Cable Data Services
DOCSIS® Provisioning of EPON Specifications

DPoE™ Physical Layer Specification

DPoE-SP-PHYv2.0-I02-130328

ISSUED

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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.

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Closed A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

Contents

Figures

Tables

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1 INTRODUCTION

DOCSIS Provisioning of EPON (DPoE) version 2.0 specifications are a joint effort of Cable Television Laboratories (CableLabs), cable operators, vendors, and suppliers to support EPON technology using existing DOCSIS-based back office systems and processes. DPoEv2.0 specifications augment the DPoE v1.0 specifications to provide requirements for additional service capabilities and corresponding provisioning and network management capabilities.

Ethernet PON (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.

DPoE specifications are focused on DOCSIS-based provisioning and operations of Internet Protocol (IP) using DOCSIS Internet service (which is typically referred to as High Speed Data (HSD)), or IP(HSD) for short, and Metro Ethernet services as described by Metro Ethernet Forum (MEF) standards. 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) together 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 available and is backwards compatible with 1G-EPON. A 1G-EPON network can be incrementally upgraded to 10G-EPON, adding or replacing ONUs as business needs require. 1G-EPON and 10G-EPON are compatible with [SCTE 174].

1G-EPON and 10G-EPON, originally defined in [802.3ah] and [802.3av] respectively, support a point-to-multipoint architecture with a centralized controller called an Optical Line Terminal (OLT) and distributed low cost Layer 2 ONUs. The basic service mapping architecture in EPON is to map Ethernet (or IP) frame header information (e.g., addresses, IP Differentiated Service Code Points, Ethernet Q tag, S-VLAN/C-VLAN ID, ISID, bridge address, etc.) to a logical circuit called a Logical Link Identifier (LLID) in [802.3ah]. The service mapping function in DPoE specifications is similar to that used in DOCSIS specifications. Both DOCSIS and DPoE networks rely on a centralized scheduler though EPON utilizes an LLID which functions like a SID in DOCSIS to support unicast, broadcast, and multicast.

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 across the DPoE Network. This is a well-recognized limitation of [802.3ah]. The challenge is that neither 1G-EPON nor 10G-EPON specify OAMP to configure the forwarding of traffic between Network to Network Interface (NNI) ports (I-NNI for MEF or NSI for L2VPN or IP(HSD)) 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 directly, 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 the ONU to forward traffic.

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 specification identifies requirements for the EPON PHY for the adaptation or additions to DOCSIS specifications that are required to support DOCSIS Provisioning of EPON.

This specification:

- Specifies interoperable implementations for various DPoE vendors; and
- Specifies additional requirements for EPON PHY layer as used in cable networks which are outside the scope of [802.3] specifications.

1.3 Goals

The DPoE PHY specification accomplishes the following objectives:

- Identify and document the requirements for Forward Error Correction.
- Define requirements for optical monitoring and power control.

This specification contains no additional normative requirements beyond the DPoE version 1.0 PHY specification.

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 DPoE Version 2.0 Specifications

A list of the specifications included in the DPoEv2.0 series is provided in Table 1. For further information please refer to http://www.cablelabs.com/dpoe/specifications.

Table 1 - DPoEv2.0 Series of Specifications

Designation	Title
DPoE-SP-ARCHv2.0	DPoE Architecture Specification
DPoE-SP-DEMARCv2.0	DPoE Demarcation Device Specification
DPoE-SP-OAMv2.0	DPoE OAM Extensions Specification
DPoE-SP-PHYv2.0	DPoE Physical Layer Specification
DPoE-SP-SECv2.0	DPoE Security and Certificate Specification
DPoE-SP-IPNEv2.0	DPoE IP Network Element Requirements
DPoE-SP-MULPIv2.0	DPoE MAC and Upper Layer Protocols Interface Specification
DPoE-SP-MEFv2.0	DPoE Metro Ethernet Forum Specification
DPoE-SP-OSSIv2.0	DPoE Operations and Support System Interface Specification
DPoE-SP-SOAMv2.0	DPoE Service-OAM Specification

1.6 Reference Architecture

The DPoE reference architecture shown in Figure 1 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 headend or hub site, and the DPoE ONU (D-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 the server elements have connectivity through an IP (TCP/IP) network. Transport of bearer traffic, and (in some cases) Layer 2 OAM Protocol Data Units (PDUs) are available through either IP or Layer 2 Ethernet-based Network Interfaces.

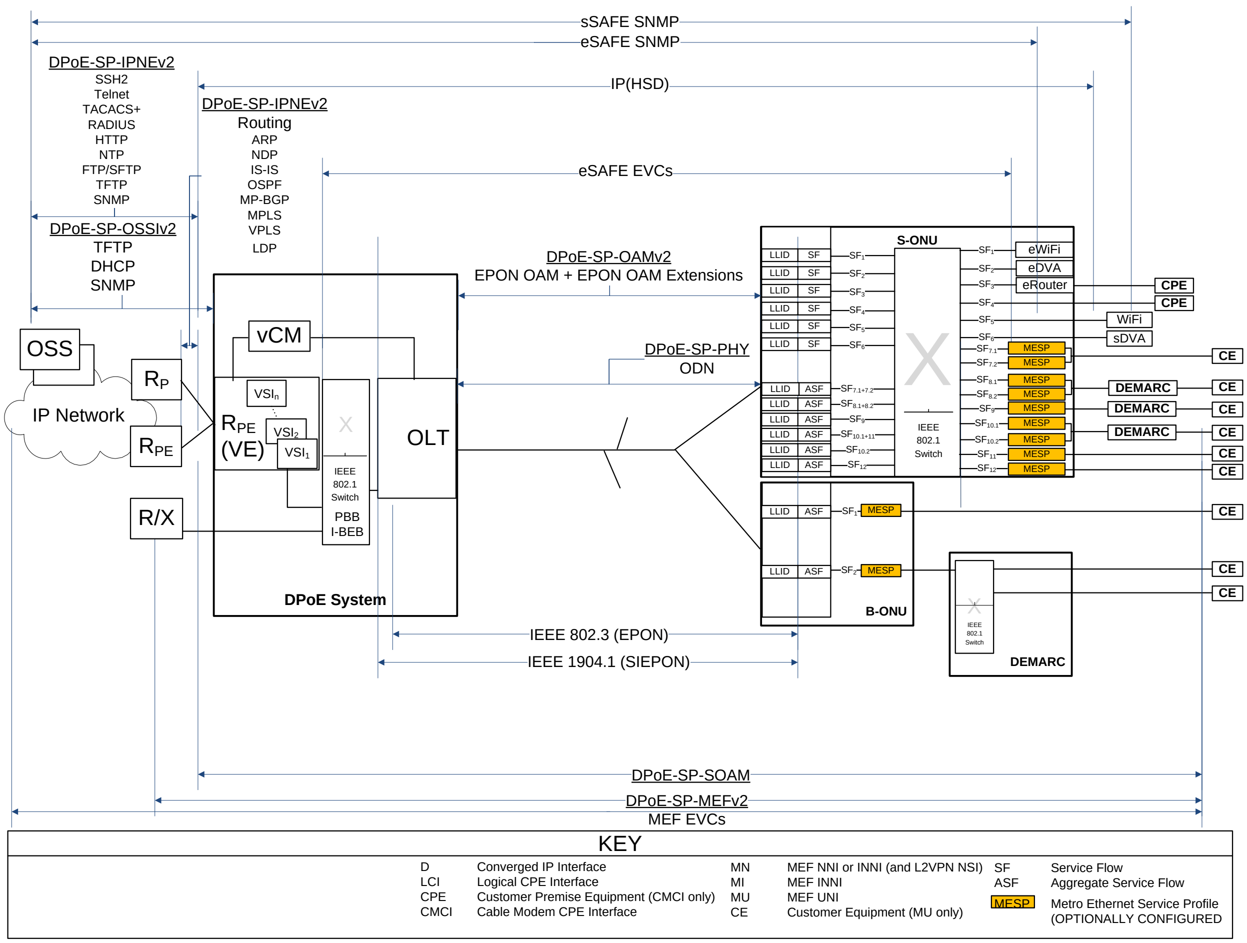

Figure 1 - DPoEv2.0 Reference Architecture

1.7 DPoE Interfaces and Reference Points

The DPoE interfaces and reference points shown in Figure 2 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 subsystems. The reference points have protocols that run across them, or have a common format of bearer traffic (with no signaling protocol). All 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.

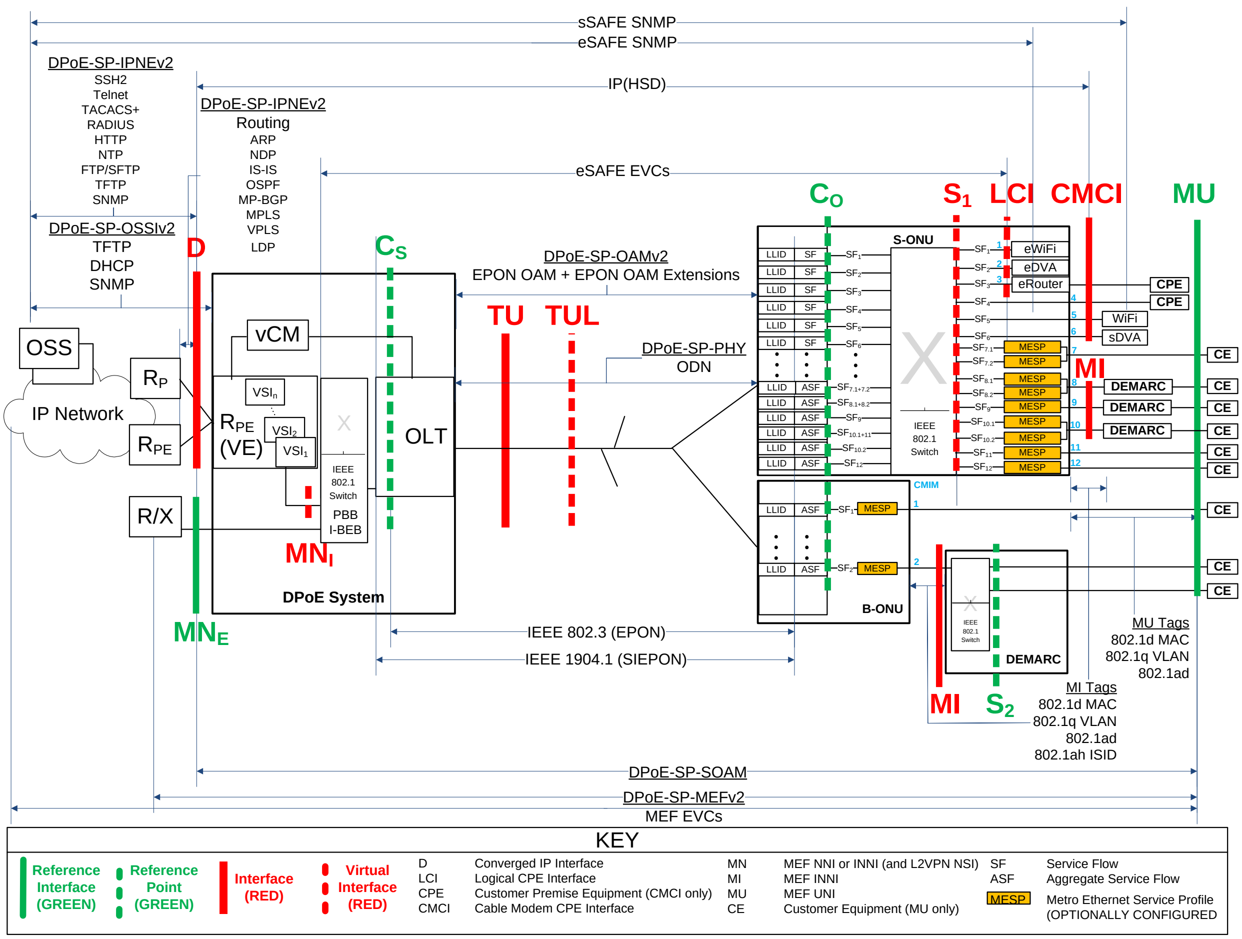

Figure 2 - DPoEv2.0 Interfaces and Reference Points

Table 2 - DPoEv2.0 Interface and Reference Point Descriptions

Interface or Reference Point		Interface or Reference Point Description
MN		MN is a logical concept used for the specification of requirements for MEF INNI that apply to both MN_E and MN_I. MN logically provides the equivalent function of a MEF INNI or L2VPN NSI. It is an NNI for Metro Ethernet services only.
	MN_E	The MN_E (MEF INNI External) interface is a substitute for the MN reference interface from DPoE version 1.0 specifications. 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.
	MN_I	The MN_I reference interface is used to describe the virtual interface between an OLT and a VPLS Virtual Switch Instance (VSI). In particular, it is used to describe the requirements for stitching VSIs to DPoE System and OLT [802.1] components such as [802.1d] bridge groups, [802.1ad] S-VLAN or C-VLAN (S-component or C-component), or [802.1ad] I-BEB (I-component) or B-BEB (B-component) backbone edge bridges. The DPoE System stitches VPLS and VPWS transport and forwarding for Metro Ethernet Services between the D interface and the MNI reference interface[1].
D		The D interface is the DOCSIS IP NNI interface. It is an operator network-facing interface, sometimes called a 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, IP/MPLS/VPLS traffic, and IP/MPLS/VPWS traffic.
TU		The TU interface is the interface between the DPoE System and the D-ONU.
TUL		The TUL interface is a virtual interface representing a logical EPON on an ODN. Each ODN has at least one TUL, and each TUL represents a MAC domain.
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 D-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 SERDES (GMII or XGMII) interface in a BP-ONU (such as an SFP-ONU, SFP+ONU or XFP-ONU), or it may be an external Ethernet interface in a BB-ONU or S-ONU. S_1 is an interface for an S-ONU. S_2 is a reference point used for explanation of services with the B-ONU.
	S_1	The S_1 interfaces are the general case of all interfaces on an S-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 B-ONU with a DEMARC device providing Metro Ethernet services.

[1] MN_I is required for IP-based forwarding and transport of Metro Ethernet services with DPoE in order to provide MEF E-LAN and E-TREE services described in DPoE version 2.0. While these services can be constructed with MN_E, these specifications do not describe the process to do so.

Interface or Reference Point	Interface or Reference Point Description
LCI	The Logical CPE Interface (LCI) interface is an eDOCSIS interface as defined in [eDOCSIS]. eSAFEs are connected to LCI interfaces.
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. Customer Premise Equipment (CPE) is connected to CMCI interfaces.
MI	MI is an S interface that operates as a MEF INNI with additional requirements as specified in [DPoE-MEFv2.0]. The MI interface is an [802.3] interface (or reference point) between a D-ONU and a DEMARC device. A D-ONU that provides a MEF INNI has an MI interface. A D-ONU can have MU as an interface and an MI reference point on different S interfaces in a single D-ONU. DEMARC devices are connected to MI interfaces.
MU	MU is an S interface (or S reference interface) that operates as a MEF UNI. The MU reference interface is an [802.3] interface (or reference point) between a D-ONU or a DEMARC device and a customer's equipment. A D-ONU that directly provides a MEF UNI (MU) interface has MU as an interface. A D-ONU can have MU as an interface and an MI reference point on different S interfaces in a single D-ONU. Customer Edge (CE) devices are connected to MU interfaces.

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.

In this specification, terms "802.1ad" and "802.1ah" are used to indicate compliance with the [802.1ad] and [802.1ah] standards, respectively, now incorporated as part of [802.1q]. For all intents and purposes, claiming compliance to [802.1q], [802.1ad] or [802.1ah] in the scope of this specification will be treated as claiming compliance to IEEE Std. 802.1Q-2011. Unless otherwise stated, claiming compliance to 802.1Q-2005 requires a specific date reference.

[10G]	P802.3av amendment to IEEE 802.3-2008: Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks, released November 2009.
[1G]	P802.3ah 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.
[802.1]	Refers to entire suite of IEEE 802.1 standards unless otherwise specified.
[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. Former amendment to 802.1Q, now part of 802.1Q-2011.
[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.
[802.3]	IEEE 802.3-2008, Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications, released 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 [802.3].
[802.3av]	IEEE 802.3AV-2009, IEEE Standard for Information technology-Telecommunications and information systems-Local and metropolitan area networks-Specific requirements, Part3: 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.
[DPoE-ARCHv2.0]	DOCSIS Provisioning of EPON, DPoE Architecture Specification, DPoE-SP-ARCHv2.0, Cable Television Laboratories, Inc.
[DPoE-DEMARCv2.0]	DOCSIS Provisioning of EPON, DPoE Demarcation Device Specification, DPoE-SP-DEMARCv2.0, Cable Television Laboratories, Inc.
[DPoE-IPNEv2.0]	DOCSIS Provisioning of EPON, IP Network Element Requirements, DPoE-SP-IPNEv2.0, Cable Television Laboratories, Inc.
[DPoE-MEFv2.0]	DOCSIS Provisioning of EPON, Metro Ethernet Forum Specification, DPoE-SP-MEFv2.0, Cable Television Laboratories, Inc.

[DPoE-MULPIv2.0] DOCSIS Provisioning of EPON, MAC and Upper Layer Protocols Requirements, DPoE-SP-MULPIv2.0, Cable Television Laboratories, Inc.

[DPoE-OAMv2.0] DOCSIS Provisioning of EPON, OAM Extensions Specification, DPoE-SP-OAMv2.0, Cable Television Laboratories, Inc.

[DPoE-OSSIv2.0] DOCSIS Provisioning of EPON, Operations and Support System Interface Specification, DPoE-SP-OSSIv2.0, Cable Television Laboratories, Inc.

[DPoE-SECv2.0] DOCSIS Provisioning of EPON, Security and Certificate Specification, DPoE-SP-SECv2.0, Cable Television Laboratories, Inc.

[DPoE-SOAMv2.0] DOCSIS Provisioning of EPON, DPoE Service-OAM Specification, DPoE-SP-SOAMv2.0, Cable Television Laboratories, Inc.

[SFF-8472] SFF-8472 Specification for Diagnostic Monitoring Interface for Optical Transceivers, Revision 10.4, released January 2009.

[SFP MSA] INF 8074i Rev 1.0, Small Form-factor Pluggable Multi-Source Agreement, released 12 May 2001.

2.2 Informative References

This specification uses the following informative references.

[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. Former amendment to 802.1Q, now part of 802.1Q-2011.

[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.

[802.3ag] IEEE Std. 802.3ag-2007™, IEEE Standard for Local and Metropolitan Area Networks-Virtual Bridged Local Area Networks-Amendment 5: Connectivity Fault Management, January 2007.

[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.

[eDOCSIS] CM-SP-eDOCSIS, Data-Over-Cable Service Interface Specifications, eDOCSIS Specification, Cable Television Laboratories, Inc.

[MULPIv3.0] Data-Over-Cable Service Interface Specifications, MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv3.0, Cable Television Laboratories, Inc.

[PHYv3.0] Data-Over-Cable Service Interface Specifications, Physical Layer Specification, CM-SP-PHYv3.0, Cable Television Laboratories, Inc.

[RFC 2011] IETF RFC 2011, SNMPv2 Management Information Base for the Internet Protocol using SMIv2, November 1996.

[RFC 2863] IETF RFC 2863, The Interfaces Group MIB, June 2000.

[RFC 3418] IETF RFC 3418, Management Information Base (MIB) for the Simple Network Management Protocol (SNMP), June 2000.

[RFC 4188] IETF RFC 4188, Definitions of Managed Objects for Bridges, September 2005.

[RFC 4293] IETF RFC 4293, Management Information Base for the Internet Protocol (IP), April 2006.

[SCTE 174] ANSI/SCTE 174 2010, Radio Frequency over Glass Fiber-to-the-Home Specification.

2.3 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027; Phone +1-303-661-9100; Fax +1-303-661-9199; http://www.cablelabs.com
- 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
- Institute of Electrical and Electronics Engineers (IEEE), +1 800 422 4633 (USA and Canada); http://www.ieee.org
- Small Form Factor Committee (SFF), http://www.sffcommittee.com
- 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 Network Elements

DPoE Network	This term means all the elements of a DPoE implementation, including at least one DPoE System, one or more D-ONUs connected to that DPoE System, and possibly one or more DEMARCs.
DPoE System	This term refers to the set of subsystems within the hub site that provides the functions necessary to meet DPoE specification requirements.
DPoE ONU (D-ONU)	This term means a DPoE-capable ONU that complies with all the DPoE specifications. There are two logical types of D-ONUs. These are the DPoE Standalone ONU (S-ONU) and the DPoE Bridge ONU (B-ONU). Requirements specified for a D-ONU must be met by all ONUs.
DPoE Standalone ONU (S-ONU)	This term means a D-ONU that provides all the functions of a B-ONU and also provides at least one CMCI port. An S-ONU can optionally have one or more eSAFEs.
DPoE Bridge ONU (B-ONU)	This term means a D-ONU that is capable of [802.1] forwarding but cannot do all the encapsulation functions required to be an S-ONU. The B-ONU is a logical definition used by the specification for requirements that apply to all types of B-ONUs. The two types of B-ONUs are the BP-ONU and the BB-ONU.
DPoE Bridge Pluggable ONU (BP-ONU)	This term means a D-ONU that is a B-ONU which is pluggable. Pluggable BP-ONUs include devices such as an SFP-ONU (1G-EPON), SFP+ONU (10G-EPON), or XFP-ONU (10G-EPON).
DPoE Bridge Baseband ONU (BB-ONU)	This term means a D-ONU that is a B-ONU which has a baseband IEEE Ethernet interface. BB-ONUs include those with one or more [802.3] baseband PMDs. (See [DPoE-ARCHv2.0], section 7.2.6.2 for examples.)
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) or the NID (as in the MEF model).

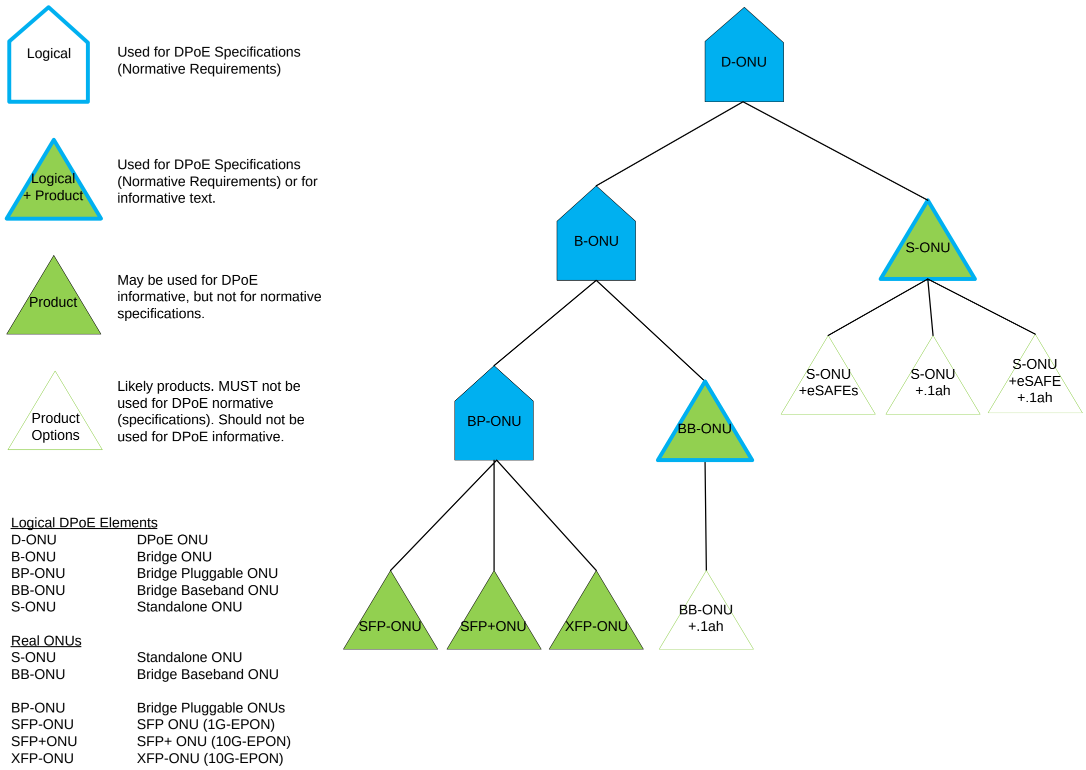

Figure 3 - D-ONU Types

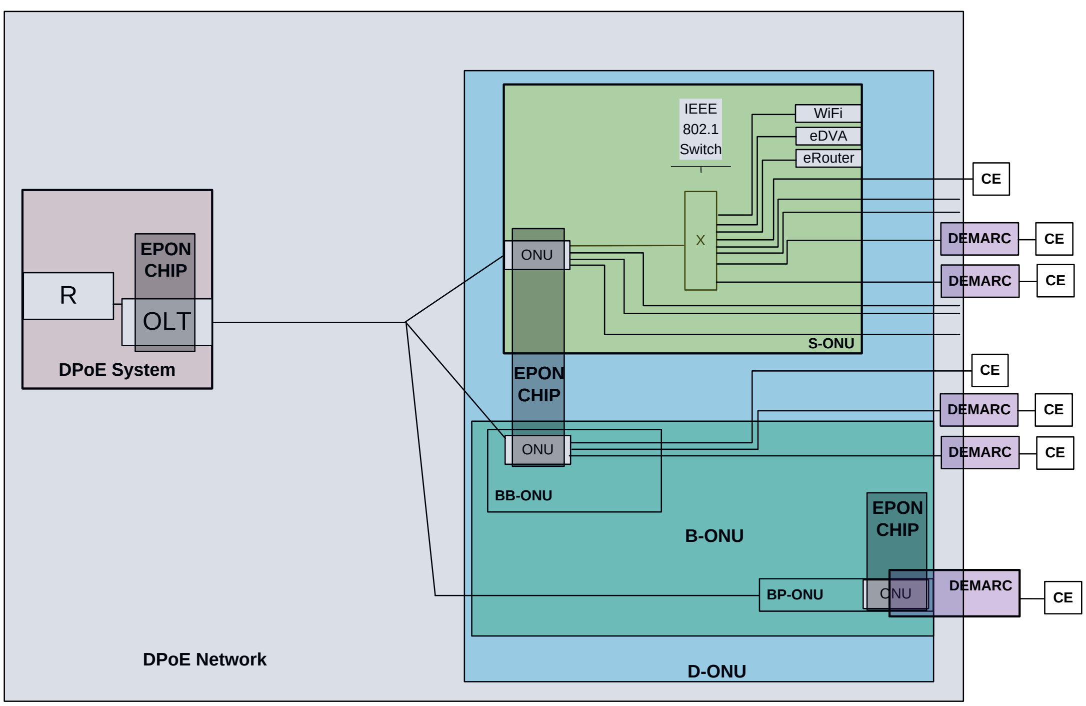

Figure 4 - DPoE Network Elements

3.2 Other Terms

1G-EPON	EPON as defined in [802.3ah]
10G-EPON	EPON as defined in [802.3ah] and amended in [802.3av]
Cable Modem CPE Interface	CMCI as defined in [MULPIv3.0]
Customer Premise Equipment (CPE)	Customer Premise Equipment as defined in [DOCSIS]
Ethernet Passive Optical Network (EPON)	Refers to both 1G-EPON and 10G-EPON collectively
EPON Operations and Maintenance Messaging (OAM)	EPON OAM messaging as defined in [802.3ah] and [DPoE-OAMv2.0]; Ethernet OAM is not the same as EPON OAM; Ethernet OAM is [802.1ag]
Logical CPE Interface	LCI as defined in [eDOCSIS]
Network Interface Device (NID)	A DEMARC device in DPoE specifications

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations:

BER	Bit error ratio
CMCI	Cable Modem CPE Interface
CoS	Class of Service
CPE	Customer Premise Equipment
DEMARC	Demarcation Device
DoS	Denial of Service
DPoE	DOCSIS Provisioning and operations of EPON
eCM	embedded Cable Modem
eDVA	embedded Digital Voice Adapter
EPON	Ethernet Passive Optical Network
EVC	Ethernet Virtual Connection
FEC	Forward error correction
IP	Internet Protocol
L2VPN	Layer 2 Virtual Private Network
LCI	Logical CPE Interface
LLID	Logical Link IDentifier
MEF	Metro Ethernet Forum
MI	MEF INNI Interface at a customer premise
MU	MEF UNI Interface
NID	Network Interface Device
NNI	Network to Network Interface
NSI	Network Systems Interface
OAM	EPON Operations Administration and Maintenance
ODN	Optical distribution network
OLT	Optical Line Termination
ONU	Optical Network Unit
OSC	Optical Splitter Combiner
PCS	Physical Coding Sublayer
PDU	Protocol Data Units
PHY	Physical Layer
PMA	Physical Medium Attachment
PMD	Physical Media Dependent (Sublayer)
PON	Passive optical network
R	IP Router

SFP	Small Form-factor Pluggable
SFP+	Small Form-factor Pluggable Plus (+)
UNI	User Network Interface
VFI	Virtual Forwarding Instance
VSI	Virtual Switch Instance
X	IEEE Ethernet Switch (Generic)
XFP	X Form-factor Pluggable

5 EPON PHY

The specifications for the EPON PHY are in [802.3ah] and [802.3av]. [802.3] contains specifications for optical module wavelengths, receiver sensitivity, and other parameters defining the EPON physical layer used in DPoE networks. Details of wavelength planning, supported optical budgets, and split ratios for particular deployments are outside the scope of this specification.

5.1 DPoE Additional PHY Requirements

DPoE Systems MUST support all of the Physical Media Dependent (PMD) classes defined in [802.3] [1G], Clause 60 (1G-EPON), and Clause 75 (10G-EPON) [10G].

5.1.1 Forward Error Correction

The DPoE System MUST support the Forward Error Correction (FEC) methods defined in [802.3], with the additional capabilities as defined in this section. The D-ONU MUST also support the Forward Error Correction (FEC) methods defined in [802.3], with the additional capabilities defined in this section.

5.1.2 [1G] FEC

A DPoE System MUST support FEC as defined in [1G]. A D-ONU MUST support FEC as defined in [1G].

The DPoE System MUST support different FEC states (enabled / disabled) in the upstream and downstream directions. Correspondingly, the D-ONU MUST support different FEC states (enabled / disabled) in the upstream and downstream directions.

The DPoE System MUST support enabling FEC on a per-logical link basis. The D-ONU MUST also support enabling FEC on a per-logical link basis. FEC may be individually enabled for one or more of the logical links on the PON, may be enabled for all logical links on the PON, or may be disabled altogether, according to operator provisioning.

At the time of registration, the D-ONU MUST automatically detect the presence of FEC-encoded frames in the downstream, and set the initial state of FEC for the link to be registered in the upstream to match. The DPoE System MUST be able to enable or disable FEC encoding according to operator provisioning via OAM after the link has registered.

5.1.3 [10G] FEC[2]

A DPoE System MUST support FEC as defined in [10G]. A D-ONU MUST support FEC as defined in [10G].

A DPoE System MAY support disabling FEC for all 10G-EPON D-ONUs connected to the given TUL interface. Note that due to the stream-based nature of FEC in 10G-EPON, there is no way to support disabling or enabling FEC on per logical link basis.

If the FEC disabling function is supported, the operator is responsible for making sure that the FEC for the given TUL interface is disabled only when selected or all connected D-ONUs have sufficient power budget margin to achieve error-free operation with FEC disabled. Given that changing FEC state (enabling or disabling) for 10G-EPON TUL interface is service affecting, the operator needs to account for the D-ONU re-registration process when changes to the FEC state are made.

A 10G-EPON D-ONU MAY support disabling FEC, if configured appropriately by the DPoE System. A 10G-EPON D-ONU MAY automatically detect the presence of an FEC encoded downstream, and set the initial state of its upstream FEC to match.

[2] Requirements associated with support for disabling FEC on 10G-EPON links will become mandatory once the appropriate mechanisms are defined in IEEE Std 802.3. Revised per PHYv2.0-N-12.0055-1 on 2/20/13 by JB.

5.2 Raman Interference Mitigation

The DPoE System MUST provide means for reducing Raman interference of the EPON downstream with other optical wavelengths by replacing [802.3] IDLE time by randomized frames as defined in this section.

Standard 1 Gbit/s Ethernet transmission features transmission of an IDLE pattern (comprising an alternating sequence of 1s and 0s) when there is no subscriber data to be transmitted. The high frequency component of such a data pattern produces interference affecting other optical wavelengths. In the [802.3ah] based DPoE Network, the downstream optical channel transmitted at the central wavelength of 1490 nm (digital data) produces a power spike at the optical channel transmitted at the central wavelength of 1550 nm (RF video). The Raman mitigation technique reduces this interference by minimizing the power transmitted in the high frequency component, as shown in Figure 5 below.

The standard Ethernet IDLE is replaced by an Ethernet frame carrying a payload with a random pattern, spreading transmitted optical power over a wider spectrum, and reducing the interference at specific other wavelengths.

Off
(Standard IDLE)

Random Data Packet
Insertion

Figure 5 - Interference Spectra Without and With Raman Mitigation

The DPoE System MUST always transmit actual network data in the downstream if such is available.

If the DPoE System detects a sufficiently long idle period on the NNI interface, with the size equal to a minimum Ethernet frame (64 bytes plus 8 bytes of preamble and 12 bytes of IPG), the DPoE System MUST replace this IDLE frame with an internally generated Ethernet frame with a random payload, as described above. This frame MUST be sent on a unicast LLID that is not connected to any D-ONU on the particular DPoE System TU (PON) interface, ensuring thus that no D-ONU can receive such a frame. The DPoE System MUST generate a payload for this frame such that it comprises a sequence of uniformly distributed random values.

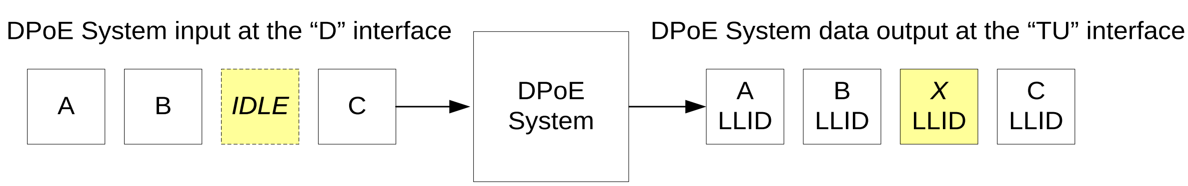

Figure 6 - IDLE Pattern Replacement Function

5.3 Optical Monitoring

A DPoE System MUST support all optical monitoring values as specified in [SFF-8472], including monitoring received optical power, transmit power, transmit bias current, internal voltage, and temperature. Similarly the D-ONU MUST support all optical monitoring values as specified in [SFF-8472], including monitoring received optical power, transmit power, transmit bias current, internal voltage, and temperature.

A DPoE System MUST be able to report received optical power on a per-logical link basis, as well as reporting received optical power during idle time on the PON upstream.

5.4 D-ONU Optical Power Control

One possible failure mode for a D-ONU is for the laser driver to remain in the enabled state outside of the assigned transmission slot, continually generating light into the PON, interfering with transmissions of other D-ONUs in the upstream. The DPoE System MUST be able to isolate such failed D-ONUs from the PON by disabling their transmitter until the D-ONU can be replaced. The DPoE System disables a D-ONU laser by means of a specialized DPoE OAM message. A D-ONU MUST support an optical power disable command from the [DPoE-OAMv2.0].

A D-ONU MUST be able to disconnect the power supply from the optical module under software control. A D-ONU MUST be able to separately control the power supplies to the transmit and receive paths of the optical module. A DPoE System MUST be able to send an OAM message to the D-ONU to signal optical power shutdown. If the DPoE System sends such a message, the D-ONU MUST turn off or disconnect the power to the optical module. Once the optical module is disconnected, the DPoE System cannot signal the D-ONU to turn on the power. Therefore, a D-ONU that implements such a feature MUST retain this setting when it is rebooted or power-cycled (in non-volatile storage). The D-ONU MAY remove this setting if it is reset by means other than a software reboot or power-cycle (for example, a RESET button or similar means).

A B-ONU that complies with the [SFP MSA] SHOULD be able to disconnect the power supply from the optical module (within the SFP module) under software control. A B-ONU that complies with the [SFP MSA] SHOULD be able to separately control the power supplies to the transmit and receive paths of the optical module within the SFP module. These requirements apply to the optical module within the B-ONU and do not apply to the SFP module itself, because the transmit and received power pins for the SFP module supply power (in parallel) to both the optical and Layer 2 subsystems within the SFP ONU.

The procedure used to detect malfunctioning D-ONUs, and the decision whether to disable them or not, is outside the scope of this specification. In general, network error statistics are used to detect any transmission problems, and malfunctioning D-ONUs are distinguished from working D-ONUs by disabling their lasers temporarily. Once the specific D-ONU has been identified as the source of the problem, it is permanently disabled using the DPoE OAM.

A DPoE System MUST provide the operator the capability to turn on or off such a rogue D-ONU detection function for each PON and for an entire DPoE System.

6 D-ONU UNI "S" INTERFACE

The S interface in Figure 2 is the User to Network Interface (UNI). D-ONUs support two types of S interfaces. These are either physical or logical interfaces. Although logical interfaces do not necessarily connect to the CPE, the transport of services to logical and physical interfaces is the same. Any S interface that is configured as a CMCI, MI, or MU interface is a physical interface.

6.1 Physical Interfaces

S-ONUs and B-ONUs that do not comply with the [SFP MSA] MUST support standard Ethernet interfaces for the S interfaces configured as (CMCI, MI, or MU) physical interfaces, as defined in [802.3].

A B-ONU that complies with the [SFP MSA] MUST support the standard SFP interface defined in the [SFP MSA]. A B-ONU that complies with the [SFP MSA] MUST also support the digital management interface defined in [SFF-8472].

6.2 Logical Interfaces

In addition to a physical interface, a D-ONU MAY have a logical Ethernet [802.3] interface. This interface could be used to provide an Ethernet transport across the PON from the DPoE System to a real physical interface within the D-ONU package. It could be a sub-interface to a switch or bridge group within the D-ONU, or a sub-interface on an [802.3] interface of a real Physical Interface as in Section 6.1 above.

Appendix I Acknowledgments

On behalf of our industry, we would like to thank the following individuals for their contributions to the development of this specification, listed in alphabetical order of company affiliation.

Contributor	Company Affiliation
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Appendix II Revision History

II.1 Engineering Change incorporated into DPOE-SP-PHYv2.0-I02-130328

ECN	ECN Date	Summary	Author
PHYv2.0-N-12.0055-1	11/29/2012	Removal of optional requirement for 10G-EPON FEC	Marek Hajduczenia