

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

IEEE Communications Society

Sponsored by the
Standards Development Board

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1904.1™-2013

14 June 2013

Currently in preview, click buy full version

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

Sponsor

**Standards Development Board
of the
IEEE Communications Society**

Approved 14 June 2013

IEEE-SA Standards Board

Abstract: This standard describes the system-level requirements needed to ensure 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 ensure the interoperability at the Physical Layer (PHY) and Data Link Layer. 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

Grateful acknowledgment is made to The Broadband Forum for the permission to use the following source material:

BBF TR-200, Using EPON in the Context of TR-101, L. D. Lamb and C. Shum, F.I.S., © Copyright 2011, The Broadband Forum, Section 1.2, Figure 1, page 10.

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA
Copyright © 2013 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 20 September 2013. Printed in the United States of America.

DPoE and DOCSIS® standards or products referred to in this standard are trademarks of the Cable Television Laboratories, Inc.

IEEE and IEEE 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-0-7381-8509-5 **STD98293**
Print: ISBN 978-0-7381-8510-1 **STDPD98293**

IEEE prohibits discrimination, harassment and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>. No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Notice and Disclaimer of Liability Concerning the Use of IEEE Documents: IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon any IEEE Standard document.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied "AS IS."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE standard is subjected to review at least every ten years. If a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Translations: The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official Statements: A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE. At conferences, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on Standards: Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important to ensure that any response to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. Any person who would like to participate in evaluating comments or revisions to an IEEE standard is welcome to join the relevant IEEE working group at <http://standards.ieee.org/develop/wg/>.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854-4141
USA

Photocopies: Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Notice to users

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at <http://standards.ieee.org/index.html> or contact the IEEE at the address listed previously. For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA Website at <http://standards.ieee.org/index.html>.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or nondiscriminatory. Users of this standard are expressly advised that

determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this standard was submitted to the IEEE-SA Standards Board for approval, the SIEPON Working Group had the following membership:

Glen Kramer, *Working Group Chair*
Ken-Ichi Suzuki, *Working Group Vice Chair*
Zhou Zhen, *Executive Secretary*
Marek Hajduczenia, *Chief Editor*

Lior Khhermosh, *Service Configuration and Provisioning Task Force Chair*
Alan M. Brown, *Service Configuration and Provisioning Task Force Editor*

Curtis Knittle, *Performance Requirements and Service Quality Task Force Chair*
Jeff Stribling, *Performance Requirements and Service Quality Task Force Editor*

Seiji Kozaki, *Service Survivability Task Force Chair*
Jeff Stribling, *Service Survivability Task Force Editor*

James Chen, *System/Device Management Task Force Chair*
Fumio Daido, *System/Device Management Task Force Editor*

Toshihiko Kusano, *Conformance Test Procedures Task Force Chair*
Marek Hajduczenia, *Conformance Test Procedures Task Force Editor for Package A*
Motoyuki Takizawa, *Conformance Test Procedures Task Force Editor for Package B*
Liu Qian, *Conformance Test Procedures Task Force Editor for Package C*

The following individuals submitted technical contributions or commented on the standard at various stages of the project development.

Venkat Arunarthi, Cortina
Victor Blake, Victor Blake
Wang Bo, China Telecommunications
Zhang Boshan, ZTE Corporation
Alan M. Brown, Aurora Networks
Xiao Chen, Alcatel-Lucent
Shen Chengbin, China Telecom
Fumio Daido, Sumitomo Electric Industries Ltd.
Peng Du, Broadcom Corporation
Hesham ElBakary, Huawei Technologies
Michael Emmert-Dortch, ARRIS
Josh Feinstein, Broadcom Corporation
Marek Hajduczenia, ZTE Corporation
Ryan Heath, Broadcom Corporation
Keisuke Inai, Mitsubishi Electric Corporation
Ryo Inohara, KDDI R&D Laboratories Inc.
Alex Izenberg, Marvell
Qiang Jiang, Broadcom Corporation
Keisuke Jinen, Sumitomo Electric Industries Ltd.
Manabu Kato, PMC-Sierra, Inc.
Lior Khhermosh, PMC-Sierra, Inc.
Mitsunobu Kimura, Hitachi, Ltd.
Curtis Knittle, Cable Television Laboratories
(CableLabs)

Shinichi Kouyama, Sumitomo Electric Industries Ltd.
Seiji Kozaki, Mitsubishi Electric Corporation
Glen Kramer, Broadcom Corporation
Toshihiko Kusano, Oliver Solutions, Ltd.
Lowell Lamb, Broadcom Corporation
Jeff Lapak, University of New Hampshire-IOL
Rick Li, Cortina
Xuguang Li, Qualcomm
Wei Lin, Huawei Technologies
Eric Lynskey, Broadcom Corporation
Bob Mandeville, Iometrix
Jeff Mandin, PMC-Sierra, Inc.
Makoto Matsuoka, Hitachi, Ltd.
Hiroaki Mukai, Mitsubishi Electric Corporation
Daisuke Murayama, NTT Corporation
Kenichi Nakura, Mitsubishi Electric Corporation
Susumu Nishihara, NTT Corporation
Kazumi Onishi, Oki Electric Industry Co., Ltd.
Liu Qian, RITT, CATR
Duane Remein, FiberHome Technologies
Shoichiro Seno, Mitsubishi Electric Corporation
Kenichi Shimamura, NEC
Santanu Sinha, Cortina
Oren Spector, Oliver Solutions, Ltd.

Jeff Stribling, Hitachi Communications Technologies America, Inc.
Takeshi Suehiro, Mitsubishi Electric Corporation
Ken-Ichi Suzuki, NTT Corporation
Masashi Tadokoro, NTT Corporation
Makoto Taguchi, PMC-Sierra, Inc.
Akihiro Takahashi, Oki Electric Industry Co., Ltd.
Motoyuki Takizawa, Fujitsu Telecom Networks, Ltd.

Kiyoshi Uematsu, Oki Electric Industry Co., Ltd.
Chengwei Wang, China Telecommunications Corp.
Lu Yang, RITT, CATR
Hosung Yoon, KT
He Yuanling, ZTE Corporation
Meiyan Zang, ZTE Corporation
Zhou Zhen, FiberHome Technologies

The following members of the entity balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Aurora Networks, Inc.
Broadcom Corporation
Cable Television Laboratories Inc. (CableLabs)
Cortina Systems
FiberHome Technologies Group
FUJITSU
Hitachi, Ltd.
KT Corp.
Maxim Integrated Products

Mitsubishi Electric Corporation
Mstar Semiconductor, Inc.
NEC Corporation
Nippon Telegraph and Telephone Corporation (NTT)
Nokia
Oki Electric Industry Co., Ltd.
Oliver Solutions
PMC-Sierra, Inc.
Qualcomm Incorporated

Research Institute of Telecommunications
Transmission of Ministry of Industry and Information Technology (RIIT) (MIIT)
Sumitomo Electric Industries, LTD
UNH-IOL
Xilinx
ZTE Corporation

When the IEEE-SA Standards Board approved this standard on 14 June 2013, it had the following membership:

John Kulick, Chair
David J. Law, Vice Chair
Richard H. Hulett, Past Chair
Konstantinos Karachalios, Secretary

Masayuki Ariyoshi
Peter Balma
Farooq Bari
Ted Burse
Wael William Diab
Stephen Dukes
Jean-Philippe Faure
Alexander Gelman

Mark Halpin
Gary Hoffman
Paul Houze
Jim Hughes
Michael Janezic
Joseph L. Koepfinger*
Oleg Logvinov

Ron Petersen
Gary Robinson
Jon Walter Rosdahl
Adrian Stephens
Peter Sutherland
Yatin Trivedi
Phil Winston
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Don Messina
IEEE Standards Program Manager, Document Development

Soo H. Kim
IEEE Client Services Manager, Professional Services

Introduction

This introduction is not part of IEEE Std 1904.1-2013, 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 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.

Contents

1	Overview	1
1.1	Scope	1
1.2	Purpose	1
1.3	Coverage	2
1.4	Overview of clauses	2
2	Normative references	4
3	Definitions, acronyms, and abbreviations	7
3.1	Definitions	7
3.2	Acronyms and abbreviations	10
3.3	Special terms	13
3.4	Primitives in SIEPON	16
3.5	Notation for state diagrams	16
3.5.1	General conventions	16
3.5.1.1	Representation of states	17
3.5.1.2	Transitions	17
3.5.2	State diagrams and accompanying text	18
3.5.3	Actions inside state blocks	18
3.5.4	State diagram variables	18
3.5.5	Operators	18
3.5.6	Timers	19
3.5.7	Hexadecimal notation	19
3.5.8	Binary notation	19
3.6	Notation for PICS	19
3.6.1	Abbreviations and special symbols	20
3.6.2	Instructions for completing the PICS proform	20
3.6.3	Additional information	21
3.6.4	Exception information	21
3.6.5	Conditional items	21
4	Specification packages	22
4.1	Introduction	22
4.2	SIEPON packages	22
4.3	Compliance with IEEE Std 20.3	25
4.4	Extended OAM	25
5	Scope and architecture	26
5.1	Introduction	26
5.2	Coverage	26
5.3	EPON system architecture	26
5.3.1	Introduction	26
5.3.2	ODN	27
5.3.3	ONU architecture	28
5.3.3.1	L-ONU	28
5.3.3.2	C-ONU	30
5.3.3.3	S-ONU	30
5.3.4	OLT architecture	30
5.3.4.1	L-OLT	31
5.3.4.2	C-OLT	33
5.3.4.3	S-OLT	33
5.3.5	Interfaces	33
5.3.5.1	ONU_MDI	33
5.3.5.2	OLT_MDI	34

5.3.5.3	ONU_LI	34
5.3.5.4	OLT_LI	34
5.3.5.5	ONU_CI	34
5.3.5.6	OLT_CI	34
5.3.5.7	Internal Interfaces	35
6	MAC Client reference model	36
6.1	Introduction	36
6.2	MAC Client reference model definition	36
6.2.1	Reference model naming nomenclature	38
6.2.1.1	Functional blocks	38
6.2.1.2	Actionable entries	38
6.2.1.3	Functional elements	39
6.3	EPON Service Path definition	40
6.3.1	ESP examples	40
6.3.2	ESP_CTRL definition	42
6.3.2.1	ESP_VECTOR signal	42
6.3.2.2	ESP_COLOR signal	43
6.4	Frame flow through reference model	43
6.4.1	Frame flow through EPON OLT	44
6.4.1.1	Downstream frames through OLT	44
6.4.1.2	Upstream frames through OLT	45
6.4.2	Frame flow through EPON ONU	46
6.4.2.1	Downstream frames through ONU	46
6.4.2.2	Upstream frames through ONU	46
6.5	Blocks in the reference model	47
6.5.1	Input	47
6.5.2	Classifier	47
6.5.2.1	Classification element (rule) structure	48
6.5.2.1.1	Classification fields	49
6.5.2.1.1.1	Flexible access mechanism	52
6.5.2.1.2	Comparison operators	52
6.5.2.2	Classifier provisioning model and parameters	53
6.5.2.2.1	Default configuration	53
6.5.2.2.2	Adding one or more rules	53
6.5.2.2.3	Deleting one or more rules	54
6.5.2.2.4	Querying one or more rules	54
6.5.2.2.5	Clearing all rules	54
6.5.2.2.6	Learning function for the Classifier	55
6.5.2.2.7	Multicast forwarding table at the Classifier	55
6.5.3	Modifier	55
6.5.3.1	Modifier provisioning model and parameters	57
6.5.3.1.1	Default configuration	58
6.5.4	Policer/Shaper	58
6.5.4.1	Policer/Shaper actionable entry	59
6.5.4.2	Policer/Shaper functional elements	59
6.5.4.3	Policer/Shaper provisioning model and parameters	59
6.5.4.3.1	Default configuration	60
6.5.5	CrossConnect	60
6.5.6	Queues	61
6.5.6.1	Default configuration	61
6.5.7	Scheduler	62
6.5.8	Output	62
7	Connectivity configurations	64
7.1	Introduction	64

7.2	VLAN configurations	64
7.2.1	VLAN operations	64
7.2.1.1	Add Tag operation.....	65
7.2.1.1.1	Add C-Tag operation	65
7.2.1.1.2	Add S-Tag operation.....	66
7.2.1.1.3	Add VLAN0 operation	66
7.2.1.1.4	Add VLAN1 operation	67
7.2.1.2	Remove Tag operation	68
7.2.1.2.1	Remove C-Tag operation.....	68
7.2.1.2.2	Remove S-Tag operation	68
7.2.1.2.3	Remove VLAN0 operation	69
7.2.1.2.4	Remove VLAN1 operation	70
7.2.1.3	Replace Tag Field operation	71
7.2.1.3.1	Replace C-Tag operation	71
7.2.1.3.2	Replace S-Tag operation.....	72
7.2.1.3.3	Replace VLAN0 operation	73
7.2.1.3.4	Replace VLAN1 operation	73
7.2.1.4	Double-tagging operations	74
7.2.2	VLAN modes.....	74
7.2.2.1	Device-based VLAN modes.....	75
7.2.2.1.1	OLT Transparent VLAN mode.....	75
7.2.2.1.2	ONU Transparent VLAN mode.....	76
7.2.2.1.3	OLT Tagging VLAN mode	78
7.2.2.1.4	ONU Tagging VLAN mode.....	80
7.2.2.1.5	OLT Translation VLAN mode.....	82
7.2.2.1.6	ONU ToS/CoS Conversion VLAN mode.....	84
7.2.2.1.7	Default configuration	86
7.2.2.1.8	Device-based VLAN management	86
7.2.2.2	Port-based VLAN modes	86
7.2.2.2.1	Transparent VLAN mode	87
7.2.2.2.2	Tagging VLAN mode	88
7.2.2.2.3	Translation VLAN mode	90
7.2.2.2.4	Filtering VLAN mode.....	92
7.2.2.2.5	N:1 Aggregation VLAN mode.....	94
7.2.2.2.6	Default configuration.....	96
7.2.2.2.7	Port-based VLAN management	97
7.2.2.2.8	MAC aging function	97
7.2.2.3	Provider Bridging (PB) VLAN modes	98
7.2.2.3.1	Transport PB VLAN mode	98
7.2.2.3.2	Encapsulation PB VLAN mode	100
7.2.2.3.3	MAC-Source-Address-based admission control function.....	101
7.3	Tunneling configurations	101
7.3.1	Tunneling operations	102
7.3.1.1	Add Tag operation.....	102
7.3.1.1.1	Add I-Header operation	102
7.3.1.1.2	Add B-Tag operation	103
7.3.1.2	Remove Tag operation	103
7.3.1.2.1	Remove I-Header operation.....	103
7.3.1.2.2	Remove B-Tag operation.....	104
7.3.1.3	Replace Tag operation.....	104
7.3.1.3.1	Replace I-Header operation	105
7.3.1.3.2	Replace I-Tag operation.....	105
7.3.1.3.3	Replace B-Tag operation	106
7.3.1.4	Double-tagging operations	106
7.3.2	Tunneling modes.....	107
7.3.2.1	Transport mode	107

7.3.2.2	Encapsulation mode	110
7.4	Multicast configurations	112
7.4.1	Introduction.....	112
7.4.1.1	Multicast transport	114
7.4.1.1.1	Multicast ESP	114
7.4.1.1.2	1G-EPON/10G-EPON coexistence requirements.....	117
7.4.1.1.3	ONU-sourced multicast transport	118
7.4.2	Multicast based on VLAN and/or MAC group address	118
7.4.2.1	Operation outline.....	118
7.4.2.1.1	OLT-based multicast management	119
7.4.2.2	MLD-based multicast control.....	119
7.4.2.2.1	ONU requirements	119
7.4.2.2.2	OLT requirements.....	119
7.4.2.3	Multicast transport based on VLAN	120
7.4.2.3.1	OLT forwarding behavior	120
7.4.2.3.2	ONU forwarding behavior	122
7.4.2.4	Multicast transport based on MAC group address	122
7.4.2.4.1	Static MAC address registration.....	122
7.4.2.4.2	Dynamic MAC address registration.....	123
7.4.3	Multicast based on combined VLAN and group address with no authorization control.....	124
7.4.3.1	Operation outline.....	124
7.4.3.1.1	OLT operation.....	124
7.4.3.1.2	ONU operation.....	124
7.4.3.2	Multicast management and control	125
7.4.3.2.1	ONU requirements	125
7.4.3.2.2	OLT requirements.....	125
7.4.3.3	Multicast transport based on VLAN and MAC group address.....	125
7.4.3.3.1	OLT forwarding behavior	126
7.4.3.3.2	ONU forwarding behavior	126
7.4.3.4	Multicast transport based on VLAN and IP multicast address.....	127
7.4.3.4.1	OLT forwarding behavior.....	128
7.4.3.4.2	ONU forwarding behavior	129
7.4.4	Multicast based on combined VLAN and group address with authorization control.....	131
7.4.4.1	Operation outline.....	131
7.4.4.1.1	OLT operation.....	131
7.4.4.1.2	ONU operation.....	131
7.4.4.2	Multicast management and control	132
7.4.4.2.1	ONU requirements	132
7.4.4.2.2	OLT requirements.....	132
7.4.4.3	Multicast transport based on VLAN and MAC group address.....	133
7.4.4.3.1	OLT forwarding behavior	133
7.4.4.3.2	ONU forwarding behavior	133
7.4.4.4	Multicast transport based on VLAN and IP multicast address.....	133
7.4.4.4.1	OLT forwarding behavior.....	133
7.4.4.4.2	ONU forwarding behavior	134
7.4.4.5	Examples of multicast with authorization control.....	134
7.4.4.5.1	Multicast client prohibited from accessing multicast content	134
7.4.4.5.2	Multicast client permitted to access multicast content.....	134
7.4.4.5.3	Multicast client permitted to temporarily access multicast content	136
7.4.5	Multicast based on combined LLID and IP group addresses.....	138
7.4.5.1	Operation outline.....	138
7.4.5.2	IGMP-based and MLD-based multicast control.....	138
7.4.5.2.1	ONU requirements	138
7.4.5.2.2	OLT requirements.....	138
7.4.5.3	Multicast forwarding based on LLID and IP address.....	139
7.4.5.3.1	OLT forwarding behavior.....	139

7.4.5.3.2	ONU forwarding behavior	141
8	Service performance and QoS guarantees	142
8.1	Introduction.....	142
8.2	Traffic types and services.....	142
8.2.1	Real-time flows with periodic fixed-size data frames.....	142
8.2.1.1	Circuit emulation service	142
8.2.1.2	Mobile backhaul service.....	142
8.2.2	Real-time flows with variable-size data frames or with periodic inactivity.....	142
8.2.2.1	VoIP service.....	143
8.2.2.2	IPTV service	143
8.2.3	Non-real-time flows that require throughput/frame loss guarantees.....	143
8.2.3.1	Guaranteed data service	143
8.2.4	Non-real-time, non-guaranteed flows	143
8.2.4.1	Best effort service	143
8.3	QoS parameters and metrics.....	143
8.3.1	Committed Information Rate and Committed Burst Size parameters.....	144
8.3.2	Excess Information Rate and Excess Burst Size parameters	144
8.3.2.1	Excess Information Rate Weight parameter.....	144
8.3.3	Peak Information Rate and Peak Burst Size parameters	145
8.3.4	Bandwidth assignment methodologies.....	145
8.3.5	Frame delay.....	146
8.3.6	Frame Delay Variation (FDV).....	147
8.3.7	Frame Loss Ratio (FLR).....	147
8.4	QoS mechanisms and configurations.....	148
8.4.1	Configuration supporting DPoE QoS model.....	148
8.4.1.1	Queue service discipline.....	148
8.4.1.2	Report queue length calculation.....	148
8.4.1.3	<i>REPORT</i> MPCPDU format.....	152
8.4.1.3.1	Number of Queue Sets	152
8.4.1.3.2	Number of queues per Queue Set	152
8.4.1.3.3	Queue #n Report.....	153
8.4.1.3.4	Ordering of Queue #n Reports across multiple Queue Sets.....	153
8.4.2	Configuration supporting dedicated thresholds.....	153
8.4.2.1	Queue service discipline.....	153
8.4.2.2	Report queue length calculation.....	154
8.4.2.3	<i>REPORT</i> MPCPDU format with dedicated thresholds	156
8.4.2.3.1	Queue #n Report.....	157
8.4.2.3.2	Maximum value of the Queue #n Report.....	158
8.4.2.3.3	Ordering of Queue #n Report across multiple Queue Sets	158
8.4.2.3.4	Interpretation of the last Queue Set.....	158
8.4.2.3.5	Number of queues per Queue Set	158
8.4.2.3.6	Number of Queue Sets	158
8.4.2.4	Queue management.....	159
8.4.3	Configuration supporting aggregated thresholds	159
8.4.3.1	Queue service discipline.....	159
8.4.3.2	Report queue length calculation.....	160
8.4.3.3	<i>REPORT</i> MPCPDU format with cumulative thresholds.....	162
8.4.3.3.1	Queue #n Report.....	163
8.4.3.3.2	Maximum value of the Queue #n Report.....	164
8.4.3.3.3	Ordering of Queue #n Report across multiple Queue Sets	164
8.4.3.3.4	Interpretation of the first or last Queue Set.....	164
8.4.3.3.5	Number of queues per Queue Set	164
8.4.3.3.6	Number of Queue Sets	165
8.4.3.4	Discovery and configuration of queue parameters	165
8.5	Performance monitoring and verification	166

8.5.1	General requirements	166
8.5.2	Management monitoring requirements	166
8.5.3	Performance monitoring parameters	167
9	Service availability	171
9.1	Device and transceiver status monitoring and diagnostic functions.....	171
9.1.1	Introduction.....	171
9.1.2	IEEE Std 802.3-defined monitoring parameters	171
9.1.2.1	Errored symbol period.....	171
9.1.2.2	Errored frames.....	171
9.1.2.3	Errored frame period	171
9.1.2.4	Errored frame seconds.....	172
9.1.2.5	1G-EPON corrected FEC block counter	172
9.1.2.6	1G-EPON uncorrected FEC block counter	172
9.1.2.7	10/1GBASE-PRX and 10GBASE-PR corrected FEC codewords counter	172
9.1.2.8	10/1GBASE-PRX and 10GBASE-PR uncorrected FEC codewords counter.....	172
9.1.3	Transceiver status monitoring for SFF-8472– and SFF-8077i–compliant DPoE devices	173
9.1.3.1	Optical transceiver temperature.....	173
9.1.3.2	Optical transceiver supply voltage	173
9.1.3.3	Optical transmitter bias current.....	173
9.1.3.4	Optical transmitter output power.....	173
9.1.3.5	Optical receiver input power	173
9.1.4	Transceiver status monitoring, with sampling time requirements.....	173
9.1.4.1	Management requirements for ONUs	173
9.1.4.2	Management requirements for OLTs	174
9.1.4.3	Measurement and monitoring requirements.....	174
9.1.4.4	Optical transceiver temperature.....	174
9.1.4.5	Optical transceiver supply voltage	174
9.1.4.6	Optical transmitter bias current	174
9.1.4.7	Optical transmitter output power.....	174
9.1.4.8	Optical receiver input power for ONUs	175
9.1.4.9	Optical receiver input power for OLTs	175
9.1.4.10	Minimum sampling time for OLTs	175
9.1.5	Transceiver status monitoring requirements	175
9.1.5.1	Management requirements	175
9.1.5.2	Measurement and monitoring requirements.....	176
9.1.5.3	Optical transceiver temperature.....	176
9.1.5.4	Optical transceiver supply voltage	176
9.1.5.5	Optical transmitter unit bias current.....	176
9.1.5.6	Optical transmitter output power.....	176
9.1.5.7	Optical receiver input power	176
9.1.6	Alarms and warnings associated with ONU transmitter status monitoring	177
9.1.7	Management for ONU alarms, warnings, and transceiver status	177
9.1.8	UNI port loop detection	177
9.1.8.1	Introduction.....	177
9.1.8.2	Functional requirements.....	178
9.1.8.3	Management and operational requirements.....	178
9.1.8.4	UNI-UNI loop conditions.....	179
9.1.9	Loopback function	179
9.2	Definitions of events	180
9.2.1	Introduction.....	180
9.2.2	Event-related management operations	180
9.2.2.1	Event set/clear	180
9.2.3	Events associated with the PON Port object.....	181
9.2.3.1	RXPowerAlarmH	182
9.2.3.2	RXPowerAlarmL	182

9.2.3.3	TXPowerAlarmH	182
9.2.3.4	TXPowerAlarmL	183
9.2.3.5	TXBiasAlarmH	183
9.2.3.6	TXBiasAlarmL	183
9.2.3.7	VccAlarmH	183
9.2.3.8	VccAlarmL	183
9.2.3.9	TempAlarmH	183
9.2.3.10	TempAlarmL	183
9.2.3.11	RXPowerWarningH	183
9.2.3.12	RXPowerWarningL	183
9.2.3.13	TXPowerWarningH	184
9.2.3.14	TXPowerWarningL	184
9.2.3.15	TXBiasWarningH	184
9.2.3.16	TXBiasWarningL	184
9.2.3.17	VccWarningH	184
9.2.3.18	VccWarningL	184
9.2.3.19	TempWarningH	184
9.2.3.20	TempWarningL	184
9.2.3.21	DownstreamDropEventsAlarm	184
9.2.3.22	UpstreamDropEventsAlarm	185
9.2.3.23	DownstreamCRCErrorFramesAlarm	185
9.2.3.24	UpstreamCRCErrorFramesAlarm	185
9.2.3.25	DownstreamOversizeFrameAlarm	185
9.2.3.26	UpstreamOversizeFrameAlarm	185
9.2.3.27	DownstreamDiscardsAlarm	185
9.2.3.28	UpstreamDiscardsAlarm	185
9.2.3.29	DownstreamErrorsAlarm	185
9.2.3.30	UpstreamErrorsAlarm	185
9.2.3.31	DownstreamDropEventsWarning	186
9.2.3.32	UpstreamDropEventsWarning	186
9.2.3.33	DownstreamCRCErrorFramesWarning	186
9.2.3.34	UpstreamCRCErrorFramesWarning	186
9.2.3.35	DownstreamOversizeFramesWarning	186
9.2.3.36	UpstreamOversizeFramesWarning	186
9.2.3.37	DownstreamDiscardsWarning	186
9.2.3.38	UpstreamDiscardsWarning	186
9.2.3.39	DownstreamErrorsWarning	186
9.2.3.40	UpstreamErrorsWarning	187
9.2.4	Events associated with the ONU object	187
9.2.4.1	EquipmentAlarm	187
9.2.4.2	PowerAlarm	187
9.2.4.3	BatteryMissing	188
9.2.4.4	BatteryFailure	188
9.2.4.5	BatteryVoltLow	188
9.2.4.6	IntrusionAlarm	188
9.2.4.7	SelfTestFailure	188
9.2.4.8	ONUTempHighAlarm and ONUTempLowAlarm	188
9.2.4.9	PON_IF_Switch	189
9.2.4.10	SleepStatusUpdate	189
9.2.4.11	ActivationSuccessEvent	189
9.2.4.12	ActivationFailureEvent	189
9.2.5	Events associated with the UNI Port object	189
9.2.5.1	EthPortAutoNegFailure	190
9.2.5.2	EthPortLOS	190
9.2.5.3	EthPortConnectionFailure	191
9.2.5.4	EthPortLoopback	191

9.2.5.5	EthPortCongestion	191
9.2.5.6	DownstreamDropEventsAlarm	191
9.2.5.7	UpstreamDropEventsAlarm	191
9.2.5.8	DownstreamCRCErrorFramesAlarm	191
9.2.5.9	UpstreamCRCErrorFramesAlarm	191
9.2.5.10	DownstreamUndersizeFramesAlarm	191
9.2.5.11	UpstreamUndersizeFramesAlarm	191
9.2.5.12	DownstreamOversizeFrameAlarm	191
9.2.5.13	UpstreamOversizeFrameAlarm	192
9.2.5.14	DownstreamFragmentsAlarm	192
9.2.5.15	UpstreamFragmentsAlarm	192
9.2.5.16	DownstreamJabbersAlarm	192
9.2.5.17	UpstreamJabbersAlarm	192
9.2.5.18	DownstreamDiscardsAlarm	192
9.2.5.19	UpstreamDiscardsAlarm	192
9.2.5.20	DownstreamErrorsAlarm	192
9.2.5.21	UpstreamErrorsAlarm	192
9.2.5.22	StatusChangeTimesAlarm	193
9.2.5.23	DownstreamDropEventsWarning	193
9.2.5.24	UpstreamDropEventsWarning	193
9.2.5.25	DownstreamCRCErrorFramesWarning	193
9.2.5.26	UpstreamCRCErrorFramesWarning	193
9.2.5.27	DownstreamUndersizeFramesWarning	193
9.2.5.28	UpstreamUndersizeFramesWarning	193
9.2.5.29	DownstreamOversizeFramesWarning	193
9.2.5.30	UpstreamOversizeFramesWarning	193
9.2.5.31	DownstreamFragmentsWarning	194
9.2.5.32	UpstreamFragmentsWarning	194
9.2.5.33	DownstreamJabbersWarning	194
9.2.5.34	UpstreamJabbersWarning	194
9.2.5.35	DownstreamDiscardsWarning	194
9.2.5.36	UpstreamDiscardsWarning	194
9.2.5.37	DownstreamErrorsWarning	194
9.2.5.38	UpstreamErrorsWarning	194
9.2.5.39	StatusChangeTimesWarning	194
9.2.6	Events defined in IEEE Std 802.3, Clause 57	195
9.2.6.1	Downstream link fault	195
9.2.6.2	Upstream link fault	195
9.2.6.3	Dying Gasp	195
9.2.6.4	ONU critical event	195
9.2.6.5	OLT critical event	196
9.2.7	Event definitions derived from ITU-T G.984.3	196
9.2.7.1	Downstream Signal Failure (SF-D) alarm	196
9.2.7.2	Upstream Signal Failure (SF-U) alarm	196
9.2.7.3	Downstream Signal Degradation (SD-D) alarm	196
9.2.7.4	Upstream Signal Degradation (SD-U) alarm	197
9.2.7.5	Configuring errored frame event parameters	197
9.2.7.6	Alarm setting and clearing process	197
9.2.7.6.1	Variables	197
9.2.7.6.2	Timers	198
9.2.7.6.3	Primitives	198
9.2.7.6.4	State diagrams	199
9.2.8	Loss of service	200
9.3	Optical link protection	200
9.3.1	Introduction	200
9.3.1.1	Terminology	200

9.3.2	Device architecture and requirements	201
9.3.2.1	Line and Client protection	201
9.3.2.1.1	Line device protection	202
9.3.2.1.2	Client device protection	202
9.3.2.2	Line fault detection	203
9.3.2.2.1	OLT detection conditions	203
9.3.2.2.2	ONU detection conditions	203
9.3.3	Trunk protection scheme	204
9.3.3.1	Functional requirements	205
9.3.3.2	C-OLT requirements	206
9.3.3.3	C-ONU requirements	207
9.3.3.4	Configuration messages	207
9.3.3.5	Trunk switching process	207
9.3.3.5.1	Variables	207
9.3.3.5.2	Timers	208
9.3.3.5.3	Functions	208
9.3.3.5.4	Primitives	209
9.3.3.5.5	State diagrams	209
9.3.4	Tree protection scheme	211
9.3.4.1	Functional requirements	212
9.3.4.2	C-OLT requirements	213
9.3.4.3	C-ONU requirements	214
9.3.4.4	Examples of tree protection switching	215
9.3.4.4.1	NMS-driven tree line switchover event	215
9.3.4.4.2	Automated tree line switching with line failure detection	216
9.3.4.4.3	Automated tree line switching with upstream line failure detection	217
9.3.4.4.4	Automated tree line switching with downstream line failure detection	217
9.3.4.5	Configuration messages	218
9.3.4.6	Tree protection process	219
9.3.4.6.1	Constants	219
9.3.4.6.2	Variables	219
9.3.4.6.3	Functions	220
9.3.4.6.4	Primitives	221
9.3.4.6.5	State diagrams	223
9.3.5	Trunk protection scheme with explicit messaging	225
9.3.5.1	Functional requirements	225
9.3.5.2	<i>HOLDOVER</i> message for trunk protection scheme	225
9.3.5.3	Examples of trunk protection switching	226
9.3.5.3.1	Automated trunk protection switching	226
9.3.5.3.2	NMS-driven trunk protection switching	226
9.3.5.4	C-OLT requirements	228
9.3.5.5	C-ONU requirements	228
9.3.5.6	Configuration messages	229
9.3.5.7	Trunk switching process	229
9.3.5.7.1	Primitives	229
9.3.5.7.2	State diagrams	229
9.4	Remote ONU transmitter power supply control function	231
9.4.1	Introduction	231
9.4.2	Remote ONU transmitter power supply control function	231
9.4.2.1	OLT requirements	231
9.4.2.2	ONU requirements	232
9.4.2.3	Coexistence requirements	232
10	Power saving	233
10.1	Introduction	233
10.1.1	Terminology	233

10.2	Objectives of power saving in EPON	234
10.3	Scope of power-saving specifications for EPON	234
10.4	EPON service and power-saving management requirements	235
10.4.1	EPON compliance requirements	235
10.4.2	EPON service requirements	235
10.4.3	Timing requirements	235
10.4.4	EPON power-saving management requirements	236
10.5	Active mechanisms of power saving for EPON	236
10.5.1	Introduction	236
10.5.2	OLT-driven power-saving mechanism	236
10.5.2.1	Introduction	236
10.5.2.2	EPON system-level requirements	236
10.5.2.3	ONU requirements	237
10.5.2.4	OLT requirements	237
10.5.2.5	Power-saving mechanism	238
10.5.2.5.1	Signaling protocol	238
10.5.2.5.2	Initiation stage	238
10.5.2.5.3	Early wake-up	239
10.5.2.5.4	Synchronized wake-up	240
10.5.2.5.5	State diagrams and variable definitions	241
10.5.2.5.5.1	Variables	241
10.5.2.5.5.2	Timers	243
10.5.2.5.5.3	Functions	243
10.5.2.5.5.4	Primitives	243
10.5.2.5.5.5	State diagrams	245
10.5.3	Power-saving mechanism with support for ONU initiation/response	246
10.5.3.1	Introduction	246
10.5.3.2	EPON system-level requirements	246
10.5.3.2.1	Sleep modes	246
10.5.3.3	Power-saving mechanism	247
10.5.3.3.1	Signaling protocol	247
10.5.3.3.2	Initiation stage	247
10.5.3.3.2.1	OLT-initiated power-saving mode	248
10.5.3.3.2.2	ONU-initiated power-saving mode	248
10.5.3.3.3	Termination stage	248
10.5.3.3.4	Early wake-up	250
10.5.3.3.5	Active mode resync wake-up mechanism	250
10.5.3.3.6	State diagrams and variables definitions	251
10.5.3.3.6.1	Variables	251
10.5.3.3.6.2	Timers	255
10.5.3.3.6.3	Functions	256
10.5.3.3.6.4	State diagrams	256
10.5.3.4	Management based on Extension MAC Control frames	259
10.5.3.4.1	Extension MAC Control frame structure for power saving	259
10.5.3.4.2	Extension MAC Control frame types for power saving	259
10.5.3.4.2.1	Extension MAC Control frame type codes for power saving	259
10.5.3.4.2.2	<i>SLEEP_ALLOW</i> message	259
10.5.3.4.2.3	<i>SLEEP_ACK</i> message	260
10.5.3.4.2.4	<i>SLEEP_INDICATION</i> message	260
10.5.4	OLT-driven power-saving mechanism with multiple sleep periods	261
10.5.4.1	Functional requirements	261
10.5.4.2	EPON compliance requirements	261
10.5.4.3	EPON system-level requirements	261
10.5.4.4	ONU requirements	262
10.5.4.5	OLT requirements	263
10.5.4.6	Power-saving mechanism	263

10.5.4.6.1	Signaling protocol.....	263
10.5.4.6.2	Initiation stage.....	263
10.5.4.6.3	Early wake-up.....	264
10.5.4.6.4	Synchronized wake-up.....	264
10.5.4.6.5	Refresh mechanism.....	265
10.5.4.6.6	State diagrams and variable definitions	265
10.5.4.6.6.1	Variables	265
10.5.4.6.6.2	Timers	267
10.5.4.6.6.3	Functions.....	267
10.5.4.6.6.4	Primitives.....	267
10.5.4.6.6.5	State diagrams.....	269
11	Security-oriented mechanisms.....	272
11.1	Introduction.....	272
11.2	Data encryption and integrity protection.....	272
11.2.1	Introduction.....	272
11.2.2	Data encryption in DPoE.....	272
11.2.3	IEEE 802.1AE data encryption.....	272
11.2.3.1	Ciphersuite	272
11.3	ONU authentication and secure provisioning	272
11.3.1	Introduction.....	272
11.3.2	MAC-address-based, Logical-ID-based, and hybrid authentication	272
11.3.2.1	Introduction.....	272
11.3.2.2	Scope.....	273
11.3.2.3	Threat model	273
11.3.2.4	Authentication mechanisms	273
11.3.2.4.1	Requirements	273
11.3.2.4.2	Operation of the OLT authentication function.....	274
11.3.2.4.3	MAC-address-based authentication	274
11.3.2.4.4	Logical-ID-based authentication.....	276
11.3.2.4.5	Hybrid authentication.....	278
11.3.2.4.6	Registration deference mechanism	278
11.3.2.4.7	Authentication state diagrams.....	279
11.3.2.4.7.1	Constants.....	279
11.3.2.4.7.2	Variables	279
11.3.2.4.7.3	Timers	280
11.3.2.4.7.4	Functions.....	280
11.3.2.4.7.5	Primitives.....	281
11.3.2.4.7.6	State diagrams.....	284
11.3.3	ONU authentication in DPoE.....	288
11.3.4	IEEE 802.1X ONU authentication.....	288
11.3.4.1	IEEE 802.1X authentication in EPON	288
11.3.4.1.1	Control frame flow to/from the Authentication agent.....	289
11.3.4.1.2	Control of user traffic according to authentication state	289
11.3.4.2	Authentication mechanisms	290
11.3.4.2.1	IEEE Std 802.1X-2004 and EAP-MD5	290
11.3.4.2.1.1	EAP framing and method.....	291
11.3.4.2.1.2	Authentication sequence	291
11.3.4.2.2	IEEE Std 802.1X-2010 and EAP-GPSK.....	291
11.3.4.2.2.1	EAP framing and method.....	292
11.3.4.2.2.2	Use of EAP-GPSK	292
12	Discovery and maintenance.....	293
12.1	Introduction.....	293
12.2	Device discovery and capability discovery.....	293
12.2.1	Non-SNMP-optimized eOAM management.....	293

12.2.1.1	MPCP/OAM discovery process	293
12.2.1.2	eOAM discovery process	293
12.2.1.2.1	Ordering of <i>Organization Specific Information</i> TLVs.....	294
12.2.1.2.1.1	Source OAM Client requirements.....	294
12.2.1.2.1.2	Destination OAM Client requirements.....	294
12.2.1.2.2	Message flow during eOAM discovery process	294
12.2.1.2.2.1	Constants.....	295
12.2.1.2.2.2	Variables	296
12.2.1.2.2.3	Timers	297
12.2.1.2.2.4	Functions.....	297
12.2.1.2.2.5	Primitives.....	297
12.2.1.2.2.6	State diagrams.....	300
12.2.1.3	OAM and eOAM keep-alive process	301
12.2.1.4	Client ONUs with multiple Line ONUs.....	301
12.2.1.4.1	Introduction.....	301
12.2.1.4.2	OLT-initiated mL-ONU discovery and registration.....	302
12.2.1.4.3	Initialization and mode-negotiation: detailed requirements.....	303
12.2.2	SNMP-optimized eOAM management.....	305
12.2.2.1	MPCP/OAM discovery process	305
12.2.2.2	eOAM discovery process	306
12.2.3	DPoE eOAM management	306
12.2.3.1	MPCP/OAM discovery process	306
12.2.3.2	eOAM discovery process	307
12.2.3.2.1	Requirements	307
12.2.3.2.2	Ordering of <i>Organization Specific Information</i> TLVs.....	308
12.2.3.2.2.1	Source OAM Client requirements.....	308
12.2.3.2.2.2	Destination OAM Client requirements.....	308
12.2.3.2.3	Message flow during eOAM discovery process	308
12.2.3.3	OAM and eOAM keep-alive process	308
12.3	Software updates.....	309
12.3.1	Software upgrade using non-SNMP-optimized eOAM mechanism	309
12.3.1.1	Software upgrade process.....	310
12.3.1.2	Software download process.....	310
12.3.1.2.1	Software image transfer modes.....	310
12.3.1.2.2	Software image download process.....	310
12.3.1.2.2.1	Software image download initiation.....	311
12.3.1.2.2.2	Software image download.....	312
12.3.1.2.2.3	Software image verification	312
12.3.1.3	Software image activation process	313
12.3.1.4	Software image committing process	313
12.3.1.5	Boot Loader process.....	314
12.3.1.6	State diagrams	315
12.3.1.6.1	Constants.....	315
12.3.1.6.2	Variables.....	316
12.3.1.6.3	Timers	318
12.3.1.6.4	Functions.....	319
12.3.1.6.5	Primitives.....	322
12.3.1.6.6	State diagrams.....	330
12.3.2	Software upgrade using SNMP-optimized eOAM management	336
12.3.2.1	Software upgrade types	336
12.3.2.2	Software upgrade procedure.....	336
12.3.2.2.1	Push-type upgrade.....	336
12.3.2.2.2	Pull-type upgrade.....	338
12.3.3	Software upgrade using DPoE eOAM management	340
12.3.3.1	Software image download process	340
12.3.3.1.1	Download initiation step	342

12.3.3.1.2	Download step	342
12.3.3.1.3	Verification step.....	343
12.3.3.1.4	Committing step.....	343
12.3.3.2	State diagrams	344
12.3.3.2.1	Constants.....	344
12.3.3.2.2	Variables	345
12.3.3.2.3	Timers	347
12.3.3.2.4	Functions.....	347
12.3.3.2.5	Primitives.....	348
12.3.3.2.6	State diagrams.....	351
13	Extended OAM for EPON.....	354
13.1	Profile-independent eOAM management.....	354
13.1.1	Requirements	354
13.1.1.1	Functional requirements.....	354
13.1.1.2	Frame size requirements.....	354
13.1.1.3	Frame rate requirements.....	354
13.1.1.4	eOAMPDU structure.....	354
13.2	Non-SNMP-optimized eOAM management.....	354
13.2.1	Timing requirements.....	354
13.2.2	eOAMPDU structure	355
13.2.2.1	eOAMPDU frame format.....	355
13.2.2.2	TLV-oriented structure.....	356
13.2.2.2.1	Variable Descriptor TLV	356
13.2.2.2.2	Variable Container TLV	357
13.2.2.3	TLVs for 802.3 OAMPDU.....	358
13.2.2.3.1	<i>Extended Information</i> TLV	358
13.2.2.3.2	<i>Event Notification</i> TLV.....	359
13.2.3	eOAMPDU	362
13.2.3.1	eOAMPDU codes.....	362
13.2.3.2	<i>eOAM_Get_Request</i> eOAMPDU.....	362
13.2.3.3	<i>eOAM_Get_Response</i> eOAMPDU.....	363
13.2.3.4	<i>eOAM_Set_Request</i> eOAMPDU.....	364
13.2.3.5	<i>eOAM_Set_Response</i> eOAMPDU	365
13.2.3.6	<i>eOAM_Authentication</i> eOAMPDU.....	365
13.2.3.6.1	<i>eOAM_Authentication_Request</i> eOAMPDU	366
13.2.3.6.2	<i>eOAM_Authentication_Response</i> eOAMPDU.....	367
13.2.3.6.3	<i>eOAM_Authentication_Success</i> eOAMPDU	367
13.2.3.6.4	<i>eOAM_Authentication_Failure</i> eOAMPDU.....	368
13.2.3.7	<i>eOAM_Software</i> eOAMPDU	368
13.2.3.7.1	<i>eOAM_Software_FileWriteRequest</i> eOAMPDU	369
13.2.3.7.2	<i>eOAM_Software_FileTransferData</i> eOAMPDU	370
13.2.3.7.3	<i>eOAM_Software_FileTransferACK</i> eOAMPDU	371
13.2.3.7.4	<i>eOAM_Software_FileTransferError</i> eOAMPDU.....	372
13.2.3.7.5	<i>eOAM_Software_EndDownloadRequest</i> eOAMPDU	372
13.2.3.7.6	<i>eOAM_Software_EndDownloadResponse</i> eOAMPDU	373
13.2.3.7.7	<i>eOAM_Software_ActivateImageRequest</i> eOAMPDU	374
13.2.3.7.8	<i>eOAM_Software_ActivateImageResponse</i> eOAMPDU	375
13.2.3.7.9	<i>eOAM_Software_CommitImageRequest</i> eOAMPDU.....	375
13.2.3.7.10	<i>eOAM_Software_CommitImageResponse</i> eOAMPDU	376
13.2.3.8	<i>eOAM_QueueConfig</i> eOAMPDU	377
13.2.3.8.1	<i>eOAM_QueueThreshold_Get</i> eOAMPDU.....	378
13.2.3.8.2	<i>eOAM_QueueThreshold_Info</i> eOAMPDU	378
13.2.3.8.3	<i>eOAM_QueueThreshold_Set</i> eOAMPDU.....	379
13.2.3.8.4	<i>eOAM_QueueThreshold_ACK</i> eOAMPDU.....	381
13.2.3.9	<i>eOAM_Event</i> eOAMPDU	382

13.2.3.9.1	<i>eOAM_EventStatus_Request</i> eOAMPDU	383
13.2.3.9.2	<i>eOAM_EventStatus_Set</i> eOAMPDU	384
13.2.3.9.3	<i>eOAM_EventStatus_Response</i> eOAMPDU	385
13.2.3.9.4	<i>eOAM_EventThreshold_Request</i> eOAMPDU	386
13.2.3.9.5	<i>eOAM_EventThreshold_Set</i> eOAMPDU	386
13.2.3.9.6	<i>eOAM_EventThreshold_Response</i> eOAMPDU	387
13.2.4	eOAMPDU return codes	388
13.3	SNMP-optimized eOAM management	390
13.3.1	eOAMPDU structure	390
13.3.1.1	eOAMPDU frame format	390
13.3.1.2	PDU type	391
13.3.1.3	RequestId	391
13.3.1.4	ErrorStatus	392
13.3.1.5	TLV-oriented structure	392
13.3.1.5.1	Variable Descriptor TLV	392
13.3.1.5.2	Variable Container TLV	393
13.3.2	eOAM sequences	394
13.3.3	eOAMPDU	395
13.3.3.1	<i>GetRequest</i> eOAMPDU	395
13.3.3.2	<i>GetResponse</i> eOAMPDU	396
13.3.3.3	<i>SetRequest</i> eOAMPDU	397
13.3.3.4	<i>SetResponse</i> eOAMPDU	398
13.3.3.5	<i>UserDatagram</i> eOAMPDU	399
13.3.3.5.1	TFTP packet format	399
13.3.3.6	<i>QueueConfig</i> eOAMPDU	400
13.3.3.6.1	<i>ReportParameter_Get</i> eOAMPDU	400
13.3.3.6.2	<i>ReportParameter_Info</i> eOAMPDU	401
13.3.3.6.3	<i>ReportParameter_Set</i> eOAMPDU	403
13.3.3.6.4	<i>ReportParameter_ACK</i> eOAMPDU	405
13.3.3.6.5	<i>QueueThreshold_Get</i> eOAMPDU	406
13.3.3.6.6	<i>QueueThreshold_Info</i> eOAMPDU	406
13.3.3.6.7	<i>QueueThreshold_Set</i> eOAMPDU	409
13.3.3.6.8	<i>QueueThreshold_ACK</i> eOAMPDU	411
13.3.3.7	<i>OnuMIB</i> eOAMPDU	413
13.3.3.8	<i>DefaultFilter</i> eOAMPDU	414
13.3.3.8.1	<i>DefaultFilter_Get</i> eOAMPDU	415
13.3.3.8.2	<i>DefaultFilter_Info</i> eOAMPDU	416
13.3.3.8.3	<i>DefaultFilter_Set</i> eOAMPDU	417
13.3.3.8.4	<i>DefaultFilter_Ack</i> eOAMPDU	418
13.3.4	eOAMPDU return codes	418
13.4	DPoE eOAM management	419
13.4.1	eOAMPDU structure	419
13.4.1.1	eOAMPDU frame format	419
13.4.1.2	TLV-oriented structure	420
13.4.1.2.1	Variable Descriptor TLV	420
13.4.1.2.2	Variable Container TLV	420
13.4.1.2.3	TLVs carrying large values	422
13.4.1.3	TLVs for 802.3 OAMPDU	422
13.4.1.3.1	<i>Extended Information</i> TLV	422
13.4.1.3.2	<i>Event Notification</i> TLV	423
13.4.1.3.2.1	LoS (0x11)	425
13.4.1.3.2.2	Key Exchange Failure (0x12)	425
13.4.1.3.2.3	Port Disabled (0x21)	425
13.4.1.3.2.4	Power Failure (0x41)	425
13.4.1.3.2.5	Statistics Alarm (0x81)	425
13.4.1.3.2.6	ONU Busy (0x82)	426

13.4.1.3.2.7	MAC Table Overflow (0x83).....	426
13.4.1.4	Multipart eOAMPDU response sequence	426
13.4.2	eOAMPDU	427
13.4.2.1	eOAMPDU codes.....	427
13.4.2.2	<i>eOAM_Get_Request</i> eOAMPDU	428
13.4.2.3	<i>eOAM_Get_Response</i> eOAMPDU.....	428
13.4.2.4	<i>eOAM_Set_Request</i> eOAMPDU	429
13.4.2.5	<i>eOAM_Set_Response</i> eOAMPDU	429
13.4.2.6	<i>eOAM_MC_Control</i> eOAMPDU	430
13.4.2.7	<i>eOAM_MC_Register</i> eOAMPDU	431
13.4.2.8	<i>eOAM_MC_Response</i> eOAMPDU	432
13.4.2.9	<i>eOAM_MC_ControlResponse</i> eOAMPDU	432
13.4.2.10	<i>eOAM_Software</i> eOAMPDU	433
13.4.2.10.1	<i>eOAM_Software</i> eOAMPDU structure	433
13.4.2.10.2	<i>eOAM_Software_WriteRequest</i> eOAMPDU	434
13.4.2.10.3	<i>eOAM_Software_FileTransferData</i> eOAMPDU	435
13.4.2.10.4	<i>eOAM_Software_FileTransferAck</i> eOAMPDU	435
13.4.2.11	<i>eOAM_KeyExchange</i> eOAMPDU	436
13.4.2.11.1	<i>eOAM_KeyExchange</i> eOAMPDU structure	437
13.4.2.11.2	<i>eOAM_KeyExchange_Assign</i> eOAMPDU.....	437
13.4.2.11.3	<i>eOAM_KeyExchange_ACK</i> eOAMPDU	438
13.4.2.12	<i>eOAM_Early_WakeUpOLT</i> eOAMPDU	439
13.4.2.13	<i>eOAM_Early_WakeUpONU</i> eOAMPDU	439
13.4.2.14	<i>eOAM_Sleep_Allowed</i> eOAMPDU.....	440
13.4.3	eOAMPDU return codes.....	440
14	Management entities.....	442
14.1	Introduction.....	442
14.2	Management entities for non-SNMP-optimized eOAM profile.....	442
14.2.1	Branch 0x07 “basic attributes”	442
14.2.1.1	Attribute <i>aPhyAdminState</i> (0x07/0x00-25).....	442
14.2.1.2	Attribute <i>aAutoNegAdminState</i> (0x07/0x00-4F).....	443
14.2.1.3	Attribute <i>aAutoNegLocalTechnologyAbility</i> (0x07/0x00-52)	443
14.2.1.4	Attribute <i>aAutoNegAdvertisedTechnologyAbility</i> (0x07/0x00-53)	444
14.2.1.5	Attribute <i>aFECAbility</i> (0x07/0x01-39)	444
14.2.1.6	Attribute <i>aFECmode</i> (0x07/0x01-3A).....	444
14.2.2	Branch 0xC7 “extended attributes”	445
14.2.2.1	Attribute <i>aOnuSerialNumber</i> (0xC7/0x00-01).....	446
14.2.2.2	Attribute <i>aOnuChipsetFwVer</i> (0xC7/0x00-02).....	447
14.2.2.3	Attribute <i>aOnuChipsetId</i> (0xC7/0x00-03).....	448
14.2.2.4	Attribute <i>aOnuTRxStatus</i> (0xC7/0x00-05).....	449
14.2.2.5	Attribute <i>aOnuCapabilities</i> (0xC7/0x00-07).....	450
14.2.2.6	Attribute <i>aOnuConfigTimeDrift</i> (0xC7/0x00-08)	452
14.2.2.7	Attribute <i>aOnuConfigSnmGlobal1</i> (0xC7/0x00-09)	453
14.2.2.8	Attribute <i>aOnuConfigSnmGlobal2</i> (0xC7/0x00-0A).....	455
14.2.2.9	Attribute <i>aOnuConfigPonActive</i> (0xC7/0x00-0B)	456
14.2.2.10	Attribute <i>aOnuCapabilitiesExt</i> (0xC7/0x00-0C)	457
14.2.2.11	Attribute <i>aOnuCapabilitiesPwrSav</i> (0xC7/0x00-0D)	458
14.2.2.12	Attribute <i>aOnuConfigPwrSav</i> (0xC7/0x00-0E)	459
14.2.2.13	Attribute <i>aOnuConfigProtection</i> (0xC7/0x00-0F).....	460
14.2.2.14	Attribute <i>aOnuConfigHguTr069</i> (0xC7/0x00-C1).....	461
14.2.2.15	Attribute <i>aPortEthStatus</i> (0xC7/0x00-11).....	462
14.2.2.16	Attribute <i>aPortEthFlowControl</i> (0xC7/0x00-12).....	463
14.2.2.17	Attribute <i>aPortEthPolicingUs</i> (0xC7/0x00-13)	463
14.2.2.18	Attribute <i>aPortEthPolicingDs</i> (0xC7/0x00-16)	465

14.2.2.19	Attribute <i>aPortLoopDetection</i> (0xC7/0x00-17)	466
14.2.2.20	Attribute <i>aPortDisableLooped</i> (0xC7/0x00-18)	466
14.2.2.21	Attribute <i>aPortVLAN</i> (0xC7/0x00-21)	467
14.2.2.22	Attribute <i>aPortClassAndMark</i> (0xC7/0x00-31)	471
14.2.2.23	Attribute <i>aMulticastVidConfig</i> (0xC7/0x00-41)	475
14.2.2.24	Attribute <i>aMulticastVlanOpConfig</i> (0xC7/0x00-42)	476
14.2.2.25	Attribute <i>aMulticastControlMode</i> (0xC7/0x00-43)	478
14.2.2.26	Attribute <i>aMulticastControlTable</i> (0xC7/0x00-44)	478
14.2.2.27	Attribute <i>aMulticastGroupCountMax</i> (0xC7/0x00-45)	483
14.2.2.28	Attribute <i>aFastLeaveCapab</i> (0xC7/0x00-46)	483
14.2.2.29	Attribute <i>aFastLeaveAdminStatus</i> (0xC7/0x00-47)	484
14.2.2.30	Attribute <i>aOnuTxPowerSupplyControl</i> (0xC7/0x00-A1)	485
14.2.2.31	Attribute <i>aOnuEdpConfigM</i> (0xC7/0x00-A2)	486
14.2.2.32	Attribute <i>aOnuEdpConfigS</i> (0xC7/0x00-A3)	487
14.2.2.33	Attribute <i>aMacAgeTimeConfig</i> (0xC7/0x00-A4)	489
14.2.2.34	Attribute <i>aPerfMonAdminStatus</i> (0xC7/0x00-B1)	490
14.2.2.35	Attribute <i>aPerfMonDataCurrent</i> (0xC7/0x00-B2)	491
14.2.2.36	Attribute <i>aPerfMonDataHistory</i> (0xC7/0x00-B3)	497
14.2.3	Branch 0x37 “identification”	504
14.2.3.1	<i>Object_ID</i> TLV	504
14.2.3.1.1	<i>ObjectType</i> field	505
14.2.3.1.2	<i>ObjectInstance</i> field	505
14.2.3.2	Examples of <i>Object_ID</i> TLV use cases (informative)	506
14.2.4	Branch 0x09 “basic actions”	508
14.2.4.1	Action <i>acOnuUniAdminStatus</i> (0x09/0x00-05)	508
14.2.4.2	Action <i>acOnuUniAutoNegRestart</i> (0x09/0x00-0B)	509
14.2.4.3	Action <i>acOnuUniNegAdminStatus</i> (0x09/0x00-0C)	509
14.2.5	Branch 0xC9 “extended actions”	510
14.2.5.1	Action <i>acOnuReboot</i> (0xC9/0x00-01)	510
14.2.5.2	Action <i>acOnuSleepControl</i> (0xC9/0x00-02)	510
14.2.5.3	Action <i>acFastLeaveAdminControl</i> (0xC9/0x00-48)	511
14.2.5.4	Action <i>acMLOnuMode</i> (0xC9/0x02-02)	512
14.3	Management entities for SNMP-optimized eOAM profile	513
14.3.1	Branch 0xB7 “extended attributes”	513
14.3.1.1	Attribute <i>aOnuEncryptionConfig</i> (0xB7/0x00-01)	514
14.3.1.2	Attribute <i>aQosQueueSetLimit</i> (0xB7/0x00-05)	514
14.3.1.3	Attribute <i>aQosFlowControl</i> (0xB7/0x00-09)	515
14.3.1.4	Attribute <i>aQueueSize</i> (0xB7/0x00-0A)	516
14.3.1.5	Attribute <i>aVlanMode</i> (0xB7/0x00-0B)	518
14.3.1.6	Attribute <i>aOnuErroredFrameWindow</i> (0xB7/0x00-0C)	518
14.3.1.7	Attribute <i>aOnuErroredFrameThr</i> (0xB7/0x00-0D)	519
14.3.1.8	Attribute <i>aQosPolicerRate</i> (0xB7/0x00-0F)	519
14.3.1.9	Attribute <i>aQosPolicerBurst</i> (0xB7/0x00-10)	520
14.3.1.10	Attribute <i>aUnipLinkMode</i> (0xB7/0x00-11)	521
14.3.1.11	Attribute <i>aVlanTagFilter</i> (0xB7/0x00-13)	522
14.3.1.12	Attribute <i>aVlanTagValue</i> (0xB7/0x00-14)	523
14.3.1.13	Attribute <i>aVlanPonVIDValue</i> (0xB7/0x00-15)	524
14.3.1.14	Attribute <i>aOnuFEC</i> (0xB7/0x00-16)	525
14.3.1.15	Attribute <i>aMcastFilterOperation</i> (0xB7/0x00-17)	526
14.3.1.16	Attribute <i>aOnuMACAddressLearning</i> (0xB7/0x00-1C)	527
14.3.1.17	Attribute <i>aPsEligibleModesCapability</i> (0xB7/0x00-20)	528
14.3.1.18	Attribute <i>aPsEarlyWakeupCapability</i> (0xB7/0x00-21)	528
14.3.1.19	Attribute <i>aPsSleepIndCapability</i> (0xB7/0x00-22)	529
14.3.1.20	Attribute <i>aPsAckCapability</i> (0xB7/0x00-23)	529
14.3.1.21	Attribute <i>aPsPowerOnDelay</i> (0xB7/0x00-24)	530
14.3.1.22	Attribute <i>aPsEarlyWakeupConfig</i> (0xB7/0x00-27)	531

14.3.1.23	Attribute <i>aPsSleepIndConfig</i> (0xB7/0x00-28)	531
14.3.1.24	Attribute <i>aPsAckEnableConfig</i> (0xB7/0x00-29)	532
14.3.1.25	Attribute <i>aPsSleepDurationConfig</i> (0xB7/0x00-2A)	532
14.3.1.26	Attribute <i>aPsActiveDurationConfig</i> (0xB7/0x00-2B)	533
14.3.1.27	Attribute <i>aPsHoldDurationConfig</i> (0xB7/0x00-2C)	533
14.3.1.28	Attribute <i>aPonpTemperature</i> (0xB7/0x00-30)	534
14.3.1.29	Attribute <i>aPonpOpticalTRxSupplyVoltage</i> (0xB7/0x00-31)	534
14.3.1.30	Attribute <i>aPonpOpticalTxBiasCurrent</i> (0xB7/0x00-32)	535
14.3.1.31	Attribute <i>aPonpOpticalTxOutputPower</i> (0xB7/0x00-33)	535
14.3.1.32	Attribute <i>aPonpOpticalRxInputPower</i> (0xB7/0x00-34)	536
14.3.1.33	Attribute <i>aUnipTosCosConversion</i> (0xB7/0x00-35)	536
14.3.1.34	Attribute <i>aPtHoldOverTimeOut</i> (0xB7/0x00-38)	538
14.3.1.35	Attribute <i>aPtTLoSOptical</i> (0xB7/0x00-39)	538
14.3.1.36	Attribute <i>aPtTLoSMAC</i> (0xB7/0x00-3A)	539
14.3.1.37	Attribute <i>aOnuSystemInfo</i> (0xB7/0x00-40)	539
14.3.1.38	Attribute <i>aUnipInfo</i> (0xB7/0x00-41)	542
14.3.1.39	Attribute <i>aOnuPriorityQueueCount</i> (0xB7/0x00-42)	543
14.3.1.40	Attribute <i>aUnipTargetQueuePriority</i> (0xB7/0x00-43)	543
14.3.1.41	Attribute <i>aOnuSoftwareDownloadInfo</i> (0xB7/0x00-44)	545
14.3.1.42	Attribute <i>aOnuConfig</i> (0xB7/0x00-45)	546
14.3.2	Branch 0xB6 “object identification”	547
14.3.2.1	<i>Object_ID</i> TLV	547
14.3.2.1.1	<i>ObjectType</i> field	547
14.3.2.1.2	<i>ObjectInstance</i> field	548
14.3.2.2	Example of <i>Object_ID</i> TLV use cases (informative)	548
14.3.3	Branch 0xB9 “extended actions”	551
14.3.3.1	Action <i>acOnuRestart</i> (0xB9/0x00-0E)	551
14.3.3.2	Action <i>acSoftwareDownload</i> (0xB9/0x00-12)	551
14.4	Management entities for DPoE eOAM profile	552
14.4.1	Branch 0xD6 “identification”	552
14.4.1.1	<i>Object Context</i> TLV	552
14.4.1.1.1	<i>ObjectType</i> field	553
14.4.1.1.2	<i>ObjectInstance</i> field	553
14.4.1.1.2.1	<i>ObjectInstance</i> field for ONU (0xD6/0x00-00)	553
14.4.1.1.2.2	<i>ObjectInstance</i> field for PON Port (0xD6/0x00-01)	554
14.4.1.1.2.3	<i>ObjectInstance</i> field for LLID (0xD6/0x00-02)	554
14.4.1.1.2.4	<i>ObjectInstance</i> field for UNI Port (0xD6/0x00-03)	554
14.4.1.1.2.5	<i>ObjectInstance</i> field for Queue (0xD6/0x00-04)	555
14.4.2	Branch 0x07 “basic attributes”	555
14.4.3	Branch 0xD7 “extended attributes”	557
14.4.3.1	ONU management	559
14.4.3.1.1	<i>Sequence</i> TLV (0xD7/0x00-01)	559
14.4.3.1.2	Attribute <i>aOnuId</i> (0xD7/0x00-02)	560
14.4.3.1.3	Attribute <i>aOnuFwVersion</i> (0xD7/0x00-03)	560
14.4.3.1.4	Attribute <i>aOnuInfoChipset</i> (0xD7/0x00-04)	561
14.4.3.1.5	Attribute <i>aOnuInfoDateManufacture</i> (0xD7/0x00-05)	562
14.4.3.1.6	Attribute <i>aOnuInfoManufacturer</i> (0xD7/0x00-06)	563
14.4.3.1.7	Attribute <i>aOnuLlidCount</i> (0xD7/0x00-07)	563
14.4.3.1.8	Attribute <i>aOnuPonPortCount</i> (0xD7/0x00-08)	564
14.4.3.1.9	Attribute <i>aOnuUniPortCount</i> (0xD7/0x00-09)	564
14.4.3.1.10	Attribute <i>aOnuInfoPacketBuffer</i> (0xD7/0x00-0A)	565
14.4.3.1.11	Attribute <i>aLlidReportThresholds</i> (0xD7/0x00-0B)	566
14.4.3.1.12	Attribute <i>aLlidForwardState</i> (0xD7/0x00-0C)	567
14.4.3.1.13	Attribute <i>aLlidOamFrameRate</i> (0xD7/0x00-0D)	568
14.4.3.1.14	Attribute <i>aOnuManOrgName</i> (0xD7/0x00-0E)	569

14.4.3.1.15	Attribute <i>aOnuCvcCvsValidity</i> (0xD7/0x00-0F)	569
14.4.3.1.16	Attribute <i>aOnuUniPortType</i> (0xD7/0x00-10)	570
14.4.3.2	Bridging	571
14.4.3.2.1	Attribute <i>aUniDynMacTableSize</i> (0xD7/0x01-01)	571
14.4.3.2.2	Attribute <i>aUniDynMacAgeLimit</i> (0xD7/0x01-02)	572
14.4.3.2.3	Attribute <i>aUniDynMacTable</i> (0xD7/0x01-03)	572
14.4.3.2.4	Attribute <i>aUniStatMacTable</i> (0xD7/0x01-04)	573
14.4.3.2.5	Attribute <i>aUniPortAutoNeg</i> (0xD7/0x01-05)	574
14.4.3.2.6	Attribute <i>aUniAdmissionControl</i> (0xD7/0x01-06)	575
14.4.3.2.7	Attribute <i>aUniMinLearnMacCount</i> (0xD7/0x01-07)	576
14.4.3.2.8	Attribute <i>aUniMaxLearnMacCount</i> (0xD7/0x01-08)	576
14.4.3.2.9	Attribute <i>aOnuMaxLearnMacCount</i> (0xD7/0x01-09)	577
14.4.3.2.10	Attribute <i>aUniLengthDiscard</i> (0xD7/0x01-0A)	577
14.4.3.2.11	Attribute <i>aUniFloodUnknown</i> (0xD7/0x01-0B)	578
14.4.3.2.12	Attribute <i>aUniLocalSwitching</i> (0xD7/0x01-0C)	578
14.4.3.2.13	Attribute <i>aOnuLlidQueueConfig</i> (0xD7/0x01-0D)	579
14.4.3.2.14	Attribute <i>aOnuFwFileName</i> (0xD7/0x01-0E)	581
14.4.3.2.15	Attribute <i>aUniMacTableFull</i> (0xD7/0x01-0F)	581
14.4.3.3	Statistics and counters	582
14.4.3.3.1	Attribute <i>aCountRxFramesGreen</i> (0xD7/0x02-01)	582
14.4.3.3.2	Attribute <i>aCountTxFramesGreen</i> (0xD7/0x02-02)	582
14.4.3.3.3	Attribute <i>aCountRxFrames2Short</i> (0xD7/0x02-03)	583
14.4.3.3.4	Attribute <i>aCountRxFrames64</i> (0xD7/0x02-04)	583
14.4.3.3.5	Attribute <i>aCountRxFrames65to127</i> (0xD7/0x02-05)	584
14.4.3.3.6	Attribute <i>aCountRxFrames128to255</i> (0xD7/0x02-06)	584
14.4.3.3.7	Attribute <i>aCountRxFrames256to511</i> (0xD7/0x02-07)	585
14.4.3.3.8	Attribute <i>aCountRxFrames512to1023</i> (0xD7/0x02-08)	585
14.4.3.3.9	Attribute <i>aCountRxFrames1024to1518</i> (0xD7/0x02-09)	586
14.4.3.3.10	Attribute <i>aCountRxFrames1519</i> (0xD7/0x02-0A)	587
14.4.3.3.11	Attribute <i>aCountTxFrames64</i> (0xD7/0x02-0B)	587
14.4.3.3.12	Attribute <i>aCountTxFrames65to127</i> (0xD7/0x02-0C)	588
14.4.3.3.13	Attribute <i>aCountTxFrames128to255</i> (0xD7/0x02-0D)	588
14.4.3.3.14	Attribute <i>aCountTxFrames256to511</i> (0xD7/0x02-0E)	589
14.4.3.3.15	Attribute <i>aCountTxFrames512to1023</i> (0xD7/0x02-0F)	589
14.4.3.3.16	Attribute <i>aCountTxFrames1024to1518</i> (0xD7/0x02-10)	590
14.4.3.3.17	Attribute <i>aCountTxFrames1519</i> (0xD7/0x02-11)	590
14.4.3.3.18	Attribute <i>aQueueDelayThr</i> (0xD7/0x02-12)	591
14.4.3.3.19	Attribute <i>aQueueDelayValue</i> (0xD7/0x02-13)	591
14.4.3.3.20	Attribute <i>aCountFramesDropped</i> (0xD7/0x02-14)	592
14.4.3.3.21	Attribute <i>aCountOctetsDropped</i> (0xD7/0x02-15)	592
14.4.3.3.22	Attribute <i>aCountOctetsDelayed</i> (0xD7/0x02-16)	593
14.4.3.3.23	Attribute <i>aCountUsOctetsUnused</i> (0xD7/0x02-17)	593
14.4.3.3.24	Attribute <i>aPonOptMonitTemp</i> (0xD7/0x02-1D)	594
14.4.3.3.25	Attribute <i>aPonOptMonitVcc</i> (0xD7/0x02-1E)	594
14.4.3.3.26	Attribute <i>aPonOptMonitBias</i> (0xD7/0x02-1F)	595
14.4.3.3.27	Attribute <i>aPonOptMonitTxPower</i> (0xD7/0x02-20)	595
14.4.3.3.28	Attribute <i>aPonOptMonitRxPower</i> (0xD7/0x02-21)	596
14.4.3.3.29	Attribute <i>aCounterRxFramesY</i> (0xD7/0x02-22)	596
14.4.3.3.30	Attribute <i>aCounterTxFramesY</i> (0xD7/0x02-23)	597
14.4.3.3.31	Attribute <i>aCounterTxOctetsG</i> (0xD7/0x02-24)	597
14.4.3.3.32	Attribute <i>aCounterRxOctetsY</i> (0xD7/0x02-25)	598
14.4.3.3.33	Attribute <i>aCounterRxOctetsG</i> (0xD7/0x02-26)	598
14.4.3.3.34	Attribute <i>aCounterTxOctetsY</i> (0xD7/0x02-27)	599
14.4.3.3.35	Attribute <i>aCounterTxFramesL2Unicast</i> (0xD7/0x02-28)	599
14.4.3.3.36	Attribute <i>aCounterTxFramesL2Multicast</i> (0xD7/0x02-29)	600
14.4.3.3.37	Attribute <i>aCounterTxFramesL2Broadcast</i> (0xD7/0x02-2A)	600

14.4.3.3.38	Attribute <i>aCounterRxFramesL2Unicast</i> (0xD7/0x02-2B)	601
14.4.3.3.39	Attribute <i>aCounterRxFramesL2Multicast</i> (0xD7/0x02-2C)	601
14.4.3.3.40	Attribute <i>aCounterRxFramesL2Broadcast</i> (0xD7/0x02-2D)	602
14.4.3.3.41	Attribute <i>aOnuCounterNumber</i> (0xD7/0x02-2E)	602
14.4.3.3.42	Attribute <i>aCounterRxFramesL2CP</i> (0xD7/0x02-2F)	603
14.4.3.3.43	Attribute <i>aCounterRxOctetsL2CP</i> (0xD7/0x02-30)	603
14.4.3.3.44	Attribute <i>aCounterTxFramesL2CP</i> (0xD7/0x02-31)	604
14.4.3.3.45	Attribute <i>aCounterTxOctetsL2CP</i> (0xD7/0x02-32)	604
14.4.3.3.46	Attribute <i>aCounterDiscardFramesL2CP</i> (0xD7/0x02-33)	605
14.4.3.3.47	Attribute <i>aCounterDiscardOctetsL2CP</i> (0xD7/0x02-34)	605
14.4.3.3.48	Attribute <i>aCounterL2TxErrors</i> (0xD7/0x02-35)	606
14.4.3.3.49	Attribute <i>aCounterL2RxErrors</i> (0xD7/0x02-36)	606
14.4.3.4	Alarms	607
14.4.3.4.1	Attribute <i>aAlarmPortStatThr</i> (0xD7/0x03-01)	607
14.4.3.4.2	Attribute <i>aAlarmLlidStatThr</i> (0xD7/0x03-02)	608
14.4.3.4.3	Attribute <i>aAlarmStatusControl</i> (0xD7/0x03-03)	609
14.4.3.5	Encryption	611
14.4.3.5.1	Attribute <i>aEncryptionKeyExpiration</i> (0xD7/0x04-01)	611
14.4.3.5.2	Attribute <i>aEncryptionMode</i> (0xD7/0x04-02)	612
14.4.3.6	Frame processing	612
14.4.3.6.1	Attribute <i>aRuleSetConfig</i> (0xD7/0x05-01)	612
14.4.3.6.1.1	<i>aRuleSetConfig.sClause</i> sub-attribute	613
14.4.3.6.1.2	<i>aRuleSetConfig.sResult</i> sub-attribute	616
14.4.3.6.1.3	<i>Port Ingress Rule</i> TLV	619
14.4.3.6.2	Attribute <i>aRuleCustomField</i> (0xD7/0x05-02)	623
14.4.3.6.2.1	Preamble/L2 Header layer	625
14.4.3.6.2.2	IEEE 802.1ah layer	626
14.4.3.6.2.3	EtherType layer	626
14.4.3.6.2.4	S-VLAN layer	626
14.4.3.6.2.5	C-VLAN layer	627
14.4.3.6.2.6	Multiprotocol Label Switching (MPLS) layer	627
14.4.3.6.2.7	IPv4 layer	627
14.4.3.6.2.8	IPv6 field	628
14.4.3.6.2.9	Generic L3 layer	628
14.4.3.6.2.10	TCP/UDP layer	628
14.4.3.6.2.11	Generic L4 layer	629
14.4.3.6.3	Attribute <i>aRuleTpidCAAlter</i> (0xD7/0x05-03)	629
14.4.3.6.4	Attribute <i>aRuleTpidSAAlter</i> (0xD7/0x05-04)	630
14.4.3.6.5	Attribute <i>aRuleIpmcFwrConfig</i> (0xD7/0x05-05)	631
14.4.3.6.6	Attribute <i>aRuleTpidIAAlter</i> (0xD7/0x05-06)	632
14.4.3.6.7	Attribute <i>aRuleTpidBAAlter</i> (0xD7/0x05-07)	633
14.4.3.7	Service-level agreements (SLAs)	634
14.4.3.7.1	Attribute <i>aRateLimitBroadcast</i> (0xD7/0x06-01)	634
14.4.3.7.2	Attribute <i>aQueueCIR</i> (0xD7/0x06-04)	634
14.4.3.7.3	Attribute <i>aFecMode</i> (0xD7/0x06-05)	635
14.4.3.7.4	Attribute <i>aQueueEIR</i> (0xD7/0x06-06)	636
14.4.3.7.5	Attribute <i>aQueueColorMarking</i> (0xD7/0x06-07)	637
14.4.3.7.6	Attribute <i>aQueueRateLimiterCap</i> (0xD7/0x06-08)	639
14.4.3.7.7	Attribute <i>aCouplingFlag</i> (0xD7/0x06-09)	641
14.4.3.8	Power saving	641
14.4.3.8.1	Attribute <i>aOnuPwrSavingCap</i> (0xD7/0xFF-FF)	641
14.4.3.9	Clock transport	642
14.4.3.9.1	Attribute <i>aClockTranspCapab</i> (0xD7/0x07-01)	642
14.4.3.9.2	Attribute <i>aClockTranspStatus</i> (0xD7/0x07-02)	643
14.4.3.9.3	Attribute <i>aClockTranspTransfer</i> (0xD7/0x07-03)	644
14.4.3.9.4	Attribute <i>aClockTranspPropagParam</i> (0xD7/0x07-04)	645

14.4.3.9.5	Attribute <i>aClockTranspRtt</i> (0xD7/0x07-05)	646
14.4.3.10	Demarc auto-configuration	646
14.4.3.10.1	Attribute <i>aDacConfig</i> (0xD7/0x08-00)	646
14.4.3.10.2	Attribute <i>aDacConfigFlags</i> (0xD7/0x08-01)	647
14.4.3.10.3	Attribute <i>aDacPassChallenge</i> (0xD7/0x08-02)	649
14.4.3.10.4	Attribute <i>aDacStatus</i> (0xD7/0x08-03)	649
14.4.4	Branch 0x09 “basic actions”	650
14.4.5	Branch 0xD9 “extended actions”	650
14.4.5.1	ONU management	651
14.4.5.1.1	Action <i>acOnuReboot</i> (0xD9/0x00-01)	651
14.4.5.2	Bridging	651
14.4.5.2.1	Action <i>acMacClearDynamicTable</i> (0xD9/0x01-01)	651
14.4.5.2.2	Action <i>acMacAddDynamicAddress</i> (0xD9/0x01-02)	651
14.4.5.2.3	Action <i>acMacDeleteDynamicAddress</i> (0xD9/0x01-03)	652
14.4.5.2.4	Action <i>acMacClearStaticTable</i> (0xD9/0x01-04)	653
14.4.5.2.5	Action <i>acMacAddStaticAddress</i> (0xD9/0x01-05)	653
14.4.5.2.6	Action <i>acMacDeleteStaticAddress</i> (0xD9/0x01-06)	654
14.4.5.3	Statistics and counters	655
14.4.5.3.1	Action <i>acCountersClear</i> (0xD9/0x02-01)	655
14.4.5.4	Alarms	655
14.4.5.4.1	Action <i>acAlarmGetCurrentSummary</i> (0xD9/0x03-01)	655
14.4.5.5	Frame processing	656
14.4.5.5.1	Action <i>acRulesClearAll</i> (0xD9/0x05-01)	656
14.4.5.5.2	Action <i>acRulesAddOne</i> (0xD9/0x05-02)	656
14.4.5.5.3	Action <i>acRulesDeleteOne</i> (0xD9/0x05-03)	656
14.4.5.6	Transmission control	656
14.4.5.6.1	Action <i>acEnableUserTraffic</i> (0xD9/0x06-01)	656
14.4.5.6.2	Action <i>acDisableUserTraffic</i> (0xD9/0x06-02)	657
14.4.5.6.3	Action <i>acLoopbackEnable</i> (0xD9/0x06-03)	657
14.4.5.6.4	Action <i>acLoopbackDisable</i> (0xD9/0x06-04)	658
14.4.5.6.5	Action <i>acLaserTxPowerOff</i> (0xD9/0x06-05)	658
14.4.6	Branch 0xD8 “programmable counters”	659
14.4.6.1	Attribute <i>aCounterGeneralN</i> (0xD8/0x00-00 to 0xD8/0x7F-FF)	659
Annex 4A	(normative) Protocol implementation conformance statement (PICS) for Package A	660
4A.1	Introduction	660
4A.2	ONU-specific PICS	661
4A.2.1	Implementation identification	661
4A.2.2	Protocol summary	661
4A.2.3	REPORT MPCP format	661
4A.2.4	Report queue length calculation	662
4A.2.5	Queue service discipline	662
4A.2.6	ONU transceiver status monitoring	662
4A.2.7	Events	663
4A.2.8	Data encryption	664
4A.2.9	ONU authentication	664
4A.2.10	Management	664
4A.2.11	Device and capability discovery	667
4A.2.12	Software update	668
4A.2.13	Management entities	668
4A.2.14	Port-specific loopback	681
4A.2.15	Power saving	682
4A.2.16	ONU VLAN modes	683
4A.2.17	ONU tunneling modes	683
4A.2.18	Multicast connectivity	684
4A.3	OLT-specific PICS	685

4A.3.1	Implementation identification	685
4A.3.2	Protocol summary	685
4A.3.3	REPORT MPCP format	685
4A.3.4	OLT transceiver status monitoring	686
4A.3.5	Events	687
4A.3.6	Data encryption	687
4A.3.7	ONU authentication	687
4A.3.8	Management	687
4A.3.9	Device and capability discovery	690
4A.3.10	Software update	691
4A.3.11	Management entities	691
4A.3.12	Port-specific loopback	701
4A.3.13	Power saving	701
4A.3.14	OLT VLAN modes	702
4A.3.15	OLT tunneling modes	702
4A.3.16	Multicast connectivity	703
4A.3.17	Multicast connectivity, coexistence	704
Annex 4B	(normative) PICS for Package B	705
4B.1	Introduction	705
4B.2	ONU-specific PICS	706
4B.2.1	Implementation identification	706
4B.2.2	Protocol summary	706
4B.2.3	REPORT MPCP format	706
4B.2.4	Report queue length calculation	708
4B.2.5	Queue service discipline	708
4B.2.6	Discovery and configuration of queue parameters	709
4B.2.7	ONU transceiver status monitoring	710
4B.2.8	Events	711
4B.2.9	Optical link protection, trunk type	711
4B.2.10	Data encryption	711
4B.2.11	ONU authentication	711
4B.2.12	Management	712
4B.2.13	Device and capability discovery	717
4B.2.14	Software update	717
4B.2.15	Management entities	718
4B.2.16	Power saving	721
4B.2.17	ONU VLAN modes	722
4B.2.18	Multicast connectivity	724
4B.3	OLT-specific PICS	725
4B.3.1	Implementation identification	725
4B.3.2	Protocol summary	725
4B.3.3	REPORT MPCP format	725
4B.3.4	Report queue length calculation	726
4B.3.5	Queue service discipline	726
4B.3.6	Discovery and configuration of queue parameters	727
4B.3.7	OLT transceiver status monitoring	727
4B.3.8	Events	728
4B.3.9	Optical link protection, trunk type	728
4B.3.10	Data encryption	729
4B.3.11	ONU authentication	729
4B.3.12	Management	730
4B.3.13	Device and capability discovery	732
4B.3.14	Software update	733
4B.3.15	Management entities	733
4B.3.16	Power saving	736

4B.3.17 OLT VLAN modes	737
4B.3.18 Multicast connectivity.....	738
4B.3.19 Multicast connectivity, coexistence	739
Annex 4C (normative) PICS for Package C	740
4C.1 Introduction.....	740
4C.2 ONU-specific PICS.....	741
4C.2.1 Implementation identification	741
4C.2.2 Protocol summary	741
4C.2.3 Support for EDP.....	741
4C.2.4 REPORT MPCP format.....	742
4C.2.5 Report queue length calculation.....	742
4C.2.6 Queue service discipline	743
4C.2.7 ONU transceiver status monitoring.....	743
4C.2.8 UNI port loop detection	743
4C.2.9 Remote ONU transmitter power supply control	744
4C.2.10 Events	744
4C.2.11 Trunk protection	746
4C.2.12 Tree protection.....	746
4C.2.13 ONU authentication	747
4C.2.14 Management.....	748
4C.2.15 Device and capability discovery	753
4C.2.16 Software update	754
4C.2.17 Management entities	755
4C.2.18 Power saving.....	762
4C.2.19 Performance monitoring	763
4C.2.20 ONU VLAN modes	764
4C.2.21 Multicast connectivity.....	766
4C.2.22 MAC aging	768
4C.3 OLT-specific PICS.....	769
4C.3.1 Implementation identification	769
4C.3.2 Protocol summary	769
4C.3.3 Support for EDP.....	769
4C.3.4 REPORT MPCP format.....	770
4C.3.5 OLT transceiver status monitoring	770
4C.3.6 UNI port loop detection	770
4C.3.7 Remote ONU transmitter power supply control	771
4C.3.8 Events	771
4C.3.9 Trunk protection	772
4C.3.10 Tree protection.....	772
4C.3.11 ONU authentication	773
4C.3.12 Management.....	774
4C.3.13 Device and capability discovery	777
4C.3.14 Software update	778
4C.3.15 Management entities	779
4C.3.16 Power saving.....	784
4C.3.17 Performance monitoring	786
4C.3.18 OLT VLAN modes	786
4C.3.19 Multicast connectivity.....	788
4C.3.20 Multicast connectivity, coexistence	791
4C.3.21 MAC aging	792
Annex 5A (informative) Relation to other architecture models	793
5A.1 Introduction.....	793
5A.2 Relation to the BBF TR-200 architecture model.....	793
5A.2.1 A single-customer ONU architecture.....	793

5A.2.2 A multi-customer ONU architecture.....	794
5A.3 Relation to the MEF 10.2 architecture model	795
Annex 7A (normative) EPON Data Path (EDP) of BBF TR-200	796
7A.1 Introduction.....	796
7A.2 EDP definition	796
7A.3 EDP identification.....	796
7A.4 EDP implementation.....	796
7A.5 EDP management.....	799
Annex 9A (informative) Measurement of bRTT in trunk-protected EPON.....	800
9A.1 Introduction.....	800
9A.2 Method 1: dynamic measurement of bRTT	800
9A.3 Method 2: post-switchover measurement of bRTT.....	801

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

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

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.

1.2 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 Information on references can be found in Clause 2.