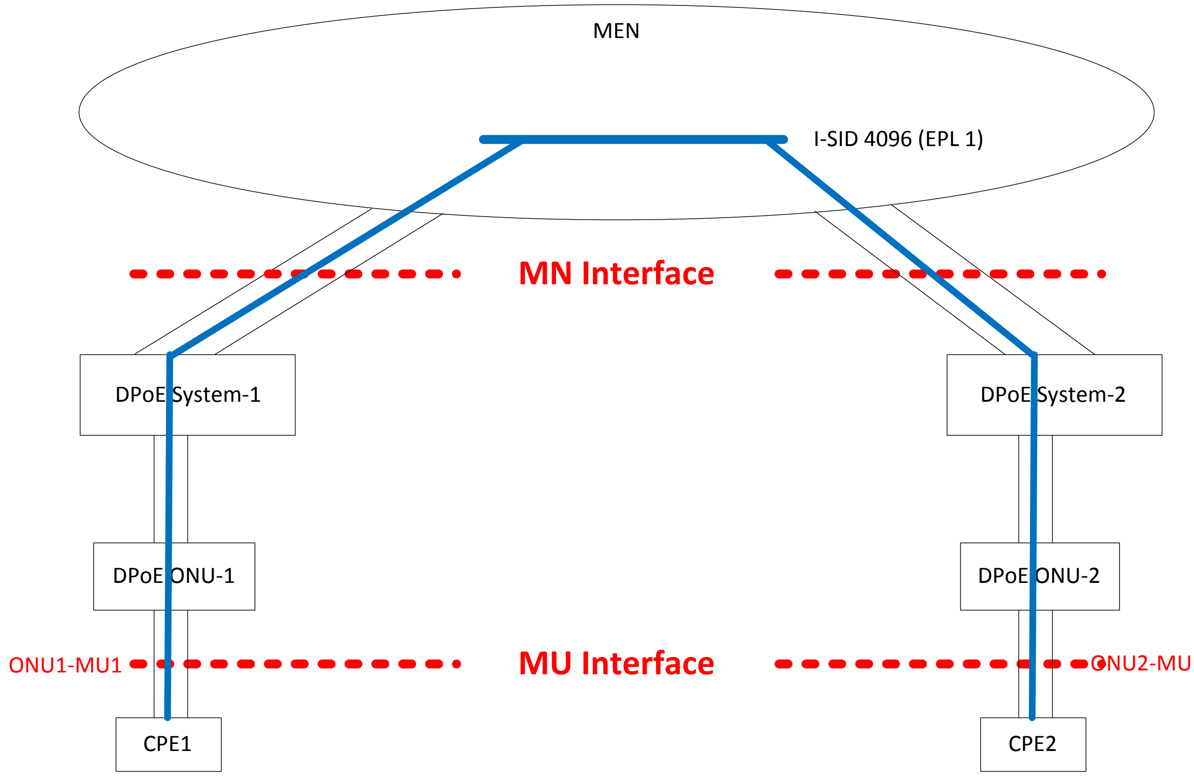

Figure 18 - Example 2 Network

Table 11 shows a subset of the DPoE Standalone ONU-1 configuration file that describes the [L2VPN] configuration for this example.

In this example, [802.1ah] encapsulation is added to customer-tagged, untagged, and priority-tagged traffic received from ONU1-MU1, at or before the C_O Reference point. [802.1ah] encapsulation includes:

- 48-bit I-Tag, which uses default TPID 0x88e7 and 24-bit I-SID. The I-SID is provisioned using TLV 43.5.2.6.1. I-SID used in this example is 0x1000 (4096).
- MAC Address of the destination B-DA, which is provisioned using TLV 43.5.2.6.2.
- MAC address of the egress MN interface.

DPoE System-1 classifies traffic received from MN interface with TPID 0x88e7 and I-SID 0x1000 into EPL1 downstream Service Flow. DPoE System-1 uses I-SID 0x1000 and B-DA to forward traffic of the downstream service flow to DPoE Standalone ONU-1 using [L2VPN] Point-to-Point Forwarding Mode. [802.1ah] encapsulation is removed at or after C_O Reference point.

Table 11 - Example 2 Configuration File

DPoE Standalone ONU with [802.1ah] encapsulation				
43				Per-CM L2VPN Encoding
37				Overall length
	08 03 FFFFFF			Vendor ID : 0xFFFFFF for GEI
	05			GEI 43.5 for L2VPN Encoding
	30			Length of GEI.5 Subtype
		01 05 EPL1		VPNID Subtype
		04 04 0x40		CMIM

DPoE Standalone ONU with [802.1ah] encapsulation				
		02		NSI Encapsulation subtype
		15		Length of GE1.5 Subtype
		06		[802.1ah] encapsulation
			01 04 0x1000	I-Tag
			02 06 0x00005e010203	Destination Mac (B-DA)
24				Upstream Service Flow Encoding
44				Length
	06 01 07			QOS Param Set Type Subtype
	10 04 10000000			Min Reserved rate
	08 04 10000000			Max Rate Sustained
	15 01 04			Scheduling Type
	17 04 5000			Nominal Polling interval
	01 02 0001			Service Flow Reference 0001
	43			Vendor-Specific Subtype:
	14			Overall length
		08 03 FFFFFF		Vendor ID for GEI
		05		GEI 43.5 for L2VPN Encoding
		7		Length of GEI.5 Subtype
			01 05 EPL1	VPNID Subtype
25				Downstream Service Flow Encoding
19				Length
		06 01 07		QOS Param set
		01 02 0001		Service Flow Reference 001
		10 04 10000000		Min Reserved rate
		08 04 10000000		Maximum Sustained Rate
23				Downstream Classifier
14				Length
	03 02 0001			Service Reference Number
	01 01 01			Classifier Reference Number
	15			[802.1ah] packet Classifier
	5			Length
		02 03 0x1000		I-SID

VI.3 Example 3: EPL with DPoE Bridge ONU with transport mode

In this example, one EPL service EPL1 is provisioned to provide EPL service between subscribers connected to MEF UNI D1-MU1 and subscribers connected to MEF UNI D2-MU1. D1-MU1 is attached to a DEMARC device, DEMARC-1, which is connected to DPoE Bridge ONU-1 using ONU1-MI1. D2-MU1 is attached to a DEMARC device DEMARC-2, which is connected to DPoE Bridge ONU-2 using ONU2-MI1. ONU1-MI1 and ONU2-MI1 are operating in Transport Mode. Each DEMARC device adds S-VLAN tag to EPL1 traffic. The S-VLAN tag uses TPID 0x88a8 and S-VLAN ID 17. Each DPoE Bridge ONU is connected to a different DPoE System. DPoE Systems implemented for MEF are connected over a MEN. Figure 19 below demonstrates the network configuration for this example.

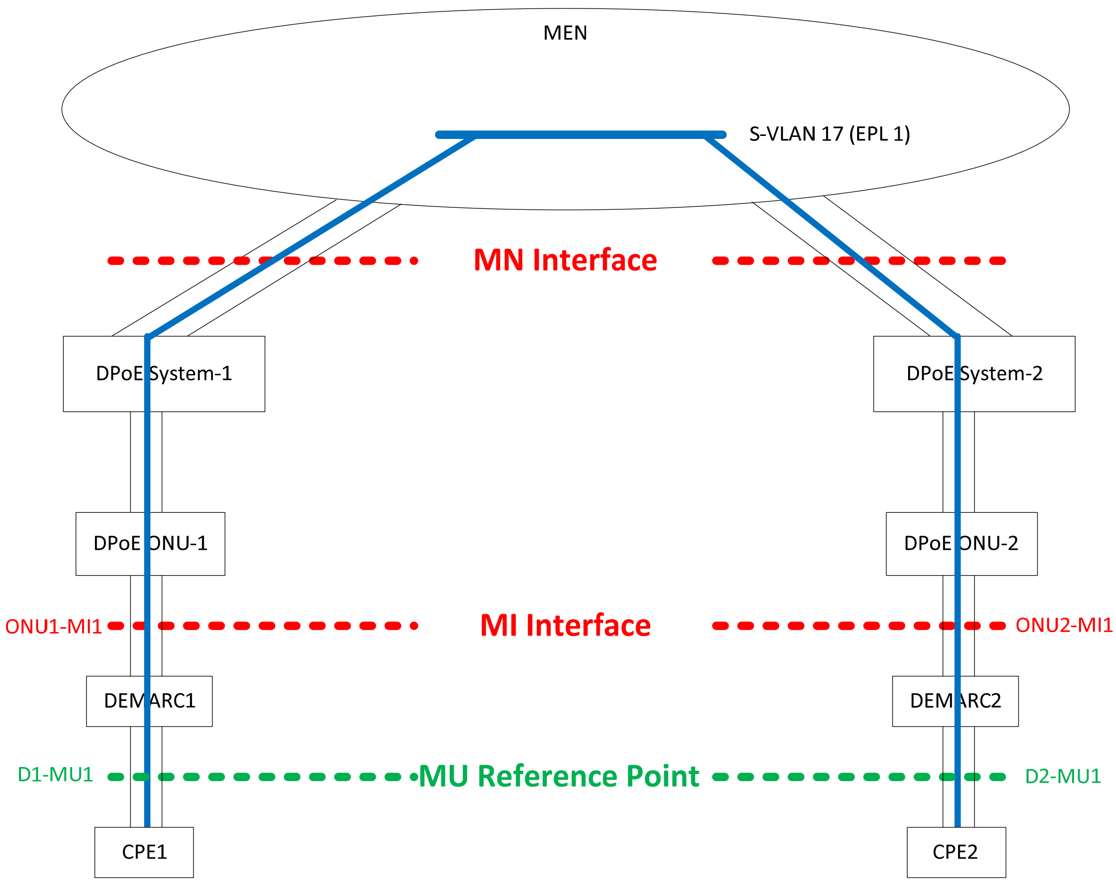

Figure 19 - Example 3 Network

Table 12 shows a subset of the DPoE Bridge ONU-1 configuration file that describes the [L2VPN] configuration for this example.

In this example, DPoE Bridge ONU-1 classifies traffic received from ONU1-MI1 with S-VLAN tag that uses TPID 0x88a8 and S-VLAN ID 17 into EPL1 upstream service flow. This traffic should be transported over the MN interface without adding or removing any tags. Similarly, DPoE System-1 classifies traffic received from the MN interface with TPID 0x88a8 and S-VLAN ID 17 into EPL1 downstream Service Flow. This traffic should be sent to ONU1-MI1 without adding or removing any tags.

Transporting frames in both downstream and upstream directions without adding or removing any tags can be achieved by configuring L2VPN Transport Mode using TLV 43.5.13.

DPoE System-1 uses S-VLAN ID 17 to forward traffic of the downstream service flow to DPoE Bridge ONU-1 using [L2VPN] Point-to-Point Forwarding Mode.

Table 12 - Example 3 Configuration File

EPL with DPoE Bridge ONU with transport mode				
43				Per-CM L2VPN Encoding
23				Overall length
	08 03FFFFFF			Vendor ID : 0xFFFFFF for GEI
	05			GEI 43.5 for L2VPN Encoding
	16			Length of GEI.5 Subtype
		01 05 EPL1		VPNID Subtype
		04 04 0x40		CMIM
		13 01 01		Transport Mode
24				Upstream Service Flow Encoding
44				Length
	06 01 07			QOS Param Set Type Subtype
	10 04 10000000			Min Reserved rate
	08 04 10000000			Max Rate Sustained
	15 01 04			Scheduling Type
	17 04 5000			Nominal Polling interval
	01 02 0001			Service Flow Reference 0001
	43			Vendor-Specific Subtype:
	14			Overall length
		08 03 FFFFFF		Vendor ID for GEI
		05		GEI 43.5 for L2VPN Encoding
		7		Length of GEI.5 Subtype
			01 05 EPL1	VPNID Subtype
25				Downstream Service Flow Encoding
19				Length
	06 01 07			QOS Param set
	01 02 0001			Service Flow Reference 001
	10 04 10000000			Min Reserved rate
	08 04 10000000			Maximum Sustained Rate
22				Upstream Classifier Encoding
13				Length
	03 02 0001			Service Flow Reference to 0001
	01 01 01			Classifier Reference
	14			[802.1ad] packet classification
	4			Length
		02 02 0x0011		SVLAN
23				Downstream Classifier
13				Length
	03 02 0001			Service Reference Number
	01 01 02			Classifier Reference
	14			[802.1ad] packet Classification
	4			Length
		2 2 0x0011		SVLAN

VI.4 Example 4: EPL with DPoE Bridge ONU with [802.1ad] tagging and TPID translation

This example is similar to Example 1, except that DPoE Bridge ONU is used and the [802.1ad] TPID of the S-VLAN tag is translated by the DPoE System to the [802.1q] TPID 0x8100 before the frame is transmitted on the MN interface. That is, the resulting upstream traffic at MN interface will be [802.1q] tagged. Although [802.1q] S-VLAN tagging is not explicitly supported in this version of the specification, this example shows that using TPID translation [802.1q] S-VLAN tagging can be supported. Figure 20 shows the network configuration used in this example.

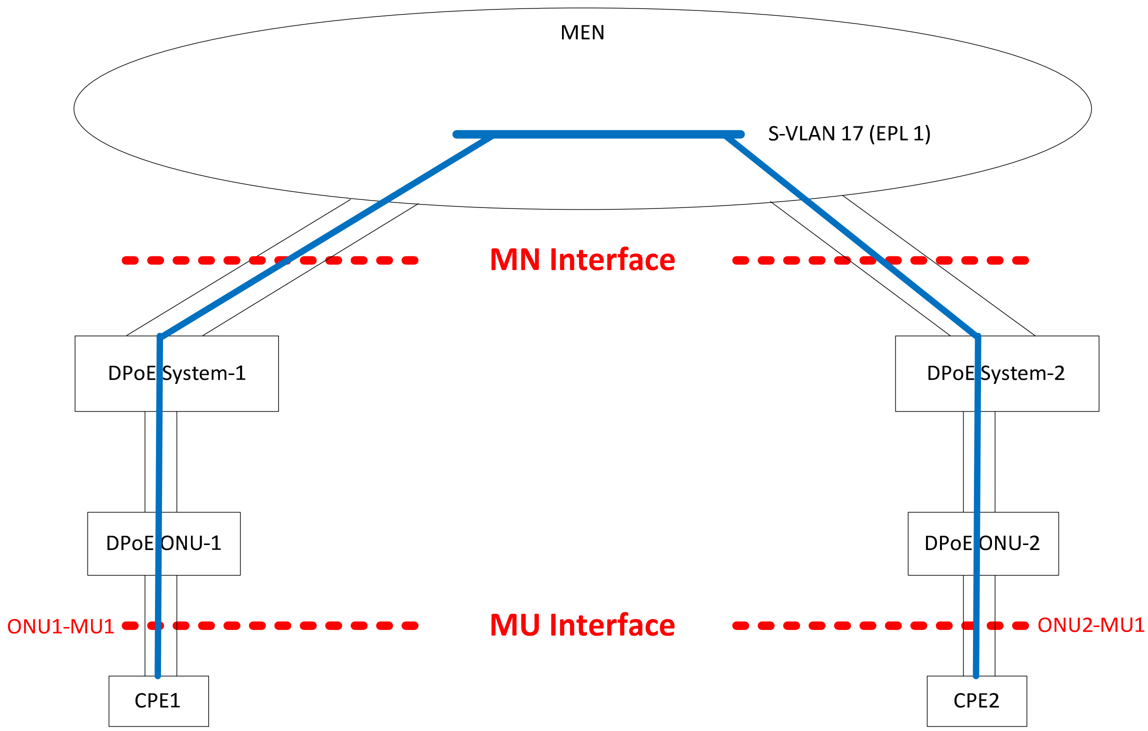

Figure 20 - Example 4 Network

Table 13 shows a subset of the DPoE Bridge ONU-1 configuration file that describes the [L2VPN] configuration for this example.

In this example, [802.1ad] S-VLAN tag is added to customer-tagged, untagged, and priority-tagged traffic received from ONU1-MU1, at or before the Co Reference point. The TPID of the S-VLAN tag is 0x88a8 and the S-VLAN ID of the S-VLAN tag is 17. The S-VLAN tag is provisioned using TLV 43.5.2.3, which uses NULL C-VLAN ID so that only the [802.1ad] S-VLAN tag is added to customer frames. DPoE System-1 translates the TPID of the S-VLAN tag to [802.1q] TPID 0x8100 before the frame is transmitted on the MN interface. TLV 43.5.14.1 is used for TPID translation in the upstream direction.

DPoE System-1 classifies traffic received from MN interface with TPID 0x8100 and S-VLAN ID 17 into EPL1 downstream Service Flow. DPoE System-1 uses S-VLAN ID 17 to forward traffic of the downstream service flow to DPoE Bridge ONU-1 using [L2VPN] Point-to-Point Forwarding Mode. Since S-VLAN tag is removed at or after Co Reference point, there is no need for TPID translation in the downstream direction.

Table 13 - Example 4 Configuration File

DPoE Bridge ONU with [802.1ad] tagging and TPID translation				
43				Per-CM L2VPN Encoding
34				Overall length

DPoE Bridge ONU with [802.1ad] tagging and TPID translation				
	08 03 FFFFFF			Vendor ID : 0xFFFFFF for GEI
	05			GEI 43.5 for L2VPN Encoding
	27			Length of GEI.5 Subtype
		01 05 EPL1		VPNID Subtype
		04 04 0x40		CMIM
		02		NSI Encapsulation subtype
		06		Length of GE1.5 Subtype
		03		[802.1ad] encapsulation
			4	Length
			0x0011	Vlan-1
			0x0000	Vlan -2
		14		TPID Translation
		04		Length
			1 2 0x8100	Upstream TPID
24				Upstream Service Flow Encoding
44				Length
	06 01 07			QOS Param Set Type Subtype
	10 04 10000000			Min Reserved rate
	08 04 10000000			Max Rate Sustained
	15 01 04			Scheduling Type
	17 04 5000			Nominal Polling interval
	01 02 0001			Service Flow Reference 0001
	43			Vendor-Specific Subtype:
	14			Overall length
		08 03 FFFFFF		Vendor ID for GEI
		05		GEI 43.5 for L2VPN Encoding
		7		Length of GEI.5 Subtype
			01 05 EPL1	VPNID Subtype
25				Downstream Service Flow Encoding
19				Length
	06 01 07			QOS Param set
	01 02 0001			Service Flow Reference 001
	10 04 10000000			Min Reserved rate
	08 04 10000000			Maximum Sustained Rate
23				Downstream Classifier
17				Length
	03 02 0001			Service Reference Number
	01 01 01			Classifier Reference
	14			
	8			Length
		1 2 0x8100		[802.1ad] TPID
		02 02 0x0011		[802.1ad] VLAN

Appendix VII Acknowledgments

On behalf of our industry, we would like to thank the following individuals for their contributions to the development of this specification.

Contributor	Company Affiliation
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Appendix VIII Revision History

VIII.1 Engineering Changes for DPoE-SP-MEFv1.0-I02-120607

The following Engineering Changes were incorporated into DPoE-SP-MEFv1.0-I02-120607:

ECN	Date Accepted	Summary
MEFv1.0-12.0013-1	03/15/12	802.1ah forwarding
MEFv1.0-12.0032-1	05/10/12	Removal of Max Concatenated burst requirement as per MULPI

VIII.2 Engineering Change for DPoE-SP-MEFv1.0-I03-120830

The following Engineering Change was incorporated into DPoE-SP-MEFv1.0-I03-120830:

ECN	Date Accepted	Summary
MEFv1.0-12.0041-1	07/26/12	Relaxation of TPID Translation Requirements