

IEEE Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON)

IEEE Communications Society

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IEEE Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON)

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Abstract: The system-level requirements needed to ensure service-level, multi-vendor interoperability of Ethernet Passive Optical Network (EPON) equipment is described. The existing IEEE 802.3 and IEEE 802.1 standards, which ensure the interoperability at the Physical Layer (PHY) and Data Link Layer, are complemented by the specifications. Specifically included in this specification are

- EPON system-level interoperability specifications covering equipment functionality, traffic engineering, and service-level quality of service/class of service (QoS/CoS) mechanisms;
- Management specifications covering equipment management, service management, and EPON power-saving mechanism.

Keywords: 1G-EPON, 10G-EPON, EPON, Ethernet Passive Optical Network, IEEE 1904.1, interoperability, QoS, quality of service, service interoperability, SIEPON

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Introduction

This introduction is not part of IEEE Std 1904.1-2017, IEEE Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON).

This standard builds upon the IEEE 802.3ah™ (1G-EPON) and IEEE 802.3av™ (10G-EPON) Physical Layer and Data Link Layer specifications and provides system-level and network-level definitions of numerous Ethernet Passive Optical Network (EPON) features, geared toward fostering interoperability between various implementations aiming to provide the same set of functionalities.^a These Service Interoperability in Ethernet Passive Optical Networks (SIEPON) features allow “plug-and-play” interoperability of the transport, service, and control planes in a multi-vendor environment. This standard serves a number of important purposes:

- Compliant EPON devices follow a common specification for the worldwide market, potentially resulting in larger volumes and reduced costs.
- Operators may not face the challenge of developing system-level specifications and interoperability testing procedures before they can deploy EPON.
- EPON vendors may not need to implement multiple options to comply with multiple proprietary/national specifications. Reduced device complexity may further reduce cost.
- Competition among EPON equipment and component suppliers may increase, thus potentially driving further innovation and cost reductions.

^a Information on references can be found in Clause 2.

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IEEE Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON)

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1 Overview

1.1 Scope

This standard describes the system-level requirements needed to provide service-level, multi-vendor interoperability of Ethernet Passive Optical Network (EPON) equipment. The specifications complement the existing IEEE 802.3™ and IEEE 802.1™ standards, which enable the interoperability at the Physical Layer and Data Link Layer.¹ Specifically included in this specification are

- EPON system-level interoperability specifications covering equipment functionality, traffic engineering, and service-level quality of service/class of service (QoS/CoS) mechanisms;
- Management specifications covering equipment management, service management, and power utilization.

¹ Information on references can be found in Clause 2.

1.2 Purpose

The purpose of this standard is to build upon the IEEE 802.3ah (1G-EPON) and IEEE 802.3av (10G-EPON) Physical Layer and Data Link Layer standards and create a system-level and network-level standard, thus allowing full “plug-and-play” interoperability of the transport, service, and control planes in a multi-vendor environment.

1.3 Coverage

This specification for Service Interoperability in Ethernet Passive Optical Networks (SIEPON) provides a series of requirements for the operation of Optical Network Unit (ONU) and Optical Line Terminal (OLT) devices. To foster interoperability across the PON among equipment from different EPON vendors, this standard specifies the flow of information exchanged between the ONU and OLT as well as their associated behaviors. The interaction between the OLT and network management system (NMS) as well as between the ONU and customer premise equipment (CPE) devices is outside the scope of this specification and not covered in this document.

1.4 Overview of clauses

This subclause provides an overview of the scope of individual clauses included in this specification:

- Clause 1 provides an overview of the IEEE 1904.1 specifications, including the scope and purpose of the specification and the scope of individual clauses.
- Clause 2 lists normative references used within this specification.
- Clause 3 presents definitions of specific terms as used in this standard. Terms may be introduced in this specification or may exist with multiple industry definitions. Additionally, a list of acronyms used in this standard is included.
- Clause 4 defines individual specification packages through references to profile-specific definitions included in the subsequent clauses.

- Clause 5 details the scope of IEEE 1904.1 specifications, looking at the EPON system-level architecture, individual network elements (ONU and OLT), and their internal structure. Line ONU/OLT, Client ONU/OLT, Service ONU/OLT, and associated interfaces are specified in this clause.
- Clause 6 presents the Media Access Control (MAC) Client reference model and its functional blocks, comprising the Client ONU/OLT devices. The clause provides their overview, description of operation, primary statistics, and additional information to be exchanged between individual functional blocks. This clause builds on the Clause 5 model of the EPON system.
- Clause 7 describes various aspects of connectivity configurations for EPON, such as frame classification, virtual local area network (VLAN) and tunneling configurations, and multicast operation that determine forwarding behavior of OLTs and ONUs.
- Clause 8 provides definitions of mechanisms, parameters, and functions directly related to QoS enforcement, performance metrics, definitions of queue service disciplines, and queue length reporting process.
- Clause 9 focuses on the service survivability aspects of the EPON system, including mechanisms for link monitoring, definitions of alarms and warnings supported by individual profiles, and optical link protection required to meet high availability requirements included in some of the service-level agreements (SLAs).
- Clause 10 addresses power-saving requirements and mechanisms for EPON, specifying the control protocol as well as ONU and OLT functional requirements.
- Clause 11 is devoted to the definition of data security and authentication mechanisms, including data link encryption and authentication of ONU devices. Authentication of CPEs is outside the scope of this specification.
- Clause 12 specifies discovery and maintenance functions, such as software update and device capability discovery.

- Clause 13 introduces profile-specific management models, each of which includes definitions of the control protocol, data units, and management functions.
- Clause 14 serves as a repository of managed objects, which are controlled using one of the profile-specific management models defined in Clause 13. Given the very specific character of management models, their managed objects are also specifically designed to cater to the requirements of particular deployment scenarios.

2 Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

BBF TR-069, CPE WAN Management Protocol, May 2004.²

BBF TR-200, Using EPON in the Context of TR-101, February 2011.²

CM-SP-MULPI, (CM-SP-MULPIv3.0-~~I14-101008~~ [I29-151210](#)), Cable Modem to Customer Premise Equipment Interface Specification.

DPoE-SP-MULPI, (DPoE-SP-MULPIv~~1.0-I01-110225~~ [I10-160602](#)), DOCSIS® Provisioning of EPON Specifications—DPoE™ MAC and Upper Layer Protocols Requirements.³

DPoE-SP-OAMv~~1.0-I01-110225~~ [I08-140807](#)), DOCSIS® Provisioning of EPON Specifications— DPoE™ OAM Extensions Specification.

[DPoE-SP-OAMv2.0, \(DPoE-SP-OAMv2.0-I09-160602\), DOCSIS® Provisioning of EPON Specifications—DPoE™ OAM Extensions Specification.](#)

DPoE-SP-OSSI, (DPoE-SP-OSSIV~~1.0-I01-110225~~ [I09-160602](#)), DOCSIS® Provisioning of EPON Specifications—DPoE™ Operations and Support System Interface Specification.

DPoE-SP-PHY, (DPoE-SP-PHYv~~1.0-I01-110225~~ [I05-160602](#)), DOCSIS® Provisioning of EPON Specifications—DPoE™ Physical Layer Specification.

² BBF technical reports (TRs) are available in electronic form from the Broadband Forum (<http://www.broadband-forum.org/technical/trlist.php>).

³ DPoE™ and DOCSIS® specifications are available from Cable Television Laboratories, Inc. (<http://cablelabs.com/>). DOCSIS and DPoE standards or products referred to in this standard are trademarks of the Cable Television Laboratories, Inc.

DPoE-SP-SEC, (DPoE-SP-SECv12.0-101-110225 105-160602), DOCSIS® Provisioning of EPON Specifications— DPoE™ Security Specification.

IEEE Std 802.1ad™-2005, IEEE Standard for Information technology—Telecommunications and information systems—Local and metropolitan area networks—IEEE Virtual Bridged Local Area Networks, Amendment 4: Provider Bridges.^{4,5}

~~IEEE Std 802.1D™-2004, IEEE Standard for Information technology—Telecommunications and information systems—Local and metropolitan area networks—Media Access Control (MAC) Bridges.~~

IEEE Std 802.1AE™-2006, IEEE Standard for Information technology—Telecommunications and information systems—Local and metropolitan area networks—Specific requirements: Media Access Control (MAC) Security.

IEEE Std 802.1Q™-20112014, IEEE Standard for Information technology—Telecommunications and information systems—Local and metropolitan area networks—Media Access Control (MAC) Bridges and Virtual Bridge Local Area Networks.

IEEE Std 802.1X™-2004, IEEE Standard for Information technology—Telecommunications and information systems—Local and metropolitan area networks—Specific requirements: Port-based Network Access Control (revision of IEEE Std 802.1™-2001).

IEEE Std 802.1X™-2010, IEEE Standard for Information technology—Telecommunications and information systems—Local and metropolitan area networks—Specific requirements: Port-based Network Access Control (revision of IEEE Std 802.1™-2004).

IEEE Std 802.3™-20122015, IEEE Standard for Ethernet.

⁴ IEEE publications are available from The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

⁵ The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

IEEE Std 802.3ahTM-2004, Amendment to IEEE Std 802.3TM-2003: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks, now part of IEEE Std 802.3TM-~~2008~~.

IEEE Std 802.3avTM-2009, Amendment 1 to IEEE Std 802.3TM-2008: Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks, [now part of IEEE Std 802.3TM](#).

IEEE Std 802.3azTM-2010, Amendment 5 to IEEE Std 802.3TM-2008: Media Access Control parameters, Physical Layers and management parameters for Energy-Efficient Ethernet.

IEEE Std 802.3.1TM-2011, Standard for Management Information Base (MIB) definitions for Ethernet.

IEEE Std 1149.1TM-2001, Standard Test Access Port and Boundary-Scan Architecture.

[IEEE Std 1588TM-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.](#)

IETF RFC 768 (August 1980), *User Datagram Protocol*, J. Postel.⁶

IETF RFC 791 (September 1981), *Internet Protocol*, J. Postel.

IETF RFC [792 \(September 1981\), Internet Control Message Protocol](#), J. Postel. IETF RFC 793 (September 1981), *Transmission Control Protocol*, J. Postel.-

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⁶ IETF requests for comments (RFCs) are available from the Internet Engineering Task Force (<http://www.ietf.org/rfc.html>).

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IETF RFC 2474 (December 1998), *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers*, K. Nichols, S. Blake, F. Baker, D. Black.

IETF RFC 2698 (September 1999), *A Two Rate Three Color Marker*, J. Heinanen, R. Guerin.

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IETF RFC 3748 (June 2004), *Extensible Authentication Protocol (EAP)*, B. Aboba, L. Blunk, J. Vollbrecht, J. Carlson, H. Levkowetz.

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[IETF RFC 4443 \(March 2006\), *Internet Control Message Protocol \(ICMPv6\) for the Internet Protocol Version 6 \(IPv6\) Specification*, A. Conta, S. Deering, M. Gupta.](#)

IETF RFC 4541 (May 2006), *Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches*, M. Christensen, K. Kimball, F. Solensky.

IETF RFC 5433 (February 2009), *Extensible Authentication Protocol—Generalized Pre-Shared Key (EAP-GPSK) Method*, T. Clancy, H. Tschofenig.

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Transmission convergence layer specification.⁷

ITU-T Recommendation G.987.1, 2010.01—10-Gigabit-capable passive optical networks (XG-PON):
General requirements.

~~MEF 6, Ethernet Services Definitions—Phase I, June 2004.~~⁸

~~MEF 6.1, Ethernet Services Definitions, Phase 2, April 2008.~~

MEF 10.2, Ethernet Services Attributes Phase 2, 27 October 2009.⁸

SFF-8472, “Specification for Diagnostic Monitoring Port for Optical Transceivers,” rev. 11, 14
September 2010.⁹

SFF-8077i, “10 Gigabit Small Form Factor Pluggable Module,” rev. 4.5, 31 August 2005.

⁷ ITU-T publications are available from the International Telecommunications Union (<http://www.itu.int/>).

⁸ MEF specifications are available in electronic form from the Metro Ethernet Forum (<http://metroethernetforum.org/index.php>).

⁹ SFF documentation is available in hard copy or electronic form from the Small Form Factor committee (<http://www.sffcommittee.com>).

3 Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹⁰

active period: An uninterrupted period of time during which the Optical Network Unit (ONU) remains in the active state.

active state: The Optical Network Unit's (ONU's) state within a power-saving cycle in which all of its subsystems in the transmit and receive paths are powered up and fully functional.

backbone frame (B-Frame): A backbone data frame that starts with Backbone Destination Address (B-DA) and Backbone Source Address (B-SA) fields and always contains an I-Tag and carries a Customer Frame (C-Frame) as a payload. A B-Frame may contain a B-Tag.

Client Optical Line Terminal (C-OLT): A C-OLT combines at least one Line OLT (L-OLT) with higher-layer functions (including Operations, Administration, and Management (OAM) Client functions; OAM functions; Media Access Control (MAC) Control Client functions; and MAC Client functions) residing above the OLT Line Interface (OLT_LI). The C-OLT is capable of establishing bidirectional connectivity with the Optical Network Units (ONUs), receiving subscriber frames and sending frames destined to subscribers, and participating in the Multipoint Control Protocol (MPCP) and OAM frame exchanges and related processes.

Client Optical Network Unit (C-ONU): A C-ONU combines at least one Line ONU (L-ONU) with higher-layer functions (including Operations, Administration, and Management (OAM) Client functions; OAM functions; Media Access Control (MAC) Control Client functions; and MAC Client functions) residing above the ONU Line Interface (ONU_LI). The C-ONU is capable of establishing bidirectional connectivity with the Optical Line Terminal (OLT), receiving subscriber frames and sending frames destined to subscribers, and participating in the Multipoint Control Protocol (MPCP) and OAM frame exchanges and related processes.

¹⁰ IEEE Standards Dictionary Online ~~subscription~~ is available at http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html <http://ieeexplore.ieee.org/>.

customer frame (C-Frame): A customer data frame that starts with Customer Destination Address (C-DA) and Customer Source Address (C-SA) fields and may contain S-Tags and/or C-Tags, depending on whether it is a single- or double-tagged frame.

Ethernet Passive Optical Network (EPON) Service Path (ESP): A logical entity representing the principal unit for unidirectional service provisioning and quality of service (QoS) enforcement in the EPON system. ESP includes the following logical blocks: Input point [I] associated with an exposed or an internal interface of a Media Access Control (MAC) Client, Classifier [C], Modifier [M], Policer/Shaper [PS], CrossConnect [X], Queue [Q], Scheduler [S], and Output point [O] associated with an exposed or an internal interface of a MAC Client.

Ethernet Passive Optical Network (EPON) system: A network segment comprising an Optical Line Terminal (OLT) and all subtended Optical Network Units (ONUs) and providing connectivity between OLT Client Interface (OLT_CI) and ONU Client Interface (ONU_CI).

image check sequence (ICS): A field embedded into the Optical Network Unit (ONU) software image and used to verify the integrity of the image.

interframe gap (IFG): A term that corresponds to interpacket gap (IPG), IEEE Std 802.3TM, 1.4.192.

Line Optical Line Terminal (L-OLT): An L-OLT represents a basic logical entity in the structure of the OLT device, and it is responsible for the Physical Layer connectivity in Ethernet Passive Optical Network (EPON). An L-OLT instantiates multiple Media Access Control (MAC) entities, where each such MAC instance offers unicast emulation service in both the upstream and downstream directions. An additional broadcast MAC entity is instantiated to offer broadcast communication to all Optical Network Units (ONUs) in the downstream direction and a return path for the Multipoint Control Protocol (MPCP) discovery process. The L-OLT may also instantiate one or more multicast MAC entities, offering downstream-only connectivity. By itself, the L-OLT is not capable of establishing bidirectional connectivity with ONUs and requires the support of the Client OLT (C-OLT) functions.

Line Optical Network Unit (L-ONU): An L-ONU represents a basic logical entity in the structure of the ONU device, and it is responsible for the Physical Layer connectivity in Ethernet Passive Optical Network (EPON). By itself, the L-ONU is not capable of establishing bidirectional connectivity with the Optical Line Terminal (OLT) and requires the support of the Client ONU (C-ONU) functions.

multicast service group: A set of Optical Network Units (ONUs) that serve multicast clients belonging to the same multicast group.

multi-dwelling unit (MDU): A type of Optical Network Unit (ONU) designed to service many residential customers in a single physical structure or a few closely grouped structures.

multi-tenant unit (MTU): A type of Optical Network Unit (ONU) designed to service several business customers in a single physical structure.

network management system (NMS): In the scope of IEEE Std 1904.1, any network management, control, information storage, and other type of entities, located in the same or different geographical locations, functionally combined to a single point of reference for Ethernet Passive Optical Network (EPON). This entity is responsible for controlling, managing, and supervising the operation of EPON. NMS combines, terminates, proxies, or snoops a number of different control and management protocols (outside the scope of this standard), used to drive the operation of the Optical Line Terminal (OLT) and its functions, providing Faults, Accounting, Configuration, Performance, and Security (FCAPS) functionality for a network operator.

Optical Line Terminal Client Interface (OLT_CI): Represents the interface between the Client OLT (C-OLT) and the Service OLT (S-OLT) functionalities. When no service-specific functions are implemented, the OLT_CI corresponds to the Network-to-Network Interface (NNI). When service-specific functions are present, the OLT_CI is an internal interface that does not correspond to any existing IEEE 802.3 or IEEE 802.1 interface.

Optical Line Terminal Line Interface (OLT_LI): Represents the interface between the Line OLT (L-OLT) and Client OLT (C-OLT) functionalities. It corresponds to the following IEEE 802.3 interfaces:

- Media Access Control (MAC) data service interface or subscriber data frames exchanged between the MAC Client and L-OLT

- MAC Control service interface for MAC Control frames exchanged between the MAC Control Client and L-OLT
- Operations, Administration, and Management (OAM) service interface for OAM frames exchanged between the OAM Client and L-OLT

Optical Line Terminal Medium Dependent Interface (OLT_MDI): Represents an interface between the Line OLT (L-OLT) and the physical Passive Optical Network (PON) medium. This interface corresponds to the MDI specified in IEEE Std 802.3, Clause 60 for 1 Gb/s Ethernet Passive Optical Network (1G-EPON) and Clause 75 for 10 Gb/s Ethernet Passive Optical Network (10G-EPON).

Optical Network Unit Client Interface (ONU_CI): Represents the interface between the Client ONU (C-ONU) and the Service ONU (S-ONU) functionalities. When no service-specific functions are implemented, the ONU_CI corresponds to the user network interface (UNI). When service-specific functions are present, the ONU_CI is an internal interface that does not correspond to any existing IEEE 802.3 or IEEE 802.1 interface.

Optical Network Unit Line Interface (ONU_LI): Represents the interface between the Line ONU (L-ONU) and Client ONU (C-ONU) functionalities. It corresponds to the following IEEE 802.3 interfaces:

- Media Access Control (MAC) data service interface or subscriber data frames exchanged between the MAC Client and L-ONU
- MAC Control service interface for MAC Control frames exchanged between the MAC Control Client and L-ONU
- Operations, Administration and Management (OAM) service interface for OAM frames exchanged between the OAM Client and L-ONU

Optical Network Unit Medium Dependent Interface (ONU_MDI): Represents an interface between the Line ONU (L-ONU) and the physical Passive Optical Network (PON) medium. This interface corresponds to the MDI specified in IEEE Std 802.3, Clause 60 for 1 Gb/s Ethernet Passive Optical Network (1G-EPON) and Clause 75 for 10 Gb/s Ethernet Passive Optical Network (10G-EPON).

power-saving cycle: A period of time comprising one active period and one sleep period.

power-saving mode: Optical Network Unit's (ONU's) operating mode consisting of repeating power-saving cycles, i.e., a mode in which an ONU repeatedly alternates between the active state and the sleep state.

Queue Set: A collection of queues whose occupancy is reported under a single report bitmap. The structures of Queue Set and Report bitmap fields are specified in IEEE Std 802.3, 64.3.6.2 for 1 Gb/s Ethernet Passive Optical Network (1G-EPON) and 77.3.6.2 for 10 Gb/s Ethernet Passive Optical Network (10G-EPON), with specific configurations defined in this standard.

service group: For a power-saving mechanism, a group of Optical Network Units (ONUs) operating in the same sleep mode and using the same power-saving parameters, including the duration of the power-saving cycle.

service-level agreement (SLA): A contractual agreement between a provider and a subscriber, which describes the performance the subscriber can expect.

service-level specification (SLS): A set of specific configuration parameters provisioned by the operator to enforce a service-level agreement (SLA).

Service Optical Line Terminal (S-OLT): An S-OLT combines one Client OLT (C-OLT) together with a number of functions residing above the OLT Client Interface (OLT_CI) and a number of Network-to-Network Interface (NNI) ports, e.g., service initiation protocols, Network Address Translation, switching, and plain old telephone ~~system~~ [service](#) (POTS), and other elements appropriate for delivery of specific subscriber services.

Service Optical Network Unit (S-ONU): An S-ONU combines one Client ONU (C-ONU) together with a number of functions residing above the ONU Client Interface (ONU_CI) and a number of user network interface (UNI) ports, e.g., control Central Processing Units (CPUs), switch(es), Voice over Internet Protocol (VoIP), residential/business gateways with Layer 2/Layer 3 capabilities, video overlay with return channel, and other elements appropriate for delivery of specific subscriber services.