

# **DOCSIS® Provisioning of EPON Specifications**

## **DPoEv2.0**

### **DPoE OAM Extensions Specification**

#### **DPoEv2.0-SP-OAMv2.0-I15-230322**

**ISSUED**

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## Document Status Sheet

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                      |                             |                   |
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### Key to Document Status Codes

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# 1 INTRODUCTION

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

Ethernet PON (EPON) is an [802.3] standard for a passive optical network (PON). A PON is a specific type of multi-access optical network. A multi-access optical network is an optical fiber based network technology that permits more than two network elements to transmit and receive on the same fiber.

DPoE specifications are focused on DOCSIS-based provisioning and operations of Internet Protocol (IP) using DOCSIS Internet service (which is typically referred to as High Speed Data (HSD)), or IP(HSD) for short, and Metro Ethernet services as described by Metro Ethernet Forum (MEF) standards. DPoE Networks offer IP(HSD) services functionally equivalent to DOCSIS networks, where the DPoE System acts like a DOCSIS CMTS and the DPoE System and DPoE Optical Network Unit (ONU) together act like a DOCSIS CM.

## 1.1 DPoE Technology Introduction

DPoE technology was established with the following common requirements already developed by operators. Each of the participant operators had previously selected 1G-EPON and 10G-EPON as the appropriate technology for one or more applications. EPON is a widely-deployed technology with a sufficient and large supply of vendors offering a variety of products for each component of the access network. 2G-EPON, as described Annex A of [DPoE-PHYv2.0], uses the same 1G upstream as 1G-EPON (operates at the effective rate of 1 Gbps), but provides a 2G downstream (operates at the effective rate of 2 Gbps). With the exception of requirements specified in Annex A of [DPoE-PHYv2.0], 2G-EPON is expected to meet all of the requirements specified for 1G-EPON. 10G-EPON technology is now becoming available and is backwards compatible with 1G-EPON. A 1G-EPON network can be incrementally upgraded to 10G-EPON, adding or replacing ONUs as business needs require. 1G-EPON, 2G-EPON, and 10G-EPON are compatible with [SCTE 174].

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

Existing [802.3ah] EPON systems do interoperate within the strict definitions of 1G-EPON. Experience with lab testing, field trials, and deployments has shown operators that 1G-EPON OLT and ONU systems typically only interoperate with a single port ONU. This is because [802.3ah] specifies the interfaces on the PON (the DPoE TU interface) but does not specify any of the other system interfaces. For example, an OLT from vendor A will register an ONU from vendor B, but it is not possible to construct a VLAN from the DPoE MN interface to an S interface. This is a well-recognized limitation of [802.3ah]. The challenge is that neither 1G-EPON nor 10G-EPON specify OAMP to forward traffic between Network to Network Interface (NNI) ports (I-NNI for MEF or NSI for L2VPN or IP(HSD)) and the PON, or UNI ports and the PON. This is not different from other Ethernet standards. For example, if two Ethernet switches from two different vendors are connected, each switch must typically be configured independently. The challenge for EPON is that the remote device (the ONU) cannot be reached, and therefore cannot be configured. A solution to this problem must then be based on developing a common (standard) method of reaching the controller for the ONU, identifying the ONU capabilities, and providing that information to the OLT so that it can configure the ONU to forward traffic.

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

## 1.2 Scope

Since the vCM operates on the DPoE System (instead of the D-ONU), a means of communication from the vCM to the D-ONU is required. The D-ONU does not require an IP stack. Therefore, [802.3] standard EPON OAM is used for messaging between the vCM on the DPoE System and the D-ONU. The OAM Extensions specified here provide additional means for such messaging for parameters not supported in the [802.3] standard EPON OAM. The [802.3] specifications allow vendor-specific OAM extensions. This document describes the usage of this extension feature to provide for a common set of OAM extensions to support interoperability between all vendors that choose to develop products in accordance with the DPoE specifications.

This document defines the interface used for conveying management information between a DPoE System and D-ONU. This specification defines message format and contents for the following types of configuration or information collection:

- General management and device capabilities
- Forwarding provisioning
- Statistics collection
- Alarm status
- Security key exchange
- Frame processing and classification
- Quality of Service provisioning
- Time Synchronization (ToD, Frequency, and Phase)

Implementations that conform to this specification are required to implement all the features defined in this specification.

Implementations may also implement other [802.3] Clause 57 OAM extensions if desired. DPoE implementations that conform to this specification must fully interoperate with other DPoE implementations that conform to this specification regardless of the presence or absence of other OAM extensions.

## 1.3 DPoE OAM Specification Goals

The goals of the DPoE OAM Specification are to:

- Provide a common method of managing D-ONUs from different vendors to ensure interoperability;
- Define packet formats and data encodings to support DPoE features;
- Provide a "toolkit" of features from which these DPoE features can be constructed (rather than just assign monolithic blocks of parameters for each feature individually);
- Establish specifications for OAM parameters, behavior, and extended features where such are needed;
- Limit complexity and cost of D-ONU devices by adapting L2 management protocols previously used in EPON.

## 1.4 Requirements

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

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

## 1.5 DPoE Version 2.0 Specifications

A list of the specifications included in the DPoE 2.0 series is provided in Table 1. For further information please refer to <http://www.cablelabs.com/specs/specification-search/?cat=dpoe&scat=dpoe-2-0>.

**Table 1 - DPoE 2.0 Series of Specifications**

| Designation       | Title                                                      |
|-------------------|------------------------------------------------------------|
| DPoE-SP-ARCHv2.0  | DPoE Architecture Specification                            |
| DPoE-SP-OAMv2.0   | DPoE OAM Extensions Specification                          |
| DPoE-SP-PHYv2.0   | DPoE Physical Layer Specification                          |
| DPoE-SP-SECv2.0   | DPoE Security and Certificate Specification                |
| DPoE-SP-IPNEv2.0  | DPoE IP Network Element Requirements                       |
| DPoE-SP-MULPIv2.0 | DPoE MAC and Upper Layer Protocols Interface Specification |
| DPoE-SP-MEFv2.0   | DPoE Metro Ethernet Forum Specification                    |
| DPoE-SP-OSSiv2.0  | DPoE Operations and Support System Interface Specification |

## 1.6 Reference Architecture

See Section 1.6 in [DPoE-ARCHv2.0].

## 1.7 DPoE Interfaces and Reference Points

See Section 1.7 in [DPoE-ARCHv2.0].

## 2 REFERENCES

### 2.1 Normative References

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

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

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [802.1]          | Refers to entire suite of IEEE 802.1 standards unless otherwise specified.                                                                                                                                                                                                                                                                                                                                                         |
| [802.1Q]         | IEEE Std 802.1Q-2018, IEEE Standard for Local and Metropolitan Area Networks – Bridges and Bridged Networks, July 2018.                                                                                                                                                                                                                                                                                                            |
| [802.3]          | IEEE Std 802.3-2012, IEEE Standard for Ethernet, December 2012.                                                                                                                                                                                                                                                                                                                                                                    |
| [802.3av]        | IEEE Std 802.3av-2009, IEEE Standard for Information Technology-Telecommunications and Information Systems – Local and Metropolitan Area Networks – Specific requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Amendment 1: Physical Layer Specifications and Management Parameters for 10Gb/s Passive Optical Networks, now part of [802.3]. |
| [1904.1A]        | IEEE Std 1904.1-2017, IEEE Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON).                                                                                                                                                                                                                                                                                                                    |
| [DPoE-ARCHv2.0]  | DOCSIS Provisioning of EPON, DPoE Architecture Specification, DPoE-SP-ARCHv2.0-I08-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                     |
| [DPoE-IPNEv2.0]  | DOCSIS Provisioning of EPON, IP Network Element Requirements, DPoE-SP-IPNEv2.0-I08-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                     |
| [DPoE-MEFv2.0]   | DOCSIS Provisioning of EPON, Metro Ethernet Forum Specification, DPoE-SP-MEFv2.0-I07-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                   |
| [DPoE-MULPIv2.0] | DOCSIS Provisioning of EPON, MAC and Upper Layer Protocols Interface Specification, DPoE-SP-MULPIv2.0-I14-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                              |
| [DPoE-OSSlv2.0]  | DOCSIS Provisioning of EPON, Operations and Support System Interface Specification, DPoE-SP-OSSlv2.0-I13-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                               |
| [DPoE-PHYv2.0]   | DOCSIS Provisioning of EPON, Physical Layer Specification, DPoE-SP-PHYv2.0-I07-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                         |
| [DPoE-SECv2.0]   | DOCSIS Provisioning of EPON, Security and Certificate Specification, DPoE-SP-SECv2.0-I07-230322, March 22, 2023, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                               |
| [DPoG-OAM]       | DOCSIS Provisioning of GPON, DPoG OAM Extensions Specification. DPoG-SP-OAMv1.0-C01-160830, August 30, 2016, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                   |

### 2.2 Informative References

This specification uses the following informative references.

|           |                                                                                                                                                                                                                   |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1588v2]  | IEEE Std 1588-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, July 2008.                                                                        |
| [802.1ad] | IEEE Std 802.1ad-2005, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 4: Provider Bridges, May 2006. Former amendment to 802.1Q, now part of 802.1Q-2011. |
| [802.1ag] | IEEE Std 802.1ag-2007, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 5: Connectivity Fault Management, December 2007.                                    |

|             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [802.1ah]   | IEEE Std 802.1ah-2008, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks – Amendment 6: Provider Backbone Bridges, January 2008. Former amendment to 802.1Q, now part of 802.1Q-2011.                                                                                                                                                                                                                   |
| [802.3ah]   | IEEE Std 802.3ah-2004, IEEE Standard for Information Technology – Telecommunications and Information Systems – Local and Metropolitan Area Networks – Specific requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks, now part of [802.3]. |
| [CMCIv3.0]  | Data-Over-Cable Service Interface Specifications, Cable Modem to Customer Premise Equipment Interface Specification, CM-SP-CMCIv3.0-I03-170510, May 10, 2017, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                  |
| [DOCSIS]    | Refers to entire suite of DOCSIS 3.0 specifications unless otherwise specified.                                                                                                                                                                                                                                                                                                                                                                    |
| [eDOCSIS]   | Data-Over-Cable Service Interface Specifications, eDOCSIS Specification, CM-SP-eDOCSIS-I31-220831, August 31, 2022, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                            |
| [MULPIv3.0] | Data-Over-Cable Service Interface Specifications, MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv3.0-C01-171207, December 7, 2017, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                         |
| [OSSIV3.0]  | Data-Over-Cable Service Interface Specifications, Operations Support System Interface Specification, CM-SP-OSSIV3.0-C01-171207, December 7, 2017, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                              |
| [PHYv3.0]   | Data-Over-Cable Service Interface Specifications, Physical Layer Specification, CM-SP-PHYv3.0-C01-171207, December 7, 2017, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                    |
| [RFC 5462]  | IETF RFC 5462, Multiprotocol Label Switching (MPLS) Label Stack Entry: "EXP" Field Renamed to "Traffic Class" Field, L. Andersson, R. Asati, February 2009.                                                                                                                                                                                                                                                                                        |
| [SCTE 174]  | ANSI/SCTE 174 2010, Radio Frequency over Glass Fiber-to-the-Home Specification.                                                                                                                                                                                                                                                                                                                                                                    |
| [SECv3.0]   | Data-Over-Cable Service Interface Specifications, Security Specification, CM-SP-SECv3.0-C01-171207, December 7, 2017, Cable Television Laboratories, Inc.                                                                                                                                                                                                                                                                                          |
| [SFF-8077i] | SFF-8077i 10 Gigabit Small Form Factor Pluggable Module, Revision 4.5, released April 13, 2004.                                                                                                                                                                                                                                                                                                                                                    |
| [SFF-8472]  | SFF-8472 Specification for Diagnostic Monitoring Interface for Optical Transceivers, Revision 10.4, released January 2009.                                                                                                                                                                                                                                                                                                                         |
| [SFP MSA]   | INF 8074i Rev 1.0, Small Form-factor Pluggable Multi-Source Agreement, released May 2001.                                                                                                                                                                                                                                                                                                                                                          |

## 2.3 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027; Phone +1-303-661-9100; Fax +1-303-661-9199; <http://www.cablelabs.com>
- Internet Engineering Task Force (IETF) Secretariat, 48377 Fremont Blvd., Suite 117, Fremont, California 94538, USA, Phone: +1-510-492-4080, Fax: +1-510-492-4001, <http://www.ietf.org>
- Institute of Electrical and Electronics Engineers (IEEE), +1 800 422 4633 (USA and Canada); <http://www.ieee.org>
- SCTE, Society of Cable Telecommunications Engineers Inc., 140 Philips Road, Exton, PA 19341 Phone: +1-800-542-5040, Fax: +1-610-363-5898, Internet: <http://www.scte.org/>
- Small Form Factor Committee (SFF), <http://www.sffcommittee.com>

## 3 TERMS AND DEFINITIONS

### 3.1 DPoE Network Elements

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

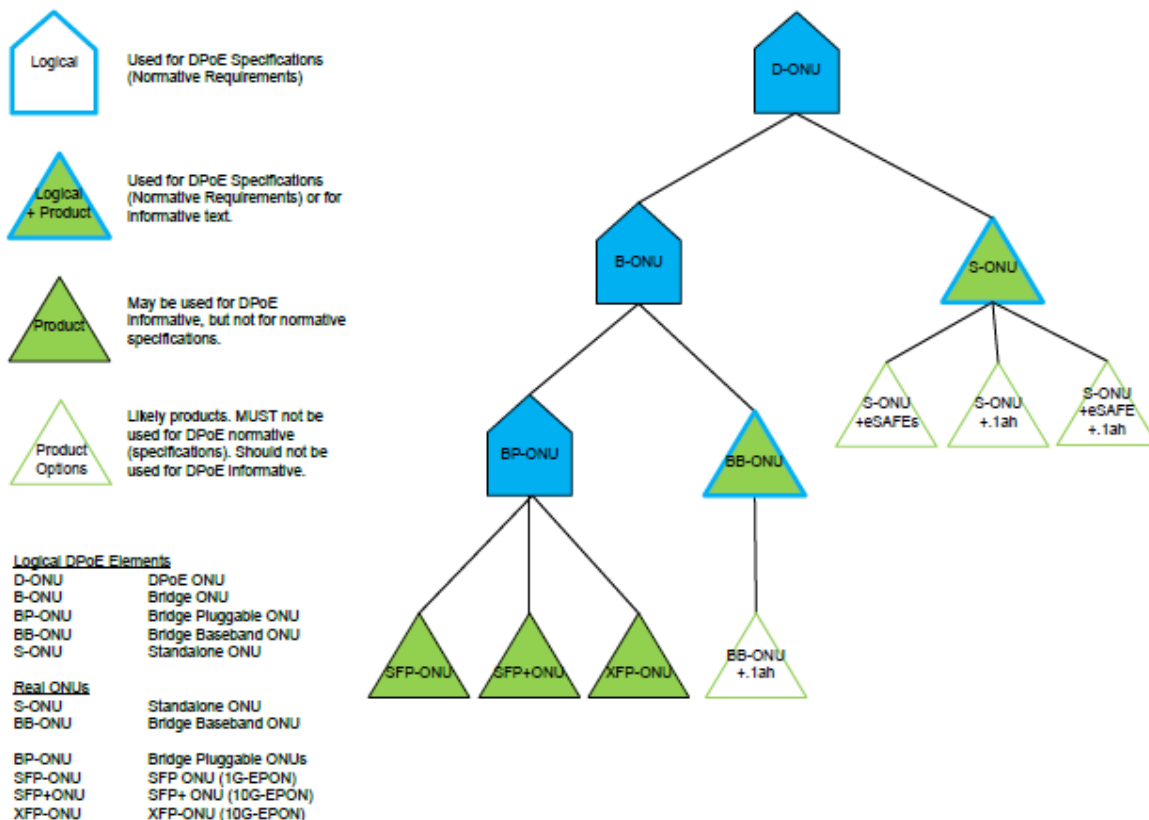


Figure 1 - D-ONU Types

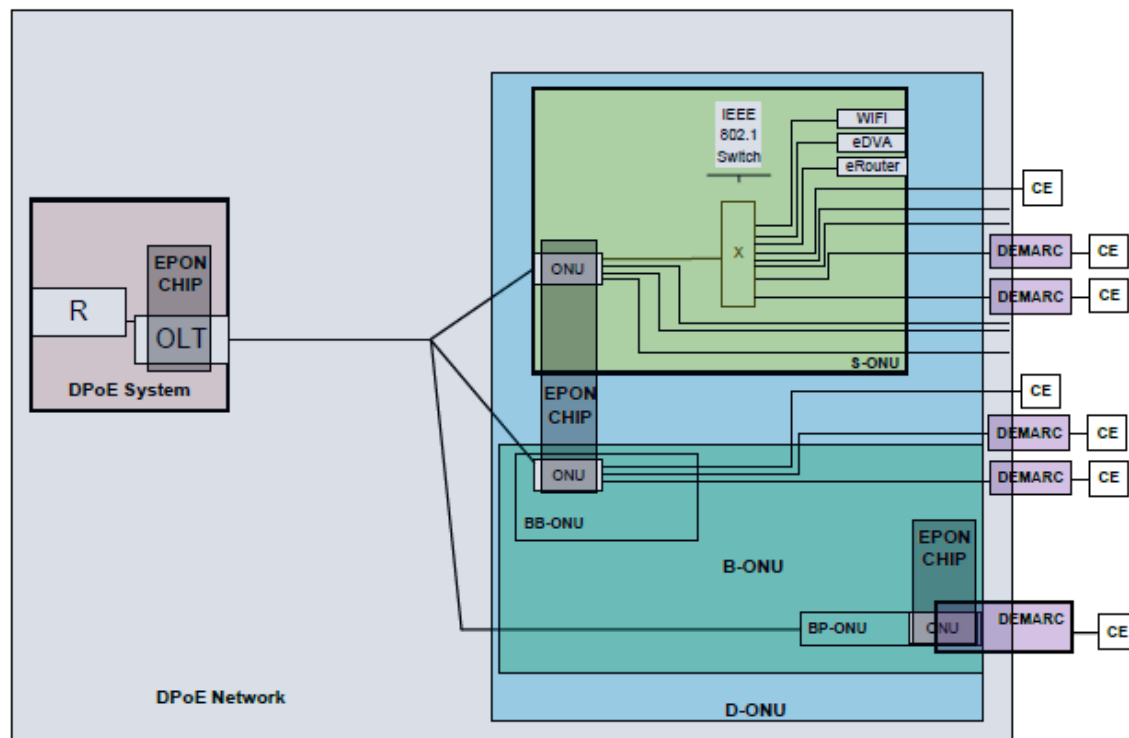


Figure 2 - DPoE Network Elements

## 3.2 Other Terms

### 1G-EPON

EPON as first defined in [802.3ah], now part of [802.3]

### 2G-EPON

EPON as defined in Annex A 2G-EPON System Definition of [DPoE-PHYv2.0]

### 10G-EPON

EPON as first defined in [802.3av], now part of [802.3]

### Cable Modem CPE Interface

CMCI as defined in [MULPIv3.0]

### Customer Premise Equipment (CPE)

Customer Premise Equipment as defined in [DOCSIS]

### Multi-Layer Switching (MLS)

A switch that can switch based on Layer 2, Layer 3, Layer 4, etc.

### Ethernet Passive Optical Network (EPON)

Refers to 1G-EPON, 2G-EPON, and 10G-EPON collectively

### EPON Operations and Maintenance Messaging (OAM)

EPON OAM messaging as defined in [802.3] and this document; Ethernet OAM is not the same as EPON OAM; Ethernet OAM is defined in [802.1ag]

### Logical CPE Interface

LCI as defined in [eDOCSIS]

### Network Interface Device (NID)

A DEMARC device in DPoE specifications

## 4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations and acronyms.

|                |                                                          |
|----------------|----------------------------------------------------------|
| <b>ACL</b>     | Access Control List                                      |
| <b>ARP</b>     | Address Resolution Protocol                              |
| <b>BCD</b>     | Binary Coded Decimal                                     |
| <b>CDR</b>     | Clock and Data Recovery                                  |
| <b>CFI</b>     | Canonical Format Indicator (in IEEE 802.1Q tag)          |
| <b>CMCI</b>    | Cable Modem CPE Interface                                |
| <b>CoS</b>     | Class of Service                                         |
| <b>CPE</b>     | Customer Premise Equipment                               |
| <b>CRC</b>     | Cyclic Redundancy Check                                  |
| <b>D-ONU</b>   | DPoE ONU                                                 |
| <b>DHCP</b>    | Dynamic Host Configuration Protocol                      |
| <b>DIA</b>     | Dedicated Internet Access                                |
| <b>DoS</b>     | Denial of Service                                        |
| <b>DPoE</b>    | DOCSIS Provisioning of EPON                              |
| <b>DR</b>      | Default Router                                           |
| <b>DSx</b>     | Digital Signal (DS1 or DS3)                              |
| <b>eCM</b>     | embedded Cable Modem                                     |
| <b>eDVA</b>    | embedded Digital Voice Adapter                           |
| <b>ENNI</b>    | External Network to Network Interface                    |
| <b>EPL</b>     | Ethernet Private Line                                    |
| <b>EPON</b>    | Ethernet Passive Optical Network                         |
| <b>EP-VLAN</b> | Ethernet Private Virtual Local Area Network              |
| <b>eSAFE</b>   | embedded Service/Application Functional Entity           |
| <b>ESP</b>     | Ethernet Service Path                                    |
| <b>EVC</b>     | Ethernet Virtual Connection                              |
| <b>E-VPL</b>   | Ethernet Virtual Private Line                            |
| <b>EVP-LAN</b> | Ethernet Virtual Private LAN                             |
| <b>FEC</b>     | Forward error correction                                 |
| <b>GBd</b>     | Gigabaud                                                 |
| <b>Gbps</b>    | Gigabits per second (as used in the industry)            |
| <b>HSD</b>     | High Speed Data                                          |
| <b>IGMP</b>    | Internet Group Management Protocol                       |
| <b>INNI</b>    | Internal Network to Network Interface                    |
| <b>IP</b>      | Internet Protocol                                        |
| <b>IP(HSD)</b> | High Speed Data (Broadband Internet Access using DOCSIS) |
| <b>IPMC</b>    | IP MultiCast                                             |
| <b>I-SID</b>   | [802.1ah] I-Component Service IDentifier                 |
| <b>LCI</b>     | Logical CPE Interface                                    |
| <b>LLID</b>    | Logical Link IDentifier                                  |
| <b>LSE</b>     | Label Stacking Entry                                     |
| <b>LOS</b>     | Loss Of Signal                                           |
| <b>MAC</b>     | Media Access Control                                     |
| <b>MPCPDU</b>  | Multi-Point Control Protocol Data Unit                   |
| <b>MEF</b>     | Metro Ethernet Forum                                     |
| <b>MI</b>      | MEF INNI Interface at a customer premise                 |

|              |                                                                  |
|--------------|------------------------------------------------------------------|
| <b>MN</b>    | MEF INNI Interface to operators MEN                              |
| <b>MPCP</b>  | Multi-Point Control Protocol                                     |
| <b>MTU</b>   | Maximum Transmission Unit                                        |
| <b>MU</b>    | MEF UNI Interface                                                |
| <b>NID</b>   | Network Interface Device                                         |
| <b>NNI</b>   | Network to Network Interface                                     |
| <b>NVS</b>   | Non-volatile Storage                                             |
| <b>OAM</b>   | EPON Operations Administration and Maintenance                   |
| <b>ODN</b>   | Optical Distribution Network                                     |
| <b>OLT</b>   | Optical Line Termination                                         |
| <b>ONU</b>   | Optical Network Unit                                             |
| <b>OSC</b>   | Optical Splitter Combiner                                        |
| <b>OUI</b>   | Organizationally Unique Identifier                               |
| <b>PDU</b>   | Protocol Data Unit                                               |
| <b>PHY</b>   | Physical Layer                                                   |
| <b>PON</b>   | Passive Optical Network                                          |
| <b>R</b>     | IP Router                                                        |
| <b>RARP</b>  | Reverse ARP                                                      |
| <b>RTT</b>   | Round Trip Time                                                  |
| <b>S-OAM</b> | Ethernet Service OAM                                             |
| <b>SA</b>    | Source Address                                                   |
| <b>SFP</b>   | Small Form-factor Pluggable                                      |
| <b>SFP+</b>  | Small Form-factor Pluggable Plus (+)                             |
| <b>TLV</b>   | Type-Length-Value                                                |
| <b>TPID</b>  | Tag Protocol Identifier                                          |
| <b>TU</b>    | Interface between DPoE System and D-ONU, roughly "the PON fiber" |
| <b>UNI</b>   | User Network Interface                                           |
| <b>vCM</b>   | Virtual Cable Modem                                              |
| <b>VID</b>   | VLAN Identifier                                                  |
| <b>VLAN</b>  | Virtual Local Area Network                                       |
| <b>WSC</b>   | Wireless Switching Center                                        |
| <b>X</b>     | IEEE Ethernet Switch (Generic)                                   |
| <b>XFP</b>   | X Form-factor Pluggable                                          |

## 5 BACKGROUND

### 5.1 IEEE 802 Link OAM for EPON

Traditional network management architecture requires the ONU to support the appropriate network management protocol or protocols. The protocol is usually SNMP, and hence would require IP layer connectivity. This requirement can result in extensive network maintenance to support every ONU on the management network at layer 3. An IP address would be assigned on the service provider's management network to each connected ONU, and ARP/RARP/DHCP issues must be addressed, as well as L3 security over the management channel. L3 management also places a larger burden on the ONU software stack, resulting in greater cost in the high-volume components of the network. The DPoE management architecture terminates network-side management protocols at the DPoE System, carrying out management functions over the TU interface using OAM. By re-using the [802.3] Clause 57 OAM packet format in DPoE specifications, the DPoE ONU (D-ONU) does not need to support additional protocol families for every possible management protocol, simplifying implementation and limiting interoperability problems.

Since [802.3] is a MAC layer standard, Clause 57 OAM messages for Ethernet links are confined in scope of control to the lower half of the data link layer. This is problematic for managing a full network, as a practical EPON ONU will likely serve as an Ethernet bridge and will have remote ports used to connect a customer LAN to EPON. Service providers running EPON need to remotely manage the entire ONU, and not just the EPON MAC. This exactly matches the requirements of the DPoE Network.

DPoE Link OAM should not be confused with Ethernet Service OAM (S-OAM). In DPoE specifications, Link OAM Protocol Data Units (PDUs), as defined in this specification, exist only on the PON. Furthermore, DPoE Link OAM PDUs are defined only for communication between a DPoE System and D-ONU. S-OAM, on the other hand, typically comprises both Performance Management and Fault Management functionality, and S-OAM PDUs can be forwarded to neighboring Ethernet networks toward a destination on a different network.

The IEEE provides a standard mechanism for extending [802.3] Clause 57 OAM, allowing other organizations to define specific extensions. One PDU opcode (0xFE) is reserved for such extensions. Also, organization-specific Type-Length-Value (TLVs) encodings can be added to some standard [802.3] Clause 57 PDUs. TLVs are used to encode information in many data communications protocols. TLVs in this document are specific to DPoE OAM and should not be confused with other uses of TLVs in other DPoE specifications. The organization defining the extension is identified by an IEEE OUI following the PDU extension opcode or TLV type. The remainder of the PDU format is then defined by the organization identified by the OUI for the frame. This document defines the format used for extensions under the DPoE OUI 0x001000.

Another advantage to extending the [802.3] Clause 57 OAM protocol is its inherent increased security. Without the extensions, an ONU functioning at L3 as a typical SNMP-managed device would extend the service provider's management network to the customer LAN. This creates potential security problems, especially with the open character of SNMP, where users could potentially gain access to the operator's management channels. Per [802.1Q], [802.3] Clause 57 OAM cannot be forwarded by a bridge, and so use of this protocol keeps the service provider's management network on the network side of the ONU and insulated from the subscriber interfaces. They also isolate the L3 user data network from the management network at a L2 protocol level, providing increased security over the management channel.

### 5.2 [802.3] Clause 57 OAM PDUs

The standard [802.3] Clause 57 PDUs are reviewed in the following sections. All OAM messages have a common header format, with EtherType 0x8809, Subtype 0x03, a Flags field that carries information about OAM state, and an opcode that defines the type of PDU. The body of each PDU depends on the opcode.

**Table 2 - IEEE Link OAM Messages Format**

| Width (Octets) | Field                             | Value (hex)                                                              |
|----------------|-----------------------------------|--------------------------------------------------------------------------|
| 6              | Ethernet DA (Destination Address) | 0x01:80:C2:00:00:02<br>([802.3]OAM multicast address)                    |
| 6              | Ethernet SA (Source Address)      | As per sending MAC                                                       |
| 2              | EtherType                         | 0x8809 (Ethernet Slow Protocol)                                          |
| 1              | Subtype                           | 0x03 ([802.3]OAM)                                                        |
| 2              | Flags                             | As per [802.3]                                                           |
| 1              | PDU Type                          | See Table 3                                                              |
| Varies         | Data/Pad                          | As defined for the Opcode.<br>Pad in OAM frames must be zero per[802.3]. |
| 4              | FCS                               | Standard FCS generated by the [802.3] MAC                                |

**Table 3 - [802.3] Clause 57 PDU Types**

| IEEE Info TLV Type    | Value (hex) |
|-----------------------|-------------|
| Information           | 0x00        |
| Event Notification    | 0x01        |
| Variable Request      | 0x02        |
| Variable Response     | 0x03        |
| Loopback Control      | 0x04        |
| Reserved              | 0x05..0xFD  |
| Organization Specific | 0xFE        |
| Reserved              | 0xFF        |

### 5.2.1 Info PDU

The Info PDU, defined in [802.3] Clause 57.4.3.1, is primarily used during the OAM Discovery phase just after a link is established, in which the OAM peers discover each other's existence and negotiate the maximum OAM frame length. Info PDUs are also periodically transmitted (once per second) as a keep-alive heartbeat for the OAM layer.

The contents of an Info PDU are a series of TLVs. [802.3] Clause 57 defines three TLV types. "Local" and "Remote" information TLVs are always present in an Info PDU, and convey basic information about the OAM channel state. [802.3] Clause 57 also defines a TLV type for an Organization-Specific TLV, which contains an OUI to denote the particular organization which defines the contents of that TLV. DPoE OAM defines an Info TLV type.

**Table 4 - [802.3] Info TLV**

| Width (Octets) | Field               | Value (hex)                                          |
|----------------|---------------------|------------------------------------------------------|
| 1              | TLV Type            | See Table 5                                          |
| 1              | Length              | Includes Type and Length fields, plus data to follow |
| Varies         | Depends on TLV Type | Depends on TLV Type                                  |

**Table 5 - [802.3] Info TLV Types**

| [802.3] Info TLV Type | Value (hex) |
|-----------------------|-------------|
| End of TLV marker     | 0x00        |
| Local Information     | 0x01        |
| Remote Information    | 0x02        |
| Reserved              | 0x03..0xFD  |
| Organization-Specific | 0xFE        |
| Reserved              | 0xFF        |

### 5.2.2 Event Notification PDU

The [802.3] Clause 57 Event Notification PDU is used to indicate the occurrence of events at one end of a link to the peer at the other end. Typically, this is "alarm" information sent from the D-ONU to the DPoE System. Event notification PDUs are not intended to function as an OSS system but to provide the ability for a D-ONU to give notice of specific events to a DPoE System. The use and distribution of this information is managed and forwarded by a DPoE System as prescribed in [DPoE-OSSlv2.0]. The Event Notification PDU format, like the Info PDU format, contains a series of Link Event TLVs. [802.3] Clause 57 defines five types of Link Event TLV. The first four are variations on the theme of reporting link fault counts (where a link fault is any of several errors that can occur in an Ethernet, such as CRC errors or frame length errors). The fifth type is reserved for organization-specific TLVs. The DPoE specification defines an extended alarm TLV type used in this PDU to convey more detailed alarm information.

Recall that all OAM frames carry three bits in the standard OAM header which indicate "link fault", "critical event", and "dying gasp" conditions at the sender. The [802.3] Clause 57 Event Notification PDU, as an OAM PDU, contains these bits, but also contains TLVs that provide more detailed information about the conditions that are present.

**Table 6 - [802.3] Event Notification TLV**

| Width (Octets) | Field               | Value (hex)                                          |
|----------------|---------------------|------------------------------------------------------|
| 1              | TLV Type            | See Table 7                                          |
| 1              | Length              | Includes Type and Length fields, plus data to follow |
| Varies         | Depends on TLV Type | Depends on TLV Type                                  |

**Table 7 - [802.3] Link Event TLV Types**

| [802.3] Link Event TLV Type   | Value (hex) |
|-------------------------------|-------------|
| End of TLV Marker             | 0x00        |
| Errored Symbol Period Event   | 0x01        |
| Errored Frame Event           | 0x02        |
| Errored Frame Period Event    | 0x03        |
| Errored Frame Seconds Summary | 0x04        |
| Reserved                      | 0x05..0xFD  |
| Organization-Specific         | 0xFE        |
| Reserved                      | 0xFF        |

### 5.2.3 Variable Request/Response PDUs

The Variable Request PDU is the means by which an OAM peer can query the attributes defined in [802.3] Clause 30, which are typically frame counters and error counters, along with basic control state of the MAC layer, such as link status or auto-negotiation results. The Variable Response PDU contains data in response to these requests. Note that in the standard protocol, all attributes are read-only. That is, the Variable Request message can retrieve values, but cannot set them.

The Variable Request PDU consists of a series of "Variable Descriptors" that identify the particular attribute to be retrieved. A Variable Descriptor is composed of "branch" and "leaf" codes that uniquely identify the attribute, at least within the IEEE-controlled numbering space. The Variable Descriptor is essentially a compound, three-byte attribute type code.

The Variable Response PDU consists of a number of Variable Containers. A Variable Container begins with a Variable Descriptor, which is followed by a Length field and then data that indicates the value of the attribute. Thus, the Variable Container is a kind of Type-Length-Value (TLV) format, where the Type is a three-byte code, and reserved values in the Length field serve as error codes.

For compatibility with standard PDUs and attribute numbering, DPoE OAM reuses these structures in its Get and Set PDU types. The contents of these standard PDUs are legal contents for the body of DPoE Get and Get Response

PDUs, although they are a subset of the possible legal responses. In this document, Variable Descriptors and Variable Containers will often be referred to simply as "TLVs".

DPoE OAM implementations must not generate such requests with the optional "package" format, as opposed to individual attributes. DPoE OAM implementations need not support the package format requests and responses.

### 5.2.4 Loopback Control PDU

The [802.3] Clause 57 Loopback PDU is used to put an individual logical link into a loopback state for testing purposes. The Info PDU is also used as a response when establishing or tearing down a loopback, as it carries state information that is useful during the transitions.

### 5.2.5 Organization-specific PDU

The [802.3] Clause 57 OAM PDU opcode 0xFE is defined to indicate an Organization-specific PDU. The contents of an Organization-specific PDU are defined by the organization indicated by the OUI in this PDU. DPoE OAM makes use of this feature to add many extended features to the basic IEEE logical link management. This document contains the definition for the format of data in organization-specific PDUs and TLVs marked by the DPoE OUI 0x001000.

In general, an EPON ONU may support many organization-specific OAM message sets. Behavior and requirements of other OAM extension sets are outside the scope of this document.

D-ONUs MAY support OAM extensions in addition to DPoE OAM. DPoE Systems MUST NOT require support for non-DPoE extensions. Similarly, D-ONUs MUST NOT require support for non-DPoE extensions. D-ONUs that support message sets other than DPoE extensions MUST NOT be deregistered simply for that reason. Similarly, D-ONUs MUST NOT fail to register with a DPoE System that supports DPoE OAM, even if that DPoE System lacks support for some other OAM message set that the D-ONU would like to use.

A DPoE System MUST NOT allow ONUs that do not support DPoE OAM to register as D-ONUs.

DPoE OAM attributes are defined in [1904.1A] and this specification.

DPoE OAM attributes designated as "Obsolete" are no longer supported.

## 5.3 D-ONU Model

For management purposes, a D-ONU is considered to have the logical structure depicted below.

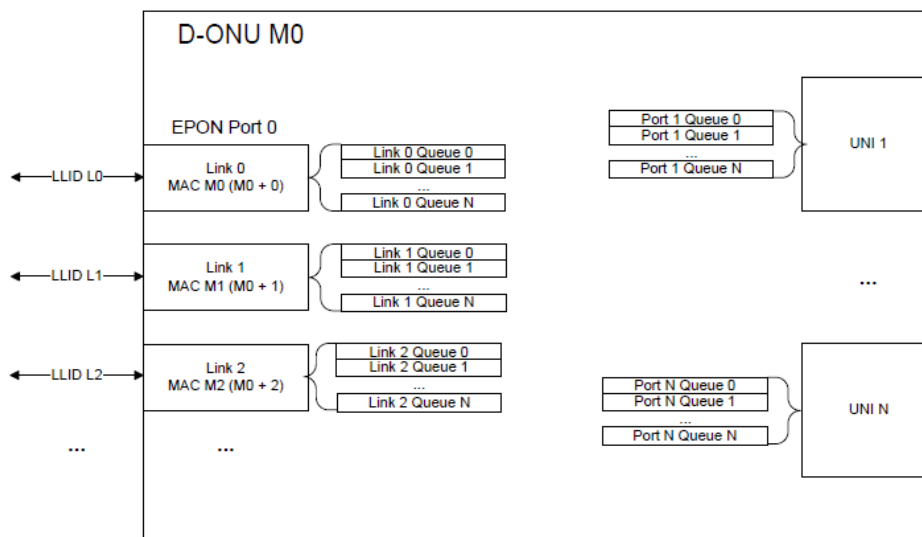


Figure 3 - D-ONU Model

A D-ONU is a device that has one or more MAC interfaces per TU interface (logical links, or just links for short), and one or more MAC interfaces on the user side (DPoE S interfaces or reference points). A switch connects the ports to transfer frames between individual MACs.

The TU interface is a single physical port shared by several MACs, each with an associated Logical Link, whereas the S interfaces (or reference points) usually have one MAC per physical port. Each of these MACs is fed by one or more priority queues. These ports, links, and queues each have OAM attributes that allow remote management.

In addition to the bidirectional (transmit/receive) links shown, D-ONUs support one or more receive-only links. Such links are used to flood traffic downstream on the PON, including unknown MAC addresses for [802.1Q] bridging or true Ethernet multicast.

## 5.4 Frame Processing

Frame processing refers to the configuration of a D-ONU to implement frame forwarding as specified in [DPoE-MEFv2.0] and [DPoE-MULPIv2.0]. Frame processing is performed to accomplish tasks such as classification in which the relative priority of a frame is determined, usually by inspecting fields within the frame, filtering frames (discarding frames with undesirable characteristics), access control (forwarding frames with desirable characteristics), or frame modification, such as adding, removing, or modifying Ethernet tags (including, for example, Tag Protocol Identifiers (TPIDs), VLAN identifiers, priority values) in a frame.

For the purpose of describing this behavior, the DPoE OAM specification (this document) adopts an abstract model of D-ONU behavior. The DPoE OAM messages define frame processing in terms of rules that match fields in a frame, and if the fields match the given values, apply a particular result to the frame. The rule results can forward or discard a frame, set a destination queue, or change the frame by adding or deleting fields. D-ONU software parses these rules and programs the D-ONU implementation-specific hardware to achieve the specified effect.

Using these rules as primitives, it is possible to construct many features. For example, an Access Control List (ACL) is a list of rules that matches MAC or IP source addresses and forward-matching frames. Traffic classification is a matter of matching frames and forwarding the frame into an appropriate priority queue based on the frame contents. Adding an Ethernet tag might be unconditional, as in the case of a VLAN tag for a port, or the tag value might be based on other attributes of the frame to tag frames according to protocol type. Rather than specify distinct OAM messages for all these features, a primitive-oriented approach is used to permit construction of additional features in the future with no additional DPoE OAM message definitions required.

It is not expected that D-ONU hardware processes these rules in software or exactly in the format presented. To be compliant with this specification, any hardware or software implementation may be used, but the DPoE System MUST implement the DPoE eOAM rule set defined in this specification. Similarly, D-ONU MUST also implement the DPoE eOAM rule set defined in this specification.

Conceptually, these packet processing rules are applied to frames as they enter ports, whether the TU interface port in the downstream or a User Network Interface (UNI) port in the upstream. For consistency, the field values as used in the rule conditions are always the values in the frame as it enters the port. Any changes to the frame from rule results are considered not to take effect until frame processing has been completed. Thus, the effect of a rule set does not depend on the order of the rules in that set.

All the rules in a port ingress rule table are applied to each frame that enters the port. The results of all rules that match are applied to the frame.

To resolve ambiguity when more than one rule or contradictory rules match the same frame, each rule is associated with a precedence value. The result is that only the highest precedence rule that matches a frame and has a particular result will be applied. Thus, for example, by using two precedence levels, it is possible to establish a single rule that provides a classification for a frame and then override that classification by matching specific control fields with a higher precedence rule (as with DOCSIS classifiers that select traffic into Secondary Service Flows). The precedence of one type of rule result (say, modifying an output field) does not conflict with the precedence of other types of result (say, forwarding the frame, or setting an output queue).

## 6 OAM OPERATION

### 6.1 OAM Discovery

The OAM discovery process defined in [802.3] has a state machine for a certain progression of OAM discovery state bits in the header for OAM messages. OAM is considered an optional feature of [802.3], but support for DPoE OAM is mandatory for all D-ONUs conforming to this standard. A D-ONU that does not actually complete OAM Discovery in a stable state, as per this standard, **MUST** be deregistered by the DPoE System after 5 seconds of attempting OAM discovery, measured from the initial OAM Info PDU sent by the OLT.

During OAM discovery, support for DPoE extensions is declared by adding an Info TLV to the Info PDUs exchanged with the DPoE System as defined in Section 5.2.1. Presence of this DPoE extension support TLV is a declaration of willingness to adhere to the requirements of the DPoE OAM extension set, including the rules on critical OAM and D-ONU behavior in this section. Lack of this TLV means that the ONU is not capable of supporting DPoE extensions, and subsequently will not be allowed to register as a D-ONU.

A D-ONU **MUST** include the DPoE OAM Support Info TLV in all OAM Info frames exchanged during the OAM Discovery phase. The D-ONU **SHOULD NOT** insert this TLV into keep-alive Info frames after OAM Discovery has completed.

### 6.2 OAM Timeout

To relieve the protocol of complexity in handling out-of-order requests and overall pacing for different D-ONUs, a DPoE System may have only one outstanding OAM request per logical link at any given time. The D-ONU must reply, or the OAM timer expire, before the DPoE System can send another OAM PDU to the D-ONU.

Unless otherwise specified, a D-ONU **MUST** respond to an OAM request from a DPoE System within one second.

If a D-ONU cannot respond before the OAM timeout, it **MUST** raise the D-ONU busy alarm. Failure to respond to OAM results in an error at the DPoE System; handling of this error is implementation-specific, but **MUST NOT** include deregistering the D-ONU. The exception to this rule is "critical" OAM. Failure to respond to critical OAM is a reason to deregister a D-ONU.

### 6.3 Critical OAM

Of the hundreds of messages and attributes in the DPoE OAM extension set, a few are deemed "critical" OAM. A successful response to these OAM messages is necessary for the network to work properly. An ONU that does not acknowledge these critical OAM commands is not operating correctly (by definition) and will be deregistered by the DPoE System. These critical OAM commands are required as part of the claim of support for DPoE extensions. An ONU that claims support for DPoE extensions is also promising to respond to these OAM commands in particular, as well as others in this document.

Critical OAM messages are sent immediately after link registration, and may also occur at other times during the D-ONU operation.

**Table 8 - Critical OAM Attributes**

| Attribute                   | Description                                                                | Value (hex) |
|-----------------------------|----------------------------------------------------------------------------|-------------|
| Device ID                   | Unique physical device identification number                               | 0xD7/0x0002 |
| Max Number Of Logical Links | Maximum number of logical links (bidirectional LLIDs) supported on the ONU | 0xD7/0x0007 |
| ONU Report Thresholds       | Controls format of MPCP REPORT PDU                                         | 0xD7/0x000B |
| Set OAM Rate                | Changes maximum allowed OAM PDU rate                                       | 0xD7/0x000D |

The critical OAM messages are described in detail below.

### 6.3.1 D-ONU Capabilities

Most of the information in the Extended Info PDU is primarily of interest to the network management system. However, a few of these attributes are snooped by DPoE System firmware, and are necessary for the DPoE System to manage D-ONUs.

The D-ONU base MAC address is considered to be the Device ID that ties multiple logical links on the same D-ONU physical device. Similarly, the number of links is necessary for a DPoE System to correctly manage D-ONUs of different configurations.

If a D-ONU does not positively acknowledge these attributes, it cannot be tracked and managed by the DPoE System, and so is deregistered to deny its entry into the DPoE Network.

### 6.3.2 Set D-ONU Report Threshold

The report threshold limits the size of the frame boundary that is reported to the DPoE System. A DPoE System scheduler generally has some maximum size it is willing to grant (the DBA token size) in order to maintain service guarantees on the PON. If the D-ONU report threshold exceeds this maximum size, then the D-ONU will report a frame boundary larger than the DPoE System can grant. In the best case, EPON efficiency is lost due to loss of frame alignment with the D-ONU, as the DPoE System limits the grant to the maximum size. The next worst effect is that SLAs cannot be correctly enforced, if the DPoE System attempts to grant to the reported frame boundary despite the fact that it is too large given the current demands on the network.

When increasing bandwidth limits, the DPoE System must first increase the OLT token size, and only then increase the D-ONU threshold. Conversely, to decrease the bandwidth limits, the D-ONU report threshold must be lowered before the OLT token size can be decreased. A positive acknowledgement from the D-ONU is necessary to be sure this report threshold has been adjusted before the OLT can be updated. If a D-ONU does not respond to this command, the OLT cannot be certain of the report threshold at the D-ONU. Rather than risk correct network behavior for all other ONUs registered on the PON, the D-ONU that fails to acknowledge this command is deregistered.

### 6.3.3 Set OAM Rate

[802.3] Clause 57 and its annexes specify a maximum rate of 10 frames/second for OAM traffic. DPoE OAM extensions allow this limit to be increased or waived entirely. However, both the DPoE System and D-ONU must agree on the actual OAM frame rate to be used. If the D-ONU and DPoE System use different OAM frame rates, the useful PDU rate would be limited by the lower of the two, as the ONU would either fail to acknowledge OAM commands (when the DPoE System rate was higher than the D-ONU) or be unable to use the increased limit (as the DPoE System would not send commands as often as the D-ONU might be willing to accept).

## 6.4 OAM Keep-alive Failure

[802.3] requires that the OAM layer return to the initial state of the OAM Discovery state machine on OAM heartbeat failure, but says nothing specifically about the Multi-Point Control Protocol (MPCP) layer in this case. It is conceivable that the OAM layer fails because of some fault in the underlying Ethernet layer controlled by MPCP. If this layer cannot transport frames, it cannot transport OAM frames, and thus resetting only the OAM layer is not likely to recover the D-ONU if the problem lies with MPCP or the Ethernet layer.

DPoE Systems MUST deregister D-ONUs at the MPCP layer if an OAM layer failure is detected. D-ONUs MUST deregister and re-register at the MPCP layer if an OAM layer failure is detected.

## 6.5 OAM and Logical Links

The DPoE System MAY use any logical link that terminates at the appropriate D-ONU to send OAM commands. The D-ONU MUST respond to commands on the same logical link on which the command was received.

## 7 [802.3] OAM PDU

In addition to the [802.3] organization-specific extension PDU opcode (0xFE), which allows definition of entirely new PDUs in addition to the standard [802.3] Clause 57 PDUs, two of the other [802.3] Clause 57 PDUs contain TLVs, which allow for extensions. The Info OAM PDU and the Event Notification OAM PDU are each composed of a series of TLVs. Each type of PDU allows an organization-specific TLV with contents as defined by that organization.

This DPoE specification defines TLVs for both the [802.3] Info PDU and the [802.3] Event Notification PDU, in addition to DPoE OAM extension PDU types (hereafter called DPoE OAM PDU types). As per [802.3], DPoE OAM extension TLVs use TLV type of 0xFE and the DPoE OUI 0x001000.

### 7.1 Info PDU

All DPoE Info TLVs have as their first type an additional TLV type that allows for multiple different types of DPoE Info TLVs. Format of additional data in the TLV depends on this DPoE TLV type.

**Table 9 - DPoE Info TLV Format**

| Width (Octets) | Field              | Value (hex)                                          |
|----------------|--------------------|------------------------------------------------------|
| 1              | TLV Type           | 0xFE (Info TLV extension)                            |
| 1              | Length             | Includes Type and Length fields, plus data to follow |
| 3              | OUI                | 0x001000                                             |
| 1              | DPoE Info TLV Type | See Table 10                                         |

The DPoE Info TLV types are shown in Table 10.

**Table 10 - DPoE Info TLV Types**

| DPoE TLV Type    | Value (hex) |
|------------------|-------------|
| DPoE OAM Support | 0x00        |

#### 7.1.1 Info TLV: DPoE OAM Support (0x00)

Presence of this TLV in the Info frames during OAM discovery indicates the DPoE System or D-ONU supports DPoE OAM. Support for the OAM PDUs also implies support for the feature set required for the DPoE System.

The 'DPoE OAM Version' field indicates the version of the eOAM supported by the given device. This field represents a major/minor version number, with the major number in bits [7:4] and the minor number in bits [3:0]. For example, the value of 0b00100000 (0x20) stored in the 'DPoE OAM Version' field represents a major version 2, minor version 0 of the DPoE OAM.

The DPoE System MUST deregister a D-ONU which reports an unsupported version of DPoE OAM.

**Table 11 - DPoE OAM Support TLV Format**

| Width (Octets) | Field              | Value (hex)               |
|----------------|--------------------|---------------------------|
| 1              | TLV Type           | 0xFE (Info TLV extension) |
| 1              | Length             | varies                    |
| 3              | OUI                | 0x001000                  |
| 1              | DPoE Info TLV Type | 0x00                      |

| Width (Octets) | Field            | Value (hex)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1              | DPoE OAM Version | Bits [7:4] represent the major version number<br>Bits [3:0] represent the minor version number<br>The following values are defined:<br>0x01 – reserved for backward compatibility reasons, same as 0x10<br>0x02 – pre-DPoE OAM, without Certificate Authority support<br>0x03 – pre-DPoE OAM, with Certificate Authority support<br>0x10 – OAM compliant with DPoE-SP-OAMv1.0-I04 and previous versions<br>0x11 – OAM compliant with DPoE-SP-OAMv1.0-I05 and subsequent versions of DPoE-SP-OAMv1.0<br><br>0x20 – OAM compliant with DPoE-SP-OAMv2.0-I01 and subsequent versions<br><br>0x21 – OAM compliant with DPoE-SP-OAMv2.0-I06 and subsequent versions<br><br>0x22 – OAM compliant with DPoE-SP-OAMv2.0-I08 and subsequent versions<br><br>0x23 – OAM compliant with DPoE-SP-OAMv2.0-I10 and subsequent versions<br><br>0x24 – OAM compliant with DPoE-SP-OAMv2.0-I12 and subsequent versions<br><br>Other values are reserved and treated as unsupported. |

## 7.2 Event Notification PDU

The DPoE Event Notification TLV is used in an [802.3] Event Notification PDU to provide more detailed alarm information than is possible with only the [802.3] Clause 57 OAM.

All DPoE alarms have a common format. The current condition of the alarm is indicated as "raised" when the condition is detected, and "clear" when the condition is no longer present. The object affected by the condition is included as object type and instance number, which matches the DPoE object context leaf codes and instance parameters in Section 8.7.

**Table 12 - DPoE Link Event TLV Format**

| Width (Octets) | Field           | Value (hex)                                                                                                                    |
|----------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------|
| 1              | TLV Type        | 0xFE (Event Notification TLV extension)                                                                                        |
| 1              | Length          | varies                                                                                                                         |
| 3              | OUI             | 0x001000                                                                                                                       |
| 1              | Event Code      | See Table 13                                                                                                                   |
| 1              | Raised          | Boolean; TRUE if the condition currently exists;<br>FALSE if it has been cleared                                               |
| 2              | Object Type     | Affected object (leaf code for object context, branch D6)                                                                      |
| 2 or 4         | Object Instance | Affected instance of this type of object. Queue object type requires four (4) bytes, other object types require two (2) bytes. |

Possible values for the Event Code are shown in Table 13. These alarm codes are grouped into Link Faults, Critical Events, and Dying Gasp alarm types, with code values numbered accordingly.

In addition to this standard header, individual alarm types may contain further alarm-type-specific information in the TLV.

**Table 13 - DPoE Event Codes**

| DPoE Event Code       | Value (hex) | Description                                                                                                   | Relevant Object Context(s)                                                               |
|-----------------------|-------------|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Link Fault Alarms     |             |                                                                                                               |                                                                                          |
| LOS                   | 0x11        | Loss of received optical power by the transceiver (ONU EPON port)<br>Link down on Ethernet PHY (ONU UNI port) | D-ONU<br>Network PON Port<br>User Port                                                   |
| Key Exchange Failure  | 0x12        | D-ONU did not observe a switch to a new key after key exchange                                                | Unicast Logical Link                                                                     |
| Reserved              | 0x13..0x1F  | Reserved                                                                                                      |                                                                                          |
| Critical Event Alarms |             |                                                                                                               |                                                                                          |
| Port Disabled         | 0x21        | Ethernet port is disabled by management action                                                                | Network PON Port<br>User Port                                                            |
| Reserved              | 0x22..0x3F  | Reserved                                                                                                      |                                                                                          |
| Dying Gasp Alarms     |             |                                                                                                               |                                                                                          |
| Power Failure         | 0x41        | Loss of power at the D-ONU (Dying Gasp)                                                                       | D-ONU                                                                                    |
| Reserved              | 0x42..0x7F  | Reserved                                                                                                      |                                                                                          |
| Other Alarms          |             |                                                                                                               |                                                                                          |
| Statistics Alarm      | 0x81        | Statistic has crossed defined alarm thresholds                                                                | Network PON Port<br>Unicast Logical Link<br>User Port<br>Queue<br>Multicast Logical Link |
| D-ONU Busy            | 0x82        | D-ONU is busy and unable to acknowledge or process further OAM until alarm clears                             | D-ONU                                                                                    |
| MAC Table Overflow    | 0x83        | D-ONU MAC Table has seen more addresses than it can hold                                                      | D-ONU<br>Network PON Port<br>User Port                                                   |
| PON_IF_Switch         | 84          | PON interface on the ONU was switched to backup                                                               | D-ONU                                                                                    |
| Reserved              | 0x84..0xFF  | Reserved                                                                                                      |                                                                                          |

### 7.2.1 LOS (0x11)

For the TU interface port, a Loss Of Signal (LOS) condition is detected by lack of incoming optical power or loss of Clock and Data Recovery (CDR) lock to the downstream bit clock. On an S interface (or reference point), the LOS condition corresponds to the Link Down condition detected by the S interface (or reference point) PHY.

### 7.2.2 Key Exchange Failure (0x12)

The Key Exchange Failure alarm indicates that a scheduled key exchange has failed to successfully complete. Encryption continues with the previous key for another key exchange interval. Another key exchange will be attempted at the next key exchange time. See [DPoE-SECv2.0] for details on key exchange procedures and detection of failure conditions.

### 7.2.3 Port Disable (0x21)

The Port Disabled event indicates that a D-ONU port has been disabled by management action. If the TU interface port is disabled, then OAM cannot be transmitted, and this alarm will be visible only locally on the D-ONU.

### 7.2.4 Power Failure (0x41)

A Power Failure alarm indicates that the D-ONU has lost power and will imminently depart the DPoE Network. A D-ONU will exercise its best effort to send an Event Notification PDU with this TLV when it detects loss of power. A D-ONU might not be able to actually send the message if the required transmission grants are not allocated by the DPoE System before the D-ONU has exhausted its endurance.

### 7.2.5 Statistics Alarm (0x81)

The Statistics Alarm indicates a crossing of predefined thresholds on some statistic (indicated in the alarm TLV). Typically, these thresholds would be set for counters for error conditions such as CRC errors. The Statistics Alarm TLV carries the following fields after the standard DPoE alarm TLV fields.

**Table 14 - Statistics Alarms Additional Fields**

| Width (Octets) | Field  | Value (hex)                                |
|----------------|--------|--------------------------------------------|
| 1              | Branch | Branch of statistic that crossed threshold |
| 2              | Leaf   | Leaf of statistic that crossed threshold   |

### 7.2.6 D-ONU Busy (0x82)

The D-ONU Busy alarm may be raised by a D-ONU to inform the DPoE System that it has become busy for an extended period and may not respond to further OAM requests in the usual timely fashion.

The DPoE System MUST ignore any OAM or eOAM timeout alarms as long as the "ONU Busy" alarm is active (raised), but not longer than 300 seconds from the last reception of the "ONU Busy" alarm. The DPoE System MUST NOT ignore any OAM or eOAM timeout alarms longer than 300 seconds from the last reception of the "ONU Busy" alarm.

### 7.2.7 MAC Table Overflow (0x83)

The MAC Table Overflow alarm is raised by a D-ONU to inform the DPoE System that an ingress MAC address has not been learned because the total number of MAC addresses has been exceeded. For example, if the D-ONU has been provisioned to allow four MAC addresses on a particular UNI port, then the first four addresses seen would be learned; the fifth address would cause this alarm to be raised.

## 8 DPOE OAM PDUS

All DPoE OAM PDU messages follow the [802.3] Clause 57-defined method of extending the OAM protocol. That is, the messages are contained in [802.3] Clause 57-defined Organization-specific OAM frames, followed by the DPoE OUI 0x001000. See Section 5.2 for more details on [802.3] Clause 57 OAM PDU formats.

**Table 15 - DPoE Extended OAM PDU Format**

| Width (Octets) | Field       | Value (hex)                                        |
|----------------|-------------|----------------------------------------------------|
| 6              | Ethernet DA | 0x0180C2-000002<br>([802.3] OAM multicast address) |
| 6              | Ethernet SA | As per sending MAC                                 |
| 2              | EtherType   | 0x8809 (Ethernet Slow Protocol)                    |
| 1              | Subtype     | 0x03 ([802.3] OAM)                                 |
| 2              | Flags       | As per [802.3]                                     |
| 1              | Opcode      | FE                                                 |
| 3              | OUI         | 0x001000                                           |
| 1              | DPoE Opcode | See Table 16                                       |

Each DPoE OAM message type is identified by a one-byte opcode immediately following the DPoE OUI. Data per individual extended DPoE OAM PDU type then follows as defined for that particular DPoE Opcode (see Table 16).

**Table 16 - DPoE Opcodes**

| DPoE Opcode                    | Value (hex) |
|--------------------------------|-------------|
| Reserved                       | 0x00        |
| Get Request                    | 0x01        |
| Get Response                   | 0x02        |
| Set Request                    | 0x03        |
| Set Response                   | 0x04        |
| Reserved, ignored on reception | 0x05        |
| Reserved, ignored on reception | 0x06        |
| Reserved, ignored on reception | 0x07        |
| Key Exchange                   | 0x08        |
| File Transfer                  | 0x09        |
| Reserved, ignored on reception | 0x0A        |
| Reserved, ignored on reception | 0x0B        |
| Reserved, ignored on reception | 0x0C        |
| eOAM_Early_WakeUpOLT           | 0xFC        |
| eOAM_Early_WakeUpONU           | 0xFD        |
| eOAM_Sleep_Allowed             | 0xFE        |

Most management functions in DPoE Systems are carried out by reading and writing individual attributes of objects in the D-ONU with the Get and Set PDUs. Setting an S interface port speed, for example, would be performed by setting the port speed attribute of the proper port object. These PDUs are essentially lists of TLVs, where each TLV represents an attribute. Since more than one instance of an object could exist in the D-ONU, the packet also contains TLVs that identify the object to which later attributes in the PDU will apply. That is, some TLVs set the current object context to which later attributes apply. Since the PDU is a list format, it is possible to conduct a number of operations on one object or several objects with just one PDU. See Section 8.2 for a description of Variable Descriptors and Variable Containers as found in the Get and Set PDUs.

Other OAM PDU types exist for specialized purposes that do not fit the object as well, such as file transfer.

## 8.1 Definitions of DPoE OAM PDUs

### 8.1.1 Get Request

The Get Request permits reading of both [802.3] Clause 30 and DPoE extended attributes in a single PDU. The data field of the PDU contains a null-terminated series of Variable Descriptors, as defined in [802.3] Clause 57 Variable Request messages.

### 8.1.2 Get Response

This Get Response OAM PDU is a response to a Get Request. The data field of the PDU contains a null-terminated series of Variable Containers, as defined in [802.3] Clause 57 Variable Request messages, where the values in the Containers are the value of the queried attributes, or possibly an error response code.

### 8.1.3 Set Request

[802.3] Clause 57 does not include means to set variables with OAM messages. It can only retrieve them with a Variable Request message. The DPoE OAM supports the setting of variables.

The format of the Set OAM PDU is similar to the Variable Response PDU. A null-terminated list of Variable Containers specifies which variables to set. The values in the Variable Containers provide new values to be set for the attribute.

The Set Request OAM PDU may contain Actions (branch 0x09 or 0xD9) as well as attributes. Actions instruct the receiving device to execute a procedure, such as clearing a table or resetting. The management actions specified in [802.3] Clause 30 are not supported in the [802.3] Clause 57 PDUs. The DPoE extensions allow these standard management actions and extended actions to be requested. Actions that have parameters (as defined for each action) have those parameters as the body of the Variable Container for the action. Actions that do not have parameters are represented as a Variable Container of zero length (length code 0x80).

Actions are distinct from setting variables, though they can have similar affects. An SNMP MIB contains "trigger attributes" that create the same effect as an action. For example, in SNMP, setting a Boolean "Reset" attribute to TRUE for a device instructs the management system to reset the device. Similarly, some attributes in [802.3] Clause 30 can be used to change system settings. For example, setting the AdminState of a PHY can turn the device on or off.

### 8.1.4 Set Response

A Set Response OAM PDU contains a null-terminated series of Variable Containers. The response codes correspond to individual Set requests or Actions in the Set Request PDU. The container typically consists of the Branch/Leaf identifier and the Width field. The Width field contains an error code.

### 8.1.5 Key Exchange

The Key Exchange PDU is used by encryption firmware to exchange keys and synchronize key switchover. See [DPoE-SECv2.0] for details on the key exchange protocols used by the DPoE Network.

### 8.1.6 File Transfer

The File Transfer PDU is used by the file transfer protocol used to upgrade D-ONU firmware. See Section 12 for details on file transfer PDUs and protocol specifications.

### 8.1.7 eOAM\_Early\_WakeUpOLT

See [1904.1A], subclause 13.4.2.12.

### 8.1.8 eOAM\_Early\_WakeUpONU

See [1904.1A], subclause 13.4.2.13.

### 8.1.9 eOAM\_Sleep\_Allowed

See [1904.1A], subclause 13.4.2.14.

## 8.2 Attribute List

The DPoE OAM Get Request and Set Request PDUs and corresponding Get Response and Set Response OAM PDUs consist of a list of Variable Descriptors or Variable Containers, as defined in [802.3] Clause 57 for the contents of the standard Variable Request and Variable Response PDUs.

A Variable Descriptor is a 3-byte value composed of a one-byte "branch" code and a two-byte "leaf" code, which uniquely identifies a particular attribute.

**Table 17 - Variable Descriptor**

| Width (Octets) | Field       | Value (hex)                         |
|----------------|-------------|-------------------------------------|
| 1              | Branch Code | 0x0: (end of list)<br>0x01 ... 0xFF |
| 2              | Leaf Code   | 0x00 00..0xFF FF                    |

Variable Containers consist of a branch/leaf pair, followed by a one-byte field that represents the length of data in the container, followed by the actual data that is the value for that attribute. Thus, a Variable Container has a typical Type-Length-Value (TLV) structure, with a compound Type field. A Variable Descriptor is just the Type portion of this TLV.

**Table 18 - Variable Container**

| Width (Octets) | Field       | Value (hex)                                                                                                                                                       |
|----------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1              | Branch Code |                                                                                                                                                                   |
| 2              | Leaf Code   |                                                                                                                                                                   |
| 1              | Length      | 0x00: length of data to follow is 128 bytes<br>0x01..7F: length of data to follow in bytes<br>0x80..FF: Response/error code (implies zero length of data follows) |
| varies         | Value       | Present only when length is greater than zero; format as defined for the branch/leaf code                                                                         |

For brevity, the acronym "TLV" is used to refer to either Variable Descriptors or Variable Containers, even though Variable Descriptors do not actually have a length or value field.

The series of TLVs in a PDU is terminated by a Variable Container or Variable Descriptor with branch, leaf, and length values of 0.

As per [802.3] Clause 57 OAM Variable Containers, Variable Container length values from 1-127 represent the length of data in the container. Zero represents a length of 128 bytes. Values 128 (0x80) and higher represent a response code to the request, indicating the result of the attempted action. All response codes imply a length of zero for the data length.

**Table 19 - DPoE Variable Response Codes**

| DPoE Variable Response Codes | Meaning                                                                                                                                                                                | Value (hex) |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| No Error                     | The operation was successfully completed. This value is also used to represent zero length in Variable Containers with no data, such as in the Set PDU for actions with no parameters. | 0x80        |
| Too Long                     | Length of result exceeded OAM PDU data field available                                                                                                                                 | 0x81        |
| Bad Parameters               | Parameters for the requested action fail error checking                                                                                                                                | 0x86        |
| No Resources                 | The device does not currently have the resources (table entries, memory, etc.) to perform the requested action                                                                         | 0x87        |
| System Busy                  | The device is not currently in the proper state to perform the requested action                                                                                                        | 0x88        |

| DPoE Variable Response Codes | Meaning                                                             | Value (hex) |
|------------------------------|---------------------------------------------------------------------|-------------|
| Undetermined Error           | Unknown or unlisted Attribute error                                 | 0xA0        |
| Unsupported                  | The Attribute requested is not supported on this device             | 0xA1        |
| May Be Corrupted             | The value of an Attribute counter may be invalid due to reset       | 0xA2        |
| Hardware Failure             | An Attribute hardware error prevented the operation from completing | 0xA3        |
| Overflow                     | Requested Attribute experienced overflow error                      | 0xA4        |

## 8.3 Data Formats

Variable Containers contain data of several common types. This section describes the format of these data types.

### 8.3.1 Integers

Integers are represented in two's-complement form, most significant byte first. Note that Containers are variable length; as a result, attributes that are integers do not have a fixed width. The transmitter may suppress leading zero bytes of integers. The receiving D-ONU or DPoE System must handle an integer in a Variable Container of any legal width (1..128 bytes). If a Variable Container is smaller than the receiving device representation, the value is extended as necessary. If the Variable Container is larger than the receiving device representation, the result is implementation-defined.

### 8.3.2 Enumerated Values

Enumerated values take one of a number of bit patterns with predefined meanings. Enumerated values are always represented in a Container with a width equal to that necessary for the largest possible such value in that particular enumerated value, with leading zeros as necessary when the actual value is shorter than the maximum possible.

### 8.3.3 Sequences

A "sequence" is a series of values, usually enumerated values. Every element in a sequence must have the same width. The number of elements in the sequence can thus be determined from the width of the Variable Container.

### 8.3.4 Structured Data Types

Many attributes consist of structured data with a number of sub-fields. The format of such structured data depends on the attribute, and is shown in a table in the definition of individual attributes below.

## 8.4 Storage Classes

OAM attribute description provides a "storage class" for each attribute, which defines the behavior of the attribute in memory.

The lack of any notation at the OAM attribute indicates that the attribute is Read-Write (RW). The vCM may write into this attribute with a Set PDU and read from this attribute with a Get PDU.

"R" denotes a Read-Only attribute. The vCM may read from this attribute with a Get PDU, but cannot Set the value stored in this attribute.

"NVS" denotes an attribute kept in Non-Volatile Storage. NVS attributes, unlike normal attributes, retain their values when an ONU resets, including power-on resets. An NVS attribute retains its value after a reset as last set with a Set PDU. Non-NVS attributes return to a default value as listed in the spec after a reset.

## 8.5 Large Values

The maximum length of data that can fit into a single Variable Container is 128 bytes. Some attribute values may be larger. Values larger than 128 bytes long are represented by a contiguous series of Variable Containers with a

repeated branch/leaf code for the attribute in question. This series of TLVs is terminated by a TLV with the same branch/leaf code, and a length of zero, to indicate the end of the large value.

The attribute value is segmented into the several TLVs as described for particular attributes. For ease of segmentation and reassembly, the value for tables of items is not necessarily broken at 128 byte boundaries, but rather the closest boundary that contains an integral number of table items. For example, a MAC address table consisting of a large number of entries, each 6 bytes long, can hold at most 21 whole MAC addresses in whole TLV (21 x 6 = 126 bytes). Rather than break the 22nd MAC address across two TLVs, the first TLV would contain 126 bytes and the next the remainder of the value.

### Example

A Get PDU contains a single Var Container to request the MAC address table from a D-ONU:D7 01 03.

Assume further that the polled D-ONU currently has 23 learned MAC addresses, and returns the response using three Variable Containers in the PDU, 21 addresses in the first TLV and 2 in the second, followed by the large value terminator:

0xD7 01 03 7E 11 12 13 14 15 16

0xD7 01 03 0C 21 22 23 24 25 26 31 32 33 34 35 36

0xD7 01 03 80

## 8.6 Multiple Part OAM Responses

Certain responses from the D-ONU to a single PDU from the DPoE System may not fit within a single OAM frame. (Variable Containers are larger than Variable Descriptors, and some values can be much larger than a single frame. Such attributes include D-ONU rule tables and learning tables.) In this case, the D-ONU must split its response across multiple OAM PDUs. The D-ONU MUST then inform the DPoE System that the complete response was not sent in one frame. In addition, the DPoE System MUST be able to detect missing OAM PDUs from a series needed to form the complete response.

To indicate that further response messages are forthcoming, the D-ONU adds a particular TLV known as a Sequence Number TLV to its response PDU.

A D-ONU SHOULD NOT insert a Sequence Number TLV into a single part response frames.

The Sequence Number TLV has the following format:

**Table 20 - Sequence Number TLV**

| Field      | Description                                                                                                           | Value (hex) |
|------------|-----------------------------------------------------------------------------------------------------------------------|-------------|
| Branch     | Branch Attribute                                                                                                      | 0xD7        |
| Leaf       | Multi-Part Response Sequence Number                                                                                   | 0x00 01     |
| Length     | One 16-bit unsigned integer                                                                                           | 0x02        |
| Sequence # | Bit 15, when set, indicates that this is the last message of its sequence.<br>Bits 0-14 are a 15 bit sequence number. | (variable)  |

To send a multiple part response requiring N PDUs, the D-ONU does the following:

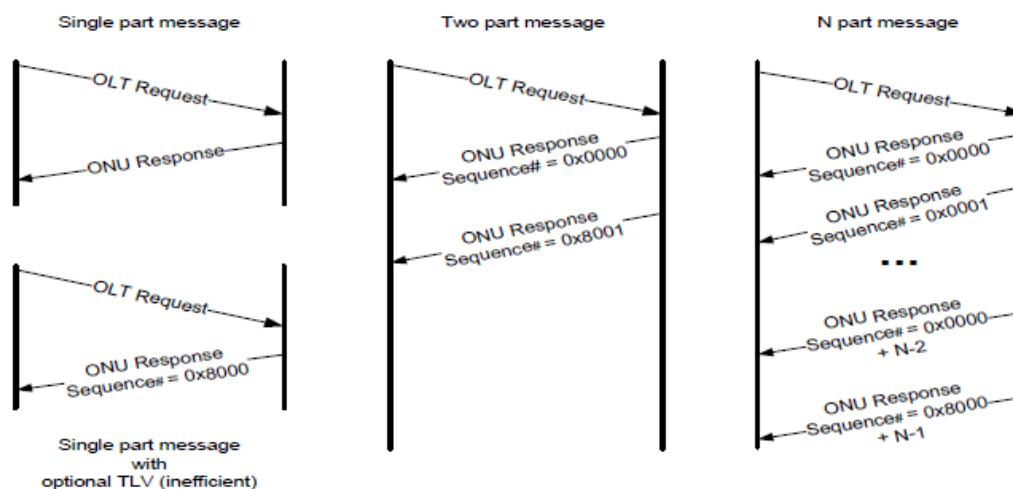
```

For the first PDU in the sequence:
    Set Sequence# = 0

For the last PDU of the sequence:
    Set bit 15 of Sequence#

For all PDUs in the sequence:
    Add a sequence TLV with the value {0xD7, 0x0001, Sequence#}
    Send the OAM PDU
    Increment Sequence#
```

Figure 4 presents a sample message exchange:



**Figure 4 - Sample Message Exchange**

## 8.7 Object Context (Branch 0xD6)

DPoE OAM extensions can manage objects other than the immediate EPON MAC instance. Also, since a D-ONU typically supports multiple ports, any attribute such as "Bytes Received" may have many instances, one for each port on the D-ONU. Therefore, the particular instance of an object must be identified to provide context for the attributes or actions.

An object context tuple in an OAM PDU sets the object to which all subsequent Variable Descriptors or Containers apply. This remains unchanged until the next object context in the PDU is processed, or the message ends. If no object context is supplied, the default context is the logical link (LLID) on which the OAM PDU was received.

A DPoE ONU is assumed to have 1 or more Ethernet interfaces in addition to the TU interface. TU Interfaces and Ethernet interfaces are identified by an 8-bit ID number that ranges from 0..N-1, using two separate numbering spaces for TU interfaces and Ethernet interfaces. The relationship of interface numbers to actual physical interfaces is defined by the DPoE ONU, but the relationship is always the same for any given DPoE ONU.

It is not necessary for the DPoE System to know the MAC addresses of the user ports to manage them via DPoE OAM.

**Table 21 - Object Context**

| Leaf (HEX) | Attribute              | Description                                              |
|------------|------------------------|----------------------------------------------------------|
| 0x00 00    | D-ONU                  | D-ONU                                                    |
| 0x00 01    | Network PON Port       | A PON port on the network side of the device             |
| 0x00 02    | Unicast Logical Link   | Unicast logical link                                     |
| 0x00 03    | User Port              | User-side Ethernet port                                  |
| 0x00 04    | Queue                  | A single queue                                           |
| 0x00 05    | MEP                    | A Service OAM frame generator Maintenance Endpoint (MEP) |
| 0x00 06    | Multicast Logical Link | Multicast (unidirectional) logical link                  |
| 0x00 07    | Reserved               | Defined in [DPoG-OAM] Specification                      |

### 8.7.1 D-ONU Object (0xD6/0x0000)

The D-ONU object identifies the D-ONU as a whole. In most cases, this object is obvious because the D-ONU is the one processing the DPoE OAM message. In some cases, a DPoE OAM PDU may want to make the current context

less specific for a particular attribute. The D-ONU Object is also necessary for some other uses, such as in an alarm TLV.

The instance number for the D-ONU object is always 0.

**Table 22 - D-ONU Object**

| Width (Octets) | Field          | Value (hex) |
|----------------|----------------|-------------|
| 1              | D-ONU instance | 0           |

### 8.7.2 Network Port Object (0xD6/0x0001)

The Network Port object identifies one of the network-side PON ports (TU interface) on the device. Network Ports are numbered sequentially starting from 0. This object cannot identify S interfaces.

**Table 23 - Network Port Object**

| Width (Octets) | Field      | Value (hex) |
|----------------|------------|-------------|
| 1              | PON Number | 0..N-1      |

### 8.7.3 Unicast Logical Link (0xD6/0x0002)

The Unicast Logical Link object identifies one of the unicast logical links registered by the D-ONU. A Unicast Logical Link instance is identified by an index that matches an LLID index in the LLID and Queue Configuration (0xD7/0x010D) attribute (see Section 9.2.1).

**Table 24 - Unicast Logical Link Object**

| Width (Octets) | Field      | Value (hex) |
|----------------|------------|-------------|
| 1              | LLID Index | 0..L-1      |

### 8.7.4 S-Interface Object (0xD6/0x0003)

The S-Interface object identifies one of the S interfaces or reference points on the D-ONU. S interfaces are numbered sequentially starting from 0.

**Table 25 - S-Interface Port Object**

| Width (Octets) | Field              | Value (hex) |
|----------------|--------------------|-------------|
| 1              | S-Interface Number | 0..N-1      |

### 8.7.5 Queue Object (0xD6/0x0004)

Queues are numbered relative to their egress port. Queue numbers start with the value 0, which is the highest priority queue, up to the value N-1, where N is the number of queues that terminate on a port. The value 0xFFFF is a special value that means "all queues for this port". This context is primarily useful for bulk statistics queries from all queues at once, as it saves setting a queue context for each queue.

**Table 26 - Queue Object**

| Width (Octets) | Field           | Value (hex)                                                                     |
|----------------|-----------------|---------------------------------------------------------------------------------|
| 2              | Object Type     | See Section 8.7. (Only User Port and Unicast Logical Link objects have queues.) |
| 1              | Object Instance | 0..N-1                                                                          |
| 1              | Queue Number    | 0..Q-1                                                                          |

### 8.7.6 Multicast Logical Link Object (0xD6/0x0006)

The Multicast Logical Link object identifies one of the multicast logical links registered in the D-ONU. A Multicast Logical Link instance is identified by 16-bit LLID value, rather than the D-ONU LLID index, as is the case for

unicast logical links. This allows using the same object context values for querying multicast statistics for any D-ONU in a given multicast group.

**Table 27 - Multicast Logical Link Object**

| Width (Octets) | Field                | Value (hex) |
|----------------|----------------------|-------------|
| 2              | Multicast LLID Value | Any         |

## 8.8 Broadcast eOAM

Broadcast eOAM, or the "broadcast eOAM channel," uses the eOAM message structure as defined in [802.3] but instead of transmitting the frame on a unicast LLID assigned to a D-ONU, the eOAM frame is transmitted using the broadcast LLID. In this manner the eOAM frame is received by all D-ONUs on the PON. The D-ONU is not expected to reply to eOAM messages received on the broadcast LLID.

## 8.9 Reserved Branch (0xC7)

The branch value 0xC7 is reserved for use in DOCSIS Provisioning of GPON specifications.

## 9 OAM ATTRIBUTES BY FUNCTION

This section further details each DPoE OAM attribute. Each attribute name is listed by its Branch/Leaf designation. For example, "Get Firmware Version (D7/80)," where the first number (D7) is the branch and the second number (80) is the leaf. These branch/leaf values are in hexadecimal. Where applicable, units for measurement and allowed ranges are specified.

Some attributes, particularly capabilities, are read-only. These attributes are denoted by an "R" after their value. Some writeable attributes are non-volatile, which is to say they persist after the D-ONU has been reset. These attributes are marked with an "NV".

### 9.1 D-ONU Management

#### 9.1.1 Device ID (0xD7/0x0002) R

Objects: D-ONU

The ONU Device ID is a non-volatile number that uniquely identifies a physical D-ONU. By definition, the D-ONU Device ID is the lowest (numerically smallest) MAC address among all MAC addresses associated with the TU interface port of a D-ONU. All logical links on a D-ONU report the same D-ONU Device ID, despite having different link MAC addresses (per [802.3]).

#### 9.1.2 Firmware Info (0xD7/0x0003) R

Objects: D-ONU

This attribute represents the D-ONU firmware version. The version number uniquely identifies a particular version of the D-ONU firmware. Format is defined by the D-ONU vendor. DPoE Systems can compare this value for equality with a provisioned value for the currently correct firmware version. "Newer than" or "compatible with" comparisons depend on version number format and should not be performed with a simple comparison. The Boot Version can be used to populate the BOOTR field in the sysDescr MIB object. Version values 0x0000 and 0xFFFF are reserved, and indicate loads that are not installed or are not available.

**Table 28 - Firmware Info**

| Size | Name             | Description                                                                   |
|------|------------------|-------------------------------------------------------------------------------|
| 2    | Boot Version     | Version of bootstrap loader (if any)                                          |
| 4    | Boot CRC-32      | CRC-32 of boot loader serves as additional unique identifier and verification |
| 2    | Firmware Version | Version of main firmware running on the D-ONU                                 |
| 4    | Firmware CRC-32  | CRC-32 of firmware serves as unique ID and verification                       |

#### 9.1.3 Chipset Info (0xD7/0x0004) R

Objects: D-ONU

This attribute represents the type of chip used on the D-ONU.

**Table 29 - Chipset Info**

| Size | Name         | Description                                                                            |
|------|--------------|----------------------------------------------------------------------------------------|
| 2    | JEDEC ID     | 16-bit chip manufacturer ID code as assigned by JEDEC                                  |
| 4    | Chip Model   | Identifies the particular kind of EPN chip. Format defined by chipset vendor           |
| 4    | Chip Version | Identifies the version or stepping of the chip model. Format defined by chipset vendor |

#### 9.1.4 Date of Manufacture (0xD7/0x0005) R

Objects: D-ONU

The date the D-ONU was manufactured, encoded in Binary Coded Decimal (BCD) digits as YYYYMMDD. For example, June 24, 2010, would be represented as 20 10 06 24.

**Table 30 - Date of Manufacture**

| Size | Name  | Description |
|------|-------|-------------|
| 2    | Year  | BCD         |
| 1    | Month | BCD         |
| 1    | Day   | BCD         |

#### 9.1.5 Manufacturer Info (0xD7/0x0006) R

Objects: D-ONU

This attribute contains the ONU serial number and manufacturer-specific information. The Serial Number is ASCII encoded and may be up to 31 characters in length and must be terminated with one or more consecutive Nulls. Any bytes following the null termination, within the length of this attribute, are considered vendor-specific encoded information.

**Table 31 - Manufacturer Info**

| Size | Name                                        | Units  |
|------|---------------------------------------------|--------|
| 64   | Serial Number + Vendor Specific Information | String |

#### 9.1.6 Max Logical Links (0xD7/0x0007) R

Objects: D-ONU

The maximum number of logical links the D-ONU supports on the EPON.

**Table 32 - Max Logical Links**

| Size | Name            | Description                                                                                                                                    |
|------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 2    | Bidirectional   | Maximum number of links which can both transmit and receive                                                                                    |
| 2    | Downstream-only | In addition to the bidirectional links, the maximum number of LLIDs which can receive data, but not transmit (unidirectional, downstream only) |

#### 9.1.7 Number of Network Ports (0xD7/0x0008) R

Objects: D-ONU

This attribute provides the total number of TU interface ports on the D-ONU.

#### 9.1.8 Number of S interfaces (0xD7/0x0009) R

Objects: D-ONU

This attribute provides the number of S interfaces on the D-ONU.

#### 9.1.9 D-ONU Packet Buffer (0xD7/0x000A) R

Objects: D-ONU

This message provides a means for the D-ONU to convey information about packet buffer capabilities to the DPoE System.

**Table 33 - D-ONU Packet Buffer**

| Size | Name                   | Description                                                                                          |
|------|------------------------|------------------------------------------------------------------------------------------------------|
| 1    | Upstream Queues        | Total number of queues available to be assigned to logical links in the upstream direction           |
| 1    | Up Queues Max Per Link | Maximum number of queues which can be assigned to a single logical link in the upstream direction    |
| 1    | Up Queue Increment     | The smallest allocatable increment of packet buffer memory in the upstream direction, in kilobytes   |
| 1    | Downstream Queues      | Total number of queues available to be assigned to logical links in the downstream direction         |
| 1    | Dn Queues Max Per Port | Maximum number of queues which can be assigned to a single UNI port in the downstream direction      |
| 1    | Dn Queue Increment     | The smallest allocatable increment of packet buffer memory in the downstream direction, in kilobytes |
| 2    | Total Packet Buffer    | Total packet buffer memory on the D-ONU (KB)                                                         |
| 2    | Up Packet Buffer       | Maximum amount of packet buffer memory which can be allocated to upstream queues                     |
| 2    | Dn Packet Buffer       | Maximum amount of packet buffer memory which can be allocated to downstream queues                   |

### 9.1.10 Report Thresholds (0xD7/0x000B)

Objects: Unicast Logical Link

This attribute represents the threshold levels used to generate REPORT MPCPDUs. The format corresponds closely to the format of the REPORT MPCPDU, except that the bitmaps for report values present are omitted. The message specifies the number of queue sets and the number of report values in each queue set to be used on the link. A DPoE System MUST insure the number of report values in each queue set is the same. For each queue set and report value, a threshold is specified.

A DPoE System MUST ensure the report thresholds for successive queue sets are increasing. A DPoE System MUST ensure the report thresholds for successive queue sets are cumulative. For example, Report Threshold 0 for Queue Set 1 must be equal to or greater than Report Threshold 0 in Queue Set 0. A higher numbered queue set includes all the data reported in earlier queue sets, plus possibly some additional data.

**Table 34 - Report Thresholds**

| Size | Description                            | Units   | Default | Min | Max    |
|------|----------------------------------------|---------|---------|-----|--------|
| 1    | Number of Queue Sets                   |         | 4       | 1   | 4      |
| 1    | Report Values Per Queue Set            |         | 1       | 1   | 8      |
| 2    | Report Threshold 0 for Queue Set 0     | EPON TQ | 2048    | 0   | 0xFFFF |
|      | ..                                     |         |         |     |        |
| 2    | Report Threshold n-1 for Queue Set 0   | EPON TQ | -       | 0   | 0xFFFF |
|      | ..                                     |         |         |     |        |
| 2    | Report Threshold 0 for Queue Set n-1   | EPON TQ | -       | 0   | 0xFFFF |
|      | ..                                     |         |         |     |        |
| 2    | Report Threshold n-1 for Queue Set n-1 | EPON TQ | -       | 0   | 0xFFFF |

### 9.1.11 Logical Link Forwarding State (0xD7/0x000C) R

Objects: Unicast Logical Link

This attribute represents the current traffic state for a logical link. User data traffic may be enabled (normal operation) or disabled (discarded by the D-ONU). Only OAM and MPCP remain enabled regardless of the logical link forwarding state. See Enable/Disable User Traffic (Section 9.6.10 and Section 9.6.11) for actions that change this state.

**Table 35 - Link State**

| Size | Description                      | Units   | Default | Min | Max |
|------|----------------------------------|---------|---------|-----|-----|
| 1    | Link State (0=Disable, 1=Enable) | Boolean | 0       | 0   | 1   |

**9.1.12 OAM Frame Rate (0xD7/0x000D)**

Objects: Unicast Logical Link

This attribute represents the maximum rate at which OAM PDUs are transmitted on a link.

Setting the Maximum OAM Frame Rate to 0 disables rate control.

The Minimum OAM Frame Rate is the heartbeat rate. This is the rate at which OAM PDUs are sent between the D-ONU and DPoE System, using an Info PDU as a "heartbeat" if there is no other OAM activity, as per [802.3]. The heartbeat rate is specified as one heartbeat PDU per specified time interval. The time interval is specified as the value provisioned in the message x 100ms. Therefore, setting the Minimum OAM Frame Rate to 10 specifies a rate of 1 PDU per 10 x 100ms. This equals 1 PDU per 1 second.

**Table 36 - OAM Frame Rate**

| Size | Description      | Units           | Default | Min                  | Max |
|------|------------------|-----------------|---------|----------------------|-----|
| 1    | Maximum OAM rate | PDUs/100ms      | 0       | 0 (Unlimited rate)   | 25  |
| 1    | Minimum OAM rate | Number of 100ms | 10      | 0 (no OAM) heartbeat | 10  |

**9.1.13 ONU Manufacturer Organization Name (0xD7/0x000E) R**

Objects: D-ONU

This attribute represents the organization which manufactured the D-ONU. The attribute is an ASCII string, with no null terminator. It is used to validate the manufacturer CVC during secure software download. The value must exactly match the subject organizationName value in the firmware manufacturer CVC. See [DPoE-SECv2.0] for details.

**Table 37 - ONU Manufacturer Organization Name**

| Size   | Description       | Units  | Default | Min | Max |
|--------|-------------------|--------|---------|-----|-----|
| varies | Organization name | string | -       | -   | -   |

**9.1.14 Firmware Mfg Time Varying Controls (0xD7/0x000F) NVS**

Objects: D-ONU

This attribute represents the firmware CVC and CVS validity times as programmed into the D-ONU. The TVC affects the validity of firmware updates. See [DPoE-SECv2.0] for details.

Time values are ASCII strings representing the time in UTC in the format YYMMDDhhmmssZ. Per [DPoE-SECv2.0], dates range from the year 1950 to 2050; the upper two digits of the year are implied.

**Table 38 - Firmware Mfg Time Varying Controls**

| Size | Description       | Units   | Default | Min           | Max           |
|------|-------------------|---------|---------|---------------|---------------|
| 13   | Code Access Start | Seconds | -       | 500101000000Z | 491231235959Z |
| 13   | CVC Access Start  | Seconds | -       | 500101000000Z | 491231235959Z |

**9.1.15 S Interface Type (0xD7/0x0010)**

Objects: D-ONU

This message provides a means for the D-ONU to convey information about the type of individual S interfaces and devices connected to them (if present and known), including embedded (eSAFE), embedded non-eSAFE (e.g., management clients), and other known CPE type devices. There are in total N S interfaces available on the D-ONU,

including physically exposed ports (MI/MU/CMCI) as well as embedded S interfaces (LCI) connecting to eSAFE and non-eSAFE (for example, management client) devices.

When an S interface is connected to an external device but is unable to determine if it is being used for IP(HSD) or MEF services, the default designation MUST be CMCI.

This attribute contains N entries, one for each S interface on the D-ONU, where each entry corresponds to the D-ONU S interface type and indicates the device type that is connected to this S interface (if any). Each S interface on the D-ONU can be associated with one and only one device type.

**Table 39 - D-ONU Port Type**

| Size | Name                 | Description                                                                                                                             |
|------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| 1    | S interface 0 type   | This field describes type of device connected to S interface 0 on D-ONU.<br>This field carries one of the values defined in Table 40.   |
| 1    | S interface 1 type   | This field describes type of device connected to S interface 1 on D-ONU.<br>This field carries one of the values defined in Table 40.   |
| ...  | ...                  | ...                                                                                                                                     |
| 1    | S interface N-1 type | This field describes type of device connected to S interface N-1 on D-ONU.<br>This field carries one of the values defined in Table 40. |

Individual S interface types are enumerated in Table 40.

**Table 40 - S interface type enumeration**

| Port type value | Enumeration (designation)         | Description                                                                                                              |
|-----------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| 0x00            | unspecified                       | Given S interface is not connected to a known external or internal device                                                |
| 0x01            | eMTA                              | Given S interface is connected to a PacketCable/eMTA                                                                     |
| 0x02            | eSTB-IP                           | Given S interface is connected to an eSTB-IP                                                                             |
| 0x03            | eSTB-DSG                          | Given S interface is connected to an eSTB-DSG                                                                            |
| 0x04            | eTEA                              | Given S interface is connected to an eTEA                                                                                |
| 0x05            | eSG                               | Given S interface is connected to an eSG                                                                                 |
| 0x06            | eRouter                           | Given S interface is connected to an eRouter                                                                             |
| 0x07            | eDVA                              | Given S interface is connected to an eDVA                                                                                |
| 0x08            | SEB eSTB-IP                       | Given S interface is connected to a SEB eSTB-IP                                                                          |
| 0x09            | CMCI                              | Given S interface is a CMCI for CPE                                                                                      |
| 0x0A            | MU                                | Given S interface is an MU for CE                                                                                        |
| 0x0B            | MI                                | Given S interface is an MI for a DEMARC                                                                                  |
| 0x0C            | Other Internal                    | Given S interface is an internal interface, connected to non-eSAFE device and not exposed externally as a subscriber UNI |
| 0x0D            | ePTA                              | Given S interface is connected to an ePTA                                                                                |
| 0x0E - 0xFF     | Reserved and ignored on reception |                                                                                                                          |

### 9.1.16 Vendor Name (D7/00 11) R

This attribute represents the ONU vendor name. The attribute is an ASCII string, with no null terminator. It can be used to populate the VENDOR field in the sysDescr MIB variable (see [DPoE-OSSv2.0]), and may or may not be the same as the ONU Manufacturer Organization Name. Format of the vendor name is vendor specific. The D-ONU SHOULD limit the vendor name length to less than 32 bytes.

**Table 41 - ONU Manufacturer Organization Name**

| Size   | Description | Units  | Default | Min | Max |
|--------|-------------|--------|---------|-----|-----|
| varies | Vendor name | string | -       | -   | -   |

**9.1.17 Model Number (D7/00 12) R**

This attribute represents the ONU model number. The attribute is an ASCII string, with no null terminator. It can be used to populate the MODEL field in the sysDescr MIB variable (see [DPoE-OSSv2.0]). Format of the model number is vendor specific. The D-ONU SHOULD limit the model number length to less than 32 bytes.

**Table 42 - ONU Model Number**

| Size   | Description  | Units  | Default | Min | Max |
|--------|--------------|--------|---------|-----|-----|
| varies | Model number | string | -       | -   | -   |

**9.1.18 Hardware Version (D7/00 13) R**

This attribute represents the ONU hardware version. The attribute is an ASCII string, with no null terminator. It can be used to populate the HW\_REV field in the sysDescr MIB variable (see [DPoE-OSSv2.0]). Format of the hardware version information is vendor specific. The D-ONU SHOULD limit the hardware version length to less than 32 bytes.

**Table 43 - ONU Hardware Version**

| Size   | Description      | Units  | Default | Min | Max |
|--------|------------------|--------|---------|-----|-----|
| varies | Hardware version | string | -       | -   | -   |

**9.1.19 EPON Mode (D7/00 14) R**

This attribute represents the EPON mode(s) supported by this ONU.

DPoE Systems that support 2G-EPON MUST support this attribute. DPoE ONUs that support 2G-EPON MUST support this attribute. DPoE Systems that support 1G-EPON and 10G-EPON SHOULD support this attribute. DPoE ONUs that support 1G-EPON and 10G-EPON SHOULD support this attribute.

**Table 44 - ONU EPON Mode**

| Size | Description | Units  | Default | Min | Max |
|------|-------------|--------|---------|-----|-----|
| 2    | EPON Mode   | Bitmap | -       | -   | -   |

**Table 45 - ONU EPON Mode Capabilities Bit Value**

| EPON Mode | Interpretation of Bit Field                                                                                                                              |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.25G DS  | Bit 1:<br>When set to 1, the ONU supports 1.25 Gb/s downstream line rate<br>When set to 0, the ONU does not support 1.25 Gb/s downstream line rate       |
| 2.5G DS   | Bit 2:<br>When set to 1, the ONU supports 2.5 Gb/s downstream line rate<br>When set to 0, the ONU does not support 2.5 Gb/s downstream line rate         |
| 10G DS    | Bit 3:<br>When set to 1, the ONU supports 10.3125 Gb/s downstream line rate<br>When set to 0, the ONU does not support 10.3125 Gb/s downstream line rate |
| Reserved  | Bits 4-7: Reserved for future use                                                                                                                        |
| 1.25G US  | Bit 8:<br>When set to 1, the ONU supports 1.25 Gb/s upstream line rate<br>When set to 0, the ONU does not support 1.25 Gb/s upstream line rate           |
| Reserved  | Bit 9: Reserved for future use                                                                                                                           |

| EPON Mode | Interpretation of Bit Field                                                                                                                           |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10G US    | Bit 10:<br>When set to 1, the ONU supports 10.3125 Gb/s upstream line rate<br>When set to 0, the ONU does not support 10.3125 Gb/s upstream line rate |
| Reserved  | Bits 11 - 15: Reserved for future use                                                                                                                 |

### 9.1.20 Software Bundle (0xD7/0x0015) R

Objects: D-ONU

This attribute represents the ONU Software Version. The Software Bundle is used to populate the SW\_REV field in the sysDescr MIB object (see [DPoE-OSSIV2.0]). There is not a prescribed versioning format and is not intended for direct comparison to previous software versions. This attribute is a null-terminated ASCII string.

**Table 46 - ONU Hardware Version**

| Size   | Description     | Units  | Default | Min | Max |
|--------|-----------------|--------|---------|-----|-----|
| varies | Software Bundle | string | -       | -   | 64  |

### 9.1.21 Reset D-ONU (0xD9/0x0001)

Objects: D-ONU

This attribute resets the D-ONU, as if from power on.

## 9.2 Bridging

### 9.2.1 Dynamic Learning Table Size (0xD7/0x0101) R

Objects: D-ONU

This attribute is a capability attribute that represents the maximum size of the D-ONU MAC address learning table for the D-ONU as a whole. The total number of MAC addresses learned by the D-ONU cannot exceed this number.

**Table 47 - Dynamic Learning Table Size**

| Size | Description                     | Units   | Default | Min | Max         |
|------|---------------------------------|---------|---------|-----|-------------|
| 4    | Dynamic MAC learning table size | Entries | n/a     | 1   | 0xFFFF FFFF |

### 9.2.2 Dynamic Address Age Limit (0xD7/0x0102)

Objects: D-ONU

This attribute represents Dynamic MAC learning table age limit.

**Table 48 - Dynamic Address Age Limit**

| Size | Description                          | Units | Default | Min | Max    |
|------|--------------------------------------|-------|---------|-----|--------|
| 2    | Dynamic MAC learning table age limit | 10 ms | 2000    | 0   | 0xFFFF |

### 9.2.3 Dynamic MAC Table (0xD7/0x0103) R

Objects: User Port

This attribute represents the dynamically learned MAC address rules of one Ethernet port. MAC address are repeated within a single attribute until that attribute is full (21 addresses = 126 bytes). If necessary, such attributes are repeated as an attribute list until the entire table has been reported.

**Table 49 - Dynamic MAC Table**

| Size | Description   | Units | Default | Min | Max |
|------|---------------|-------|---------|-----|-----|
| 6    | MAC address 0 | -     | --      | -   | -   |
| ..   | MAC address 1 | -     | -       | -   | -   |

### 9.2.4 Static MAC Table (0xD7/0x0104) R

Objects: User Port

This attribute represents the statically provisioned MAC address table. The data structure is the same as the Get Dynamic MAC Table attribute above.

### 9.2.5 Interface Port Auto-negotiation (0xD7/0x0105)

Objects: Network Port, User Port

This attribute represents the auto-negotiation advertisement values used by a port. The set command specifies the values to advertise, while the get command returns the current values along with the values the port can physically support.

**Table 50 - Interface Port Auto-Negotiation**

| Size | Description                                                                                                                         | Units  | Default         | Min | Max |
|------|-------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----|-----|
| 2    | Bit array of maximum capabilities (see Table 51).<br>In Set request message, this field is set to 0x00-00 and ignored on reception. | Bitmap | Depends on port | -   | -   |
| 2    | Bit array of current capabilities (see Table 51). A capability is advertised as supported when its bit = 1.                         | Bitmap | Depends on port | -   | -   |

**Table 51 - Port Capabilities**

| Auto-Negotiation Capability |             |
|-----------------------------|-------------|
| Half Duplex                 | Bit 0 (LSB) |
| Full Duplex                 | Bit 1       |
| 10 Mbps                     | Bit 2       |
| 100 Mbps                    | Bit 3       |
| 1000 Mbps                   | Bit 4       |
| 10 Gbps                     | Bit 5       |
| Flow Control                | Bit 6       |
| Auto MDI/MDI-X              | Bit 7       |
| 2.5 Gbps                    | Bit 8       |
| 5 Gbps                      | Bit 9       |
| Unused (set to 0)           | Bit 10-15   |

### 9.2.6 Source Address Admission Control (0xD7/0x0106)

Objects: User Port

This attribute controls the operation of the MAC Source Address-based admission control function operating on the DPoE ONU port in context in the upstream direction

**Table 52 - Source Address Admission Control**

| Size | Description                                                                                                                          | Units | Default | Min | Max |
|------|--------------------------------------------------------------------------------------------------------------------------------------|-------|---------|-----|-----|
| 1    | Indicates whether the Source Address Admission Control for the given DPoE ONU port is enabled or not.<br>0 = disabled<br>1 = enabled | enum  | 0       | 0   | 1   |

The MAC Source Address-based admission control function operating on the selected DPOE ONU port in the upstream direction controls what frames received from DPOE ONU ports are admitted for upstream transmission. When the MAC Source Address-based admission control function is disabled, all frames received from the DPOE ONU port are admitted for upstream transmission. When the MAC Source Address-based admission control function is enabled, the DPoE ONU MUST drop any frame received from the DPOE ONU ports if the MAC Source Address for such a frame is not present in the MAC address admission control table on the DPOE ONU. The said table may be filled through dynamic MAC learning or configured through provisioning.

### 9.2.7 MAC Learning Min Guarantee (0xD7/0x0107)

Objects: User Port

This attribute represents minimum number of MAC addresses that can be learned on an individual UNI port.

**Table 53 - MAC Learning Min Guarantee**

| Size | Description              | Units   | Default | Min | Max |
|------|--------------------------|---------|---------|-----|-----|
| 2    | Minimum guaranteed limit | Entries | 40      | 0   | 40  |

### 9.2.8 MAC Learning Max Allowed (0xD7/0x0108)

Objects: User Port

This attribute represents maximum allowed number of MAC addresses on an individual S interface.

**Table 54 - MAC Learning Max Allowed**

| Size | Description           | Units   | Default | Min | Max    |
|------|-----------------------|---------|---------|-----|--------|
| 2    | Maximum allowed limit | Entries | n/a     | 0   | 0xFFFF |

### 9.2.9 MAC Learning Aggregate Limit (0xD7/0x0109)

Objects: D-ONU

This message represents the aggregate dynamic MAC address limit for the D-ONU as a whole. This is the maximum number of addresses that can be learned by all ports combined. Setting the limit to zero disables MAC learning on the D-ONU.

**Table 55 - MAC Learning Aggregate Limit**

| Size | Description                                   | Units   | Default | Min | Max    |
|------|-----------------------------------------------|---------|---------|-----|--------|
| 2    | The D-ONU aggregate dynamic MAC address limit | Entries | 0       | 0   | 0xFFFF |

### 9.2.10 Len Error Discard (0xD7/0x010A)

Objects: User Port

This attribute represents the Length Error Discard Enable status of the D-ONU ports. Length errors occur when the layer 2 length does not match the frame length.

**Table 56 - Len Error Discard**

| Size | Description                                                                                                                       | Units   | Default | Min | Max |
|------|-----------------------------------------------------------------------------------------------------------------------------------|---------|---------|-----|-----|
| 1    | If Length Error Discard Enable<br>0: Frames with a Length Error will be passed<br>1: Frames with a Length Error will be discarded | Boolean | 1       | 0   | 1   |

**9.2.11 Flood Unknown (0xD7/0x010B)**

Objects: D-ONU

This message represents the configuration for flooding of downstream frames whose destination addresses have not been learned. Disabling will cause these frames to be discarded.

**Table 57 - Flood Unknown**

| Size | Description                                                                  | Units   | Default | Min | Max |
|------|------------------------------------------------------------------------------|---------|---------|-----|-----|
| 1    | Flood Unknown DA option<br>0: Drop unknown MAC DA<br>1: Flood unknown MAC DA | Boolean | 1       | 0   | 1   |

**9.2.12 Local Switching (0xD7/0x010C)**

Objects: User Port

This attribute represents the configuration of a port for local switching. With local switching enabled, a port may send traffic to any other user-side port of the D-ONU. This feature should be used with caution for unknown flooding.

**Table 58 - Local Switching**

| Size | Description                                                                       | Units   | Default | Min | Max |
|------|-----------------------------------------------------------------------------------|---------|---------|-----|-----|
| 1    | Local Switching option<br>0: Disable local switching<br>1: Enable local switching | Boolean | 0       | 0   | 1   |

**9.2.13 LLID and Queue Configuration (0xD7/0x010D)**

Objects: D-ONU

Status: Obsolete

**9.2.14 Firmware Filename (0xD7/0x010E) NVS R**

Objects: D-ONU

This attribute represents the name of the DPoE ONU firmware file, as obtained by the vCM from the OSS. This attribute is read-only by OAM and is set during the software update process, where the name of the DPoE ONU firmware file is carried in the File Transfer Write Request PDU. The DPoE ONU firmware file name has the format of a null-terminated ASCII string.

**9.2.15 MAC Table Full Behavior (0xD7/0x010F)**

Objects: User Port

This attribute controls behavior of the D-ONU MAC address learning process when it has reached a limit of MAC addresses, and a new address is discovered. The default behavior is to discard the new address. The alternative is to overwrite the oldest address in the table with the newly discovered address.

**Table 59 - MAC Table Full Behavior**

| Size | Description                                                                    | Units      | Default | Min | Max |
|------|--------------------------------------------------------------------------------|------------|---------|-----|-----|
| 1    | MAC Table Full option<br>0: Discard new address<br>1: Overwrite oldest address | Enumerated | 0       | 0   | 1   |

**9.2.16 Multicast LLID (0xD7/0x0110)**

Objects: ONU

See [1904.1A], subclause 14.4.3.2.15.

**9.2.17 UNI MAC Learned (0xD7/0x0111)**

Objects: ONU

Status: Obsolete

**9.2.18 ONU Max Frame Size Capability (0xD7/0x0112)**

Objects: ONU

See [1904.1A], subclause 14.4.3.2.15

**9.2.19 UNI Max Frame Size Limit (0xD7/0x0113)**

Objects: User Port

See [1904.1A], subclause 14.4.3.2.16

**9.2.20 ONU Port Config (0xD7/0x0114)**

Objects: ONU

See [1904.1A], subclause 14.4.3.2.17

**9.2.21 Queue Config (0xD7/0x0115)**

Objects: LLID, User Port

See [1904.1A], subclause 14.4.3.2.18

**9.2.22 Clear Dynamic MAC Table (0xD9/0x0101)**

Objects: D-ONU, User Port

This action clears the dynamically learned MAC addresses table for the object in context, either a particular port, or the D-ONU as a whole (all S ports on the D-ONU).

**9.2.23 Add Dynamic MAC Address (0xD9/0x0102)**

Objects: User Port

This attribute adds one or more dynamic MAC addresses to the table for the port in context.

**Table 60 - Add Dynamic MAC Address**

| Size | Description   | Units | Default | Min | Max |
|------|---------------|-------|---------|-----|-----|
| 6    | MAC address 0 | --    | -       | -   | -   |
| ..   | MAC address 1 | -     | -       | -   | -   |

### 9.2.24 Delete Dynamic MAC Address (0xD9/0x0103)

Objects: User Port

This attribute deletes one or more dynamic MAC addresses to the table for the port in context. Format is the same as for Add Dynamic MAC Address.

### 9.2.25 Configure eSAFE (0xD7/0x0116)

Objects: ONU

**Table 61 - Configure eSAFE**

| Size   | Description              | Length   | Format |
|--------|--------------------------|----------|--------|
| varies | eSAFE Configuration File | variable | TLV    |

This message is used to forward one or more eSAFE-specific TLVs contained in the DOCSIS Configuration file downloaded by the vCM associated with this device.

For example, eSAFEs may be enabled/disabled according to specific eSAFE-defined methods. The example below shows enable/disable for an eRouter.

#### Enable/Disable eRouter

A valid eRouter Initialization Mode Encoding contains exactly one instance of this TLV.

| Type | Length | Value                                                                                                                                                         |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | 1      | 0: Disabled<br>1: IPv4 Protocol Enabled<br>2: IPv6 Protocol Enabled<br>3: Dual IP Protocol Enabled<br>4-255: Invalid<br>Default: 3 (Dual IP Protocol Enabled) |

**Note:** If the target ONU does not contain the specified eSAFE, the above configuration is ignored by the ONU.

### 9.2.26 Enable/Disable eMTA/eDVA (0xD7/0x0117)

Objects: ONU

**Table 62 - Enable/Disable eMTA/eDVA**

| Size   | Description              | Length               | Format                                         |
|--------|--------------------------|----------------------|------------------------------------------------|
| varies | eMTA/eDVA Enable/Disable | 12(IPv4) or 36(IPv6) | vCM DHCP Option 122 sub options 1 and 2 (IPv4) |

This message provides the ability to enable or disable an eMTA using the existing DHCP option handling mechanism. The following format and content is required:

```

0                               1                               2                               3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               option-code               |               option-length               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               sub-option-1               |
.
.
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               sub-option-2               |
.
.
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Option-code: 2170 (0x087A) for IPv6 or 0122 (0x007A) for IPv4

Option-length:n (12 for IPv4, 36 for IPv6)

Sub-option-1: The multimedia telephony adapter (MTA) portion of the device listens to this IP address of the DHCP server. This has two special values:

1. All 0's i.e., 0.0.0.0 for IPv4 (which will disable the MTA),
2. All 1's i.e., 255.255.255.255 for IPv4 (which will instruct the MTA to accept replies from any DHCP server).

Sub-option 2: A second DHCP server's IP address. Otherwise the same as sub-option-1.

### 9.2.27 Clear Static MAC Table (0xD9/0x0104)

Objects: D-ONU, User Port

This action clears the entire static MAC address table for the object in context, either a particular port, or the D-ONU as a whole (all S ports on the D-ONU).

### 9.2.28 Add Static MAC Address (0xD9/0x0105)

Objects: User Port

This attribute adds one or more static MAC addresses from the forwarding table for the port in context.

**Table 63 - Add Static MAC Address**

| Size | Description   | Units | Default | Min | Max |
|------|---------------|-------|---------|-----|-----|
| 6    | MAC address 0 | -     | -       | -   | -   |
| ...  | MAC address 1 | -     | -       | -   | -   |

### 9.2.29 Delete Static MAC Address (0xD9/0x0106)

Objects: User Port

This attribute adds one or more static MAC addresses from the forwarding table for the port in context.

**Table 64 - Delete Static MAC Address**

| Size | Description   | Units | Default | Min | Max |
|------|---------------|-------|---------|-----|-----|
| 6    | MAC address 0 | -     | -       | -   | -   |
| ..   | MAC address 1 | -     | -       | -   | -   |

### 9.2.30 Config Multicast LLID (0xD9/0x0107)

Objects: ONU

See [1904.1A], subclause 14.4.5.2.7.

### 9.2.31 Get UNI MAC Learned (0xD9/0x0108)

Objects: User Port

See [1904.1A], subclause 14.4.5.2.8.

## 9.3 Statistics And Counters

Many counter attributes can be used with different object context to provide various granularity on the statistics. For example, a "frames transmitted" counter attribute might be applicable to queues, logical links, or ports. D-ONUs MAY implement the coarser granularity counters by summing over all the finer-grained objects that feed into the coarser ones.

### 9.3.1 Rx Frames Green (0xD7/0x0201)

Objects: Network Port, User Port, Unicast Logical Link, Multicast Logical Link, Queue

This attribute represents the count of frames received at one port. If color marking is not in use, all received frames are considered "green" frames.

**Table 65 - Rx Frames Green**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames received at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.2 Tx Frames Green (0xD7/0x0202)

Objects: Network Port, User Port, Unicast Logical Link, Queue

This attribute represents the count of frames transmitted from one port. If color shaping is not in use, all transmitted frames are considered "green" frames.

**Table 66 - Tx Frames Green**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.3 Rx Frame Too Short (0xD7/0x0203)

Objects: Network Port, User Port

This attribute represents RxFrameTooShort counter of one port.

**Table 67 - Rx Frame Too Short**

| Size | Description                         | Units  | Default | Min | Max                   |
|------|-------------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrameTooShort counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.4 Rx Frame 64 (0xD7/0x0204)

Objects: Network Port, User Port

This attribute represents RxFrame64 counter of one port.

**Table 68 - Rx Frame**

| Size | Description                   | Units  | Default | Min | Max                   |
|------|-------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame64 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.5 Rx Frame 65\_127 (0xD7/0x0205)

Objects: Network Port, User Port

This attribute represents RxFrame65\_127 counter of one port.

**Table 69 - Rx Frame 65\_127**

| Size | Description                       | Units  | Default | Min | Max                   |
|------|-----------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame65_127 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.6 Rx Frame 128\_255 (0xD7/0x0206)

Objects: Network Port, User Port

This attribute represents RxFrame128\_255 counter of one port.

**Table 70 - Rx Frame 128\_255**

| Size | Description                        | Units  | Default | Min | Max                   |
|------|------------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame128_255 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.7 Rx Frame 256\_511 (0xD7/0x0207)**

Objects: Network Port, User Port

This attribute represents RxFrame256\_511 counter of one port.

**Table 71 - Rx Frame 256\_511**

| Size | Description                        | Units  | Default | Min | Max                   |
|------|------------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame256_511 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.8 Rx Frame 512\_1023 (0xD7/0x0208)**

Objects: Network Port, User Port

This attribute represents RxFrame512\_1023 counter of one port.

**Table 72 - Rx Frame 512\_1023**

| Size | Description                         | Units  | Default | Min | Max                   |
|------|-------------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame512_1023 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.9 Rx Frame 1024\_1518 (0xD7/0x0209)**

Objects: Network Port, User Port

This attribute represents RxFrame1024\_1518 counter of one port.

**Table 73 - Rx Frame 1024\_1518**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame1024_1518 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.10 Rx Frame 1519 Plus (0xD7/0x020A)**

Objects: Network Port, User Port

This attribute represents RxFrame1519Plus counter of one port.

**Table 74 - Rx Frame 1519 Plus**

| Size | Description                         | Units  | Default | Min | Max                   |
|------|-------------------------------------|--------|---------|-----|-----------------------|
| 8    | RxFrame1519Plus counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.11 Tx Frame 64 (0xD7/0x020B)**

Objects: Network Port, User Port

This attribute represents TxFrame64 counter of one port.

**Table 75 - Tx Frame 64**

| Size | Description                   | Units  | Default | Min | Max                   |
|------|-------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFrame64 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.12 Tx Frame 65\_127 (0xD7/0x020C)**

Objects: Network Port, User Port

This attribute represents TxFrame65\_127 counter of one port.

**Table 76 - Tx Frame 65\_127**

| Size | Description                       | Units  | Default | Min | Max                   |
|------|-----------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFrame65_127 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.13 Tx Frame 128\_255 (0xD7/0x020D)

Objects: Network Port, User Port

This attribute represents TxFrame128\_255 counter of one port.

**Table 77 - Tx Frame 128\_255**

| Size | Description                        | Units  | Default | Min | Max                   |
|------|------------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFrame128_255 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.14 Tx Frame 256\_511 (0xD7/0x020E)

Objects: Network Port, User Port

This attribute represents TxFrame256\_511 counter of one port.

**Table 78 - Tx Frame 256\_511**

| Size | Description                        | Units  | Default | Min | Max                   |
|------|------------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFrame256_511 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.15 Tx Frame 512\_1023 (0xD7/0x020F)

Objects: Network Port, User Port

This attribute represents TxFrame512\_1023 counter of one port.

**Table 79 - Tx Frame 512\_1023**

| Size | Description                         | Units  | Default | Min | Max                   |
|------|-------------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFrame512_1023 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.16 Tx Frame 1024\_1518 (0xD7/0x0210)

Objects: Network Port, User Port

This attribute represents TxFrame1024\_1518 counter of one port.

**Table 80 - Tx Frame 1024\_1518**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFrame1024_1518 counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.17 Tx Frame 1519 Plus (0xD7/0x0211)

Objects: Network Port, User Port

This attribute represents TxFrame1519Plus counter of one port.

**Table 81 - Tx Frame 1519 Plus**

| Size | Description                        | Units  | Default | Min | Max                   |
|------|------------------------------------|--------|---------|-----|-----------------------|
| 8    | TxFram1519Plus counter of one port | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.18 Queue Delay Threshold (0xD7/0x0212)**

Objects: Queue

This attribute represents Threshold for Delay that causes Bytes Delayed counter to increment for a queue, hereafter referred to as "DelayThreshold". The current object context is used to identify the queue for which this attribute is relevant.

**Table 82 - Queue Delay Threshold**

| Size | Description                     | Units | Default | Min | Max  |
|------|---------------------------------|-------|---------|-----|------|
| 1    | QueueDelayThreshold for a queue | 100us | 0x1E    | 0   | 0xFF |

**9.3.19 Queue Delay (0xD7/0x0213)**

Objects: Queue

This attribute represents Maximum Frame Delay experienced since statistic reset for a queue. The current object context is used to identify the queue for which this attribute is relevant.

**Table 83 - Queue Delay**

| Size | Description            | Units | Default | Min | Max                   |
|------|------------------------|-------|---------|-----|-----------------------|
| 8    | QueueDelay for a queue | 100us | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.20 Frames Dropped (0xD7/0x0214)**

Objects: Queue

This attribute represents the frames dropped due to queue overflow or rate control discard ("red" frames). The current object context is used to identify the queue for which this attribute is relevant.

**Table 84 - Frames Dropped**

| Size | Description                       | Units  | Default | Min | Max                   |
|------|-----------------------------------|--------|---------|-----|-----------------------|
| 8    | FramesDropped counter for a queue | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.21 Bytes Dropped (0xD7/0x0215)**

Objects: Queue

This attribute represents the bytes dropped due to queue overflow or rate control discard (bytes in "red" frames). The current object context is used to identify the queue for which this attribute is relevant.

**Table 85 - Bytes Dropped**

| Size | Description                      | Units | Default | Min | Max                   |
|------|----------------------------------|-------|---------|-----|-----------------------|
| 8    | BytesDropped counter for a queue | bytes | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.22 Bytes Delayed (0xD7/0x0216)**

Objects: Queue

This attribute represents the bytes in frames with a D-ONU queue residency time greater than DelayThreshold for a queue. The current object context is used to identify the queue for which this attribute is relevant.

**Table 86 - Bytes Delayed**

| Size | Description                      | Units | Default | Min | Max                   |
|------|----------------------------------|-------|---------|-----|-----------------------|
| 8    | BytesDelayed counter for a queue | bytes | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.23 Tx Bytes Unused (0xD7/0x0217)**

Objects: Unicast Logical Link

This attribute represents the bytes granted to the Unicast Logical Link but not filled with transmitted data.

**Table 87 - Tx Bytes Unused**

| Size | Description                       | Units | Default | Min | Max                   |
|------|-----------------------------------|-------|---------|-----|-----------------------|
| 8    | TxBytesUnused counter of one LLID | bytes | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.24 Optical Mon Temperature (0xD7/0x021D)**

Objects: Network Port

This attribute represents the current optical module temperature, expressed in the form of a 16 bit signed twos complement value in increments of 1/256 degrees Celsius valid between -40C and +125C.

**Table 88 - Optical Mon Temperature**

| Size | Description         | Units   | Default | Min    | Max    |
|------|---------------------|---------|---------|--------|--------|
| 2    | Current temperature | 1/256 C | -       | 0x8000 | 0x7FFF |

**9.3.25 Optical Mon Vcc (0xD7/0x021E)**

Objects: Network Port

This attribute represents the current optical module Vcc.

**Table 89 - Optical Mon Vcc**

| Size | Description | Units  | Default | Min | Max    |
|------|-------------|--------|---------|-----|--------|
| 2    | Current Vcc | 100 uV | -       | 0   | 0xFFFF |

**9.3.26 Optical Mon Tx Bias Current (0xD7/0x021F)**

Objects: Network Port

This attribute represents the current optical module Tx bias current.

**Table 90 - Optical Mon Tx Bias Current**

| Size | Description     | Units | Default | Min | Max    |
|------|-----------------|-------|---------|-----|--------|
| 2    | Current Tx bias | 2 uA  | -       | 0   | 0xFFFF |

**9.3.27 Optical Mon Tx Power (0xD7/0x0220)**

Objects: Network Port

This attribute represents the current optical module Tx power.

**Table 91 - Optical Mon Tx Power**

| Size | Description      | Units | Default | Min | Max    |
|------|------------------|-------|---------|-----|--------|
| 2    | Current Tx power | 0.1uW | -       | 0   | 0xFFFF |

**9.3.28 Optical Mon Rx Power (0xD7/0x0221)**

Objects: Network Port

This attribute represents the current optical module Rx power.

**Table 92 - Optical Mon Rx Power**

| Size | Description      | Units | Default | Min | Max    |
|------|------------------|-------|---------|-----|--------|
| 2    | Current Rx power | 0.1uW | -       | 0   | 0xFFFF |

### 9.3.29 Rx Frames Yellow (0xD7/0x0222)

Objects: Network Port, User Port, Unicast Logical Link, Multicast Logical Link, Queue

This attribute represents the count of frames received at one port. If color marking is not in use, this value is zero.

**Table 93 - Rx Frames Yellow**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames received at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.30 Tx Frames Yellow (0xD7/0x0223)

Objects: Network Port, User Port, Unicast Logical Link, Queue

This attribute represents the count of frames transmitted from one port. If color shaping is not in use, all transmitted frames are considered "green" frames.

**Table 94 - Tx FramesYellow**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.31 Tx Bytes Green (0xD7/0x0224)

Objects: Network Port, User Port, Unicast Logical Link, Queue

This attribute represents the count of bytes in green frames transmitted from one port. If color shaping is not in use, all transmitted frames are considered "green" frames.

**Table 95 - Tx Bytes Green**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.32 Rx Bytes Yellow (0xD7/0x0225)

Objects: Network Port, User Port, Unicast Logical Link, Multicast Logical Link,, Queue

This attribute represents the count of bytes in yellow frames received at one port. If color shaping is not in use, this value is zero.

### 9.3.33 Rx Bytes Green (0xD7/0x0226)

Objects: Network Port, User Port, Unicast Logical Link, Multicast Logical Link, Queue

This attribute represents the count of bytes in green frames received at one port. If color shaping is not in use, all received frames are considered "green" frames.

**Table 96 - Rx Bytes Green**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.34 Tx Bytes Yellow (0xD7/0x0227)**

Objects: Network Port, User Port, Unicast Logical Link, Queue

This attribute represents the count of bytes in yellow frames transmitted from one port. If color shaping is not in use, this value is zero.

**Table 97 - Tx Bytes Yellow**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.35 Tx Frames Unicast (0xD7/0x0228)**

Objects: Network Port, User Port

This attribute represents the count of frames transmitted with a unicast L2 DA.

**Table 98 - Tx Frames Unicast**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.36 Tx Frames Multicast (0xD7/0x0229)**

Objects: Network Port, User Port

This attribute represents the count frames transmitted with a multicast L2 DA (bit 40 set).

**Table 99 - Tx Frames Multicast**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.37 Tx Frames Broadcast (0xD7/0x022A)**

Objects: Network Port, User Port

This attribute represents the count of frames transmitted with the broadcast L2 DA (all 1s).

**Table 100 - Tx Frames Broadcast**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames transmitted from object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.38 Rx Frames Unicast (0xD7/0x022B)**

Objects: Network Port, User Port

This attribute represents the count frames received with a L2 unicast DA (bit 40 = 0).

**Table 101 - Rx Frames Unicast**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames received at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.39 Rx Frames Multicast (0xD7/0x022C)**

Objects: Network Port, User Port

This attribute represents the count of frames received with a multicast L2 DA (bit 40 set).

**Table 102 - Rx Frames Multicast**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames received at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.40 Rx Frames Broadcast (0xD7/0x022D)

Objects: Network Port, User Port

This attribute represents the count of frames received with the broadcast L2 DA (all 1s).

**Table 103 - Rx Frames Broadcast**

| Size | Description                          | Units  | Default | Min | Max                   |
|------|--------------------------------------|--------|---------|-----|-----------------------|
| 8    | Frames received at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.41 Number of Programmable Counters (0xD7/0x022E) R

Objects: D-ONU

This capabilities attribute indicates the number of programmable frame/byte counters supported by the D-ONU hardware.

### 9.3.42 L2CP Frames Rx (0xD7/0x022F)

Objects: Network Port, User Port

Number of layer 2 control protocol frames received.

**Table 104 - L2CP Frames Rx**

| Size | Description                               | Units  | Default | Min | Max                   |
|------|-------------------------------------------|--------|---------|-----|-----------------------|
| 8    | L2CP frames received at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.43 L2CP Octets Rx (0xD7/0x0230)

Objects: Network Port, User Port

Number of octets in layer 2 control protocol frames received.

**Table 105 - L2CP Octets Rx**

| Size | Description                                         | Units  | Default | Min | Max                   |
|------|-----------------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Octets in L2CP frames received at object in context | Octets | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.44 L2CP Frames Tx (0xD7/0x0231)

Objects: Network Port, User Port

Number of layer 2 control protocol frames transmitted.

**Table 106 - L2CP Frames Tx**

| Size | Description                                  | Units  | Default | Min | Max                   |
|------|----------------------------------------------|--------|---------|-----|-----------------------|
| 8    | L2CP frames transmitted at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

### 9.3.45 L2CP Octets Tx (0xD7/0x0232)

Objects: Network Port, User Port

Number of octets in layer 2 control protocol frames transmitted.

**Table 107 - L2CP Octets Tx**

| Size | Description                                            | Units  | Default | Min | Max                   |
|------|--------------------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Octets in L2CP frames transmitted at object in context | Octets | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.46 L2CP Frames Discarded (0xD7/0x0233)**

Objects: Network Port, User Port

Number of layer 2 control protocol frames discarded (because the D-ONU was configured to discard those protocols, rather than tunnel or peer them).

**Table 108 - L2CP Frames Discarded**

| Size | Description                                | Units  | Default | Min | Max                   |
|------|--------------------------------------------|--------|---------|-----|-----------------------|
| 8    | L2CP frames discarded at object in context | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.47 L2CP Octets Discarded (0xD7/0x0234)**

Objects: Network Port, User Port

Number of octets in layer 2 control protocol frames discarded (because the D-ONU was configured to discard those protocols, rather than tunnel or peer them).

**Table 109 - L2CP Octets Discarded**

| Size | Description                                          | Units  | Default | Min | Max                   |
|------|------------------------------------------------------|--------|---------|-----|-----------------------|
| 8    | Octets in L2CP frames discarded at object in context | Octets | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.48 Tx L2 Errors (0xD7/0x0235)**

Objects: Network Port, User Port

Number of frames that failed to transmit because of an error in the data link layer (too many collisions, etc.).

**Table 110 - Tx L2 Errors**

| Size | Description                                                        | Units  | Default | Min | Max                   |
|------|--------------------------------------------------------------------|--------|---------|-----|-----------------------|
| 8    | L2 frames discarded at object in context in the transmit direction | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.49 Rx L2 Errors (0xD7/0x0236)**

Objects: Network Port, User Port

Number of received frames discarded due to errors in the frame (FCS errors, length errors, etc.).

**Table 111 - Rx L2 Errors**

| Size | Description                                                       | Units  | Default | Min | Max                   |
|------|-------------------------------------------------------------------|--------|---------|-----|-----------------------|
| 8    | L2 frames discarded at object in context in the receive direction | Frames | -       | 0   | 0xFFFF FFFF FFFF FFFF |

**9.3.50 Frames Over Limit Dropped Uni (0xD7/0x0237)**

See [1904.1A], subclause 14.4.3.3.50.

**9.3.51 9.3.51 Octets Over Limit Dropped UNI (0xD7/0x0238)**

See [1904.1A], subclause 14.4.3.3.51.

### 9.3.52 Clear Counters (0xD9/0x0201)

Objects: D-ONU

This action clears all statistics counters for the D-ONU.

### 9.3.53 Programmable Frame/Byte Counter (0xD8/nnnn) R

Objects: D-ONU

There are a maximum of 32,768 programmable counter attributes, "Programmable Counter 0" through "Programmable Counter 32767". The 0xD8 branch indicates a programmable counter; the leaf code indicates the exact counter. Programmable counters count both bytes and frames. The leaf codes of a frame counter and the corresponding byte counter are related; the frame counter with leaf code I corresponds to the byte counter with leaf code I + 0x8000.

The programmable counter index for the frame counter (0..32767) is used as the parameter for the Increment Counter rule result. The rule result increments both the frame and byte counters for frames that match the rule condition.

### 9.3.54 Alarms

Alarms are indicated by the D-ONU to the DPoE System using DPoE Event Notification TLVs in an [802.3] Clause 57 Event Notification PDU.

### 9.3.55 Port Stat Threshold (0xD7/0x0301)

Objects: Network Port, User Port

This attribute allows the OAM client to specify an alarm to be generated when a port statistics counter exceeds a certain value at the end of a 1-second sampling period. A rising threshold and a falling threshold (high-water mark and low-water mark) are provided to allow hysteresis. The alarm condition will occur when the statistic is greater than or equal to the rising threshold. The alarm condition will be cleared when the statistic is less than or equal to the falling threshold. A value of 0 for the rising threshold means that the alarm is disabled.

**Table 112 - Port Stat Threshold**

| Size | Description                                           | Units   | Default | Min | Max         |
|------|-------------------------------------------------------|---------|---------|-----|-------------|
| 3    | Statistic Attribute branch/leaf                       | -       | -       | 0   | 0xFF FFFF   |
| 4    | Rising Threshold (to set alarm; 0 disables the alarm) | As stat | -       | 0   | 0xFFFF FFFF |
| 4    | Falling Threshold (to clear alarm)                    | As stat | -       | 0   | 0xFFFF FFFF |

### 9.3.56 Link Stat Threshold (0xD7/0x0302)

Objects: Unicast Logical Link, Multicast Logical Link

This attribute allows the OAM client to specify an alarm to be generated when a Unicast Logical Link statistics counter exceeds a certain value at the end of a 1-second sampling period. A rising threshold and a falling threshold (high-water mark and low-water mark) are provided to allow hysteresis. The alarm condition will occur when the statistic is greater than or equal to the rising threshold. The alarm condition will be cleared when the statistic is less than or equal to the falling threshold. A value of 0 for the rising threshold means that the alarm is disabled.

**Table 113 - Link Stat Threshold**

| Size | Description                                           | Units   | Default | Min | Max         |
|------|-------------------------------------------------------|---------|---------|-----|-------------|
| 3    | Statistic Attribute Branch/Leaf                       | -       | -       | 0   | 0xFF FFFF   |
| 4    | Rising Threshold (to set alarm; 0 disables the alarm) | As stat | -       | 0   | 0xFFFF FFFF |
| 4    | Falling Threshold (to clear alarm)                    | As stat | -       | 0   | 0xFFFF FFFF |

### 9.3.57 Suspend/Resume Alarm Reporting (0xD7/0x0303)

Objects: D-ONU, User Port, PON Port, Queue, Unicast Logical Link, Multicast Logical Link

This attribute allows the DPoE System to enable or disable transmission of alarm messages generated by the given context object. An enabled alarm behaves normally per the definition for that alarm. While an alarm is disabled, a D-ONU MUST NOT signal this alarm in an Event Notification TLV. Alarms can be disabled on a per-object basis. The object is specified using the Object Context TLV. A single Suspend/Resume Alarm Reporting message carries a total of N alarm status information tuples, where each alarm is described by the (Event Code, Enabled/Disabled) tuple, as shown in Table 114. Only Event Codes that are relevant to the object context should be included in the message. Attempting to enable or disable an alarm message which is not relevant to the associated object context will result in an error..

**Table 114 - Alarm Enable**

| Size | Description                                   | Units        | Default | Min | Max  |
|------|-----------------------------------------------|--------------|---------|-----|------|
| 1    | Event Code(0)                                 | See Table 13 | -       | 0   | 0xFF |
| 1    | Enabled /Disabled [0] (Enabled=1, Disabled=0) | Boolean      | 0       | 0   | 1    |
| ..   | ..                                            | ..           | ..      | ..  | ..   |
| 1    | Event Code [N-1]                              | See Table 13 | -       | 0   | 0xFF |
| 1    | Enabled/Disabled [N-1]                        | Boolean      | 0       | 0   | 1    |

When the Suspend/Resume Alarm attribute (0xD7/0x0303) is carried in the Get Response eOAMPDU, it contains the (Event Code, Enabled/Disabled) tuple for all defined alarm codes listed in Table 13 that are relevant for the current object context.

### 9.3.58 Retrieve Current Alarm Summary (0xD9/0x0301)

Objects: D-ONU

This action directs the D-ONU to send a report of all currently raised alarm conditions. To report, the D-ONU generates a series of one or more Event Notification PDUs containing DPoE Alarm TLVs corresponding to all current alarm conditions at the D-ONU.

## 9.4 Security

Security attributes control encryption on the EPON and individual S (UNI) interfaces. Details of encryption methods and their use can be found in [DPoE-SECv2.0].

### 9.4.1 Encryption Key Expiry Time (0xD7/0x0401)

Objects: Unicast Logical Link

This attribute represents the timeout value for encryption keys. A new key will be generated and exchanged periodically, as this timer expires. A timeout value of 0 is used to disable security (i.e., encryption). The minimum non-zero value should be at least 10 seconds.

**Table 115 - Encryption Key Expiry Time**

| Size | Description   | Units | Default | Min  | Max    |
|------|---------------|-------|---------|------|--------|
| 2    | Timeout value | sec   | 0       | 0/10 | 0xFFFF |

### 9.4.2 Encryption Mode (0xD7/0x0402)

Objects: Unicast Logical Link

This attribute sets the encryption method to be used on a particular logical link. Details of encryption methods are defined in [DPoE-SECv2.0].

**Table 116 - Encryption Mode**

| Size | Description                                                      | Units | Default | Min | Max |
|------|------------------------------------------------------------------|-------|---------|-----|-----|
| 1    | Encryption Method<br>0: None<br>1: 1Down<br>2: 10Down<br>3: 10Bi | enum  | 0       | 0   | 3   |

### 9.4.3 S Interface Encryption Mode (0xD7/0403)

Objects: User Port

This attribute sets or retrieves the status of User Port, S interface, authentication, and encryption. Details of S interface authentication and encryption are defined in [DPoE-SECv2.0].

**Table 117 - S Interface Encryption Mode**

| Size | Description                                                                   | Units | Default | Min | Max |
|------|-------------------------------------------------------------------------------|-------|---------|-----|-----|
| 1    | S Interface Encryption<br>0: Off<br>1: IEEE 802.1 AE Static, pre-shared, CAK. | enum  | 1       | 0   | 1   |

## 9.5 Frame Processing

### 9.5.1 Port Ingress Rule (0xD7/0x0501)

Objects: Network Port, User Port

This attribute represents a rule in the ingress table of the current port. A single rule, which can be complex and larger than the 128-byte contents of a single TLV, is represented in an OAM frame as a series of TLVs with this attribute code. The first byte of the attribute is always a subtype indicator, which indicates the structure of the rest of the TLV contents.

A single rule is represented by a sequential series of Port Ingress Rule TLVs, which must start with one Header subtype, then one or more Clause subtype TLVs, then one or more Result subtype TLVs, and finally end with a Terminator subtype. For each rule, DPoE System MUST include one Header subtype, one or more Clause subtypes, one or more Result subtypes, and end with the Terminator subtype. Similarly, for each rule, D-ONU MUST include one Header subtype, one or more Clause subtypes, one or more Result subtypes, and end with the Terminator subtype.

The entire table of rules for a port would be represented as a large attribute, and thus include one or more Header/Clause/Result/Terminator sequences, ultimately terminated by a zero-length container with the Port Ingress Rule attribute value.

**Table 118 - Rule Attribute Subtypes**

| Field Value | Name       | Description                                                                                                                            |
|-------------|------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 0           | Terminator | Indicates end of one individual rule                                                                                                   |
| 1           | Header     | Information which pertains to the entire rule                                                                                          |
| 2           | Clause     | One single clause of the rule condition; all clauses are ANDed together to form the condition that determines whether the rule matches |
| 3           | Result     | One single result that occurs if the rule condition is true                                                                            |

#### 9.5.1.1 Rule Attribute - Terminator Subtype

The terminator subtype indicates the end of a single rule. There are no further contents in the body of this subtype.

### 9.5.1.2 Rule Attribute - Header Subtype

All rules begin with a Rule attribute of the Header subtype.

**Table 119 - Rule Attribute Header Subtype**

| Size                                                                                                                                                                                                                                                     | Name       | Description                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------------------|
| 1                                                                                                                                                                                                                                                        | Subtype    | Header (01)                         |
| 1                                                                                                                                                                                                                                                        | Precedence | Precedence of the rule (0x00..0xFF) |
| Note:<br>0x00 is considered the highest rule precedence value, and 0xFF the lowest. Note that is the reverse of the order in the DOCSIS config file TLVs; the DPoE System inverts the precedence range when constructing DPoE OAM rules from those TLVs. |            |                                     |

### 9.5.1.3 Rule Attribute - Clause Subtype

Rule clauses define the condition that must evaluate to true for the rule to match a frame. All clauses of a rule are evaluated and the individual results ANDed together to determine the match condition. An individual clause is a binary operation which relates a field in the frame with a constant match value via a binary operator.

**Table 120 - Rule Attribute Clause Subtype**

| Size   | Name               | Description                                                                      |
|--------|--------------------|----------------------------------------------------------------------------------|
| 1      | Subtype            | Clause (02)                                                                      |
| 1      | Field Code         | Code representing the field of the frame for this clause; see Table 121.         |
| 1      | Field Instance     | Which instance of a field identified by code (if there is more than one)         |
| 1      | MSB Mask           | Bits to ignore on the most significant side of the field                         |
| 1      | LSB Mask           | Bits to ignore on the least significant side of the field                        |
| 1      | Operator           | Binary operator for this rule                                                    |
| 1      | Match Value Length | Number of bytes of Match Value to follow                                         |
| varies | Match Value        | Constant value combined with field value via the binary operator for this clause |

Some fields, such as VLAN tags, occur in multiple instances in some frames. To distinguish two such fields, a Field Instance is used in conjunction with the Field Code. Instances of such fields are numbered starting from 0 in the order in which they are transmitted in the frame. So, for example, C-VLAN tag 0 would be the outermost tag in a frame, immediately after the addresses, with two C-VLAN tags, with C-VLAN tag 1 being the inner tag, closer to the payload of the frame.

The most-significant- and least-significant-bits masks are used to reduce the number of field codes and provide flexibility for frame processing rules. A VLAN tag, for instance, is coded as one field. Commonly, however, rules might be interested in just the Tag Protocol Identifier (TPID), just the Class of Service (CoS), or just the VID portions of this field. A rule can compare these subfields by using the MSB and LSB masks to isolate the sub-field of interest. Similarly, the IPv4 TOS field is 8 bits wide, but the same bits are interpreted as IP Precedence (upper three bits) or DSCP. Any of these interpretations can be accommodated with the single IPv4 TOS field and the proper masks. Refer to Appendix IV for examples of sub-field identifiers for rule definition. Note that the I-Tag field is considered in Link OAM to be 48 bits in length, which deviates from [802.1ah] because it does not include the Customer Destination or Source MAC address.

The match value is a variable-length field, always an integral number of octets wide. Values are right-aligned in this field, occupying the least significant bits.

Since IPv4 and IPv6 headers have similar semantics, and a single frame can only be one or the other, but not both, of these types, some field codes are re-used for the IP equivalents like the addresses or priority fields. Rule sets that need to treat the same field differently based on protocol should use the EtherType field to distinguish IPv4 from IPv6.

**Table 121 - Field Codes**

| Value (hex) | Description                               | Multiple?   |
|-------------|-------------------------------------------|-------------|
| 0x00        | LLID Index ( <b>Note 2</b> )              | N           |
| 0x01        | L2 Destination MAC address                | N           |
| 0x02        | L2 Source MAC address                     | N           |
| 0x03        | L2 Type/Len                               | N           |
| 0x04        | B-DA ([802.1ah])                          | N           |
| 0x05        | B-SA ([802.1ah])                          | N           |
| 0x06        | I-Tag ([802.1ah])                         | N           |
| 0x07        | S-VLAN Tag                                | Y           |
| 0x08        | C-VLAN Tag                                | Y           |
| 0x09        | MPLS Label Stacking Entry (LSE)           | Y           |
| 0x0A        | IPv4 TOS/IPv6 Traffic Class               | N           |
| 0x0B        | IPv4 TTL/IPv6 Hop Limit                   | N           |
| 0x0C        | IPv4/IPv6 Protocol Type ( <b>Note 3</b> ) | N           |
| 0x0D        | IPv4 Source Address                       | N           |
| 0x0E        | IPv6 Source Address                       | N           |
| 0x0F        | IPv4 Destination Address                  | N           |
| 0x10        | IPv6 Destination Address                  | N           |
| 0x11        | IPv6 Next Header                          | Y* (Note 1) |
| 0x12        | IPv6 Flow Label                           | N           |
| 0x13        | TCP/UDP source port                       | N           |
| 0x14        | TCP/UDP destination port                  | N           |
| 0x15        | B-Tag ([802.1ah])                         | N           |
| 0x16        | Reserved                                  | -           |
| 0x17        | Reserved                                  | -           |
| 0x18        | Custom field 0                            | N           |
| 0x19        | Custom field 1                            | N           |
| 0x1A        | Custom field 2                            | N           |
| 0x1B        | Custom field 3                            | N           |
| 0x1C        | Custom field 4                            | N           |
| 0x1D        | Custom field 5                            | N           |
| 0x1E        | Custom field 6                            | N           |
| 0x1F        | Custom field 7                            | N           |
| 0x20        | Reserved for DPoG specifications          | N           |
| 0x21        | LLID Value ( <b>Note 4</b> )              | N           |

| Value<br>(hex)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Description | Multiple? |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------|
| <p>Note 1:<br/>IPv6 extension headers are instantiated in the sense that there can be a variable number of them. However, they are not ordered in a frame. The instance number for this field is not the usual 0..N-1th instance of an instanced field, but is instead the Next Header value for that header type assigned by the IANA.</p> <p>Note 2:<br/>LLID Index represents the local index of the logical link instantiated on the DPoE ONU. For example, for a DPoE ONU supporting 8 LLIDs, the value of LLID Index would range from 0 to 7. In this way, the LLID Index has only local, DPoE ONU specific meaning. The LLID Index matches the LLID in order of the link MAC address. That is, LLID Index 0 on a particular DPoE ONU is the LLID with the numerically lowest MAC address on that DPoE ONU; LLID Index 1 is the next higher MAC address, and so on.</p> <p>Note 3:<br/>IPv6 Protocol Type represents the Next Header field of the last extension header in the chain, which might contain any number of optional extension headers.</p> <p>Note 4:<br/>Valid LLID values are defined in [802.3], 76.2.6.1.3.2.</p> |             |           |

**Table 122 - Rule Operators**

| Field Value | Symbol | Description                                  |
|-------------|--------|----------------------------------------------|
| 0           | F      | Never match                                  |
| 1           | ==     | Field equal to value                         |
| 2           | !=     | Field not equal to value                     |
| 3           | <=     | Field less than or equal to value            |
| 4           | >=     | Field greater than or equal to value         |
| 5           | exists | True if field exists (value ignored)         |
| 6           | !exist | True if field does not exist (value ignored) |
| 7           | T      | Always match                                 |

**9.5.1.4 Rule Attribute - Result Subtype**

Rule results represent the processing performed on a frame when the frame matches the rule condition.

**Table 123 - Rule Attribute Result Subtype**

| Size   | Name              | Description                                        |
|--------|-------------------|----------------------------------------------------|
| 1      | Subtype           | Result (03)                                        |
| 1      | Rule Result       | Rule Result (see Table 124)                        |
| varies | Result Parameters | Rule Result Parameters, as defined for each result |

**Table 124 - Rule Results**

| Code<br>(hex) | Name    | Description                                  | Parameter<br>Len | Parameter                                                         |
|---------------|---------|----------------------------------------------|------------------|-------------------------------------------------------------------|
| 0x00          | NOP     | No operation                                 | 0                |                                                                   |
| 0x01          | Discard | Set Discard Flag for Frame                   | 0                |                                                                   |
| 0x02          | Forward | Clear Discard Flag for Frame (Forward Frame) | 0                |                                                                   |
| 0x03          | Queue   | Set destination queue for frame              | 4                | {object type, object instance, queue number}, as in Section 8.7.5 |
| 0x04          | Set     | Set output field                             | 4+ n             | Field to set; n bytes of value                                    |
| 0x05          | Copy    | Copy output field                            | 4                | Field to set from field used in last clause of rule               |
| 0x06          | Delete  | Delete field                                 | 2                | Field Code to remove from frame                                   |
| 0x07          | Insert  | Insert field                                 | 2                | Field Code to insert into frame                                   |

| Code (hex) | Name              | Description                                                                                | Parameter Len | Parameter                                   |
|------------|-------------------|--------------------------------------------------------------------------------------------|---------------|---------------------------------------------|
| 0x08       | Replace           | Delete field and Insert current output field                                               | 2             | Field Code to replace                       |
| 0x09       | Clear Delete      | Do not delete field (override other Delete result)                                         | 2             | Field Code not to delete                    |
| 0x0A       | Clear Insert      | Do not insert field (override other Insert result)                                         | 2             | Field Code not to insert                    |
| 0x0B       | Increment Counter | Increments programmable counter for frames that match this rule, and bytes in those frames | 2             | Index for programmable counter to increment |

#### 9.5.1.4.1 NOP

The NOP result has no net effect, and does not affect the state of the frame. It can be useful as a placeholder result.

#### 9.5.1.4.2 Discard

Frames are considered to be associated with a "discard" flag. If the discard flag is true after all rule processing, the frame will be discarded. This result sets the discard flag to true.

#### 9.5.1.4.3 Forward

The Forward result sets the discard flag for a frame to false. The frame will be forwarded. (See the Queue result, Section 9.5.1.4.4.)

#### 9.5.1.4.4 Queue

The Queue result sets the destination queue for a frame. A queue is specified as a {object type, object instance, queue number} tuple as defined in Section 8.7.5. Only TU interface ports have LLIDs. The object type indicates whether the port is a LLID or User Port, and uses the same values as the Object Context. Note that this parameter has the same format as the Queue Object defined in Section 8.7.5. (See Table 26).

#### 9.5.1.4.5 Set

The Set result sets the value of an output field for the frame. The result takes as parameters the field descriptor to set, followed by the value for that field. Bits protected by the Mask values are not modified by the Set operation. This feature allows setting just part of a field; for example, just the PCP bits in a VLAN tag. Values for fields that are not an integral multiple of eight bits wide are right-justified in the parameter value, and are padded with zeros on the left (most significant) bits.

**Table 125 - Set Parameters**

| Size   | Name           | Description                                    |
|--------|----------------|------------------------------------------------|
| 1      | Field Code     | Field code to set                              |
| 1      | Field Instance | Field Instance to set                          |
| 1      | MSB Mask       | Number of most significant bits not to modify  |
| 1      | LSB Mask       | Number of least significant bits not to modify |
| varies | Value          | New value for output field                     |

#### 9.5.1.4.6 Copy

The Copy result copies the value of some field into the specified output field. The source field is the field used in the last clause of the rule condition. Typically this result is used to copy priority fields, such as IP TOS to [802.1Q] CoS bits, or to copy an inner VLAN tag to an outer one. Bits of the output field protected by the Mask values are not modified by the Copy operation.

**Table 126 - Copy Parameters**

| Size | Name           | Description                                    |
|------|----------------|------------------------------------------------|
| 1    | Field Code     | Field code to set                              |
| 1    | Field Instance | Field Instance to set                          |
| 1    | MSB Mask       | Number of most significant bits not to modify  |
| 1    | LSB Mask       | Number of least significant bits not to modify |

**9.5.1.4.7 Delete**

This result marks a field of a frame to be deleted. If the Delete flag is set after all rules have been processed, the deleted field will not be present in a forwarded frame. This result is commonly used to remove VLAN tags or other encapsulation from a frame. Note that it is not possible to delete just part of a field with "Mask" bits similar to some other field syntax.

**Table 127 - Delete Parameters**

| Size | Name           | Description              |
|------|----------------|--------------------------|
| 1    | Field Code     | Field Code to delete     |
| 1    | Field Instance | Field Instance to delete |

**9.5.1.4.8 Insert**

The Insert result adds a field to a frame. If the Insert flag is set after all rules have been processed, the output field will be added to the frame. The value of the field normally will be Set by some other rule result. The default value for a field that did not exist in the frame is all zeroes. This result is commonly used to add VLAN tags or other encapsulation to a frame.

**Table 128 - Insert Parameters**

| Size | Name           | Description              |
|------|----------------|--------------------------|
| 1    | Field Code     | Field Code to insert     |
| 1    | Field Instance | Field Instance to insert |

**9.5.1.4.9 Replace**

Replace combines the Insert and Delete results into a single operation for convenience, resulting in overwriting a field of a frame with a new value. This result is commonly used to translate priority values or VLAN tag values.

**Table 129 - Replace Parameters**

| Size | Name           | Description               |
|------|----------------|---------------------------|
| 1    | Field Code     | Field Code to replace     |
| 1    | Field Instance | Field Instance to replace |

**9.5.1.4.10 Clear Delete**

This result clears the Delete flag for a field, reversing the decision of a lower precedence rule to delete the given field.

**Table 130 - Clear Delete Parameters**

| Size | Name           | Description            |
|------|----------------|------------------------|
| 1    | Field Code     | Field Code to keep     |
| 1    | Field Instance | Field Instance to keep |

**9.5.1.4.11 Clear Insert**

This result clears the Insert flag for a field, reversing the decision of a lower precedence rule to insert the given field.

**Table 131 - Clear Insert Parameters**

| Size | Name           | Description                  |
|------|----------------|------------------------------|
| 1    | Field Code     | Field Code not to insert     |
| 1    | Field Instance | Field Instance not to insert |

### 9.5.2 Custom Field (0xD7/0x0502)

Objects: Network Port, User Port

This attribute represents the fields parsed from each frame that are used in frame processing rules to filter or classify the frames.

Each D-ONU port contains a table of ingress rules that are applied to the frames received on the port. Each field is programmed with a field code. The code describes the field parsed from the frame in terms of protocol layer, dword in the frame, bit start, and bit width.

**Table 132 - Custom Field**

| Size | Description                        | Units             | Default | Min | Max  |
|------|------------------------------------|-------------------|---------|-----|------|
| 1    | Field Code (see Table 119)         | enum              | -       | 18  | 0x1F |
| 1    | Layer select                       | See Table 133     | -       | 0   | 8    |
| 1    | 32-bit word offset                 | 32-bit words      | -       | 0   | 8    |
| 1    | Least significant bit (bit offset) | Bits              | -       | 0   | 31   |
| 1    | Bit width                          | Bits              | -       | 1   | 32   |
| 1    | Reference Count                    | Number of clauses | -       | 0   | 255  |

The Reference Count indicates the number of clauses in rules that are currently using this field. If the field is currently unused, the Reference Count will be zero. When this is the case, the Layer Select, Dword offset, Least significant bit, and Bit width fields will contain the maximum possible values.

Fields with a non-zero Reference Count cannot be reprogrammed with the Set PDU. All rules using a given field must be deleted, reducing the reference count to zero, before the meaning of that field is changed.

The Reference Count field is ignored in Set messages, and should be set to zero by the transmitter.

**Table 133 - Custom Field Layer Values**

| Layer Value | Name               | Description                                                                         |
|-------------|--------------------|-------------------------------------------------------------------------------------|
| 0x0         | Preamble/L2        | LLID, DA, SA, SNAP headers (if present)                                             |
| 0x1         | Preamble/[802.1ah] | LLID, B-DA, B-SA, I-Tag                                                             |
| 0x2         | EtherType          | L2 protocol type of remainder of the frame                                          |
| 0x3         | S-VLAN Tags        | All S-VLAN tags in the frame                                                        |
| 0x4         | C-VLAN Tags        | All C-VLAN tags in the frame                                                        |
| 0x5         | MPLS LSEs          | MPLS LSEs, if any, in the frame                                                     |
| 0x6         | IPv4               | Frames with EtherType 0800                                                          |
| 0x7         | IPv6               | Frames with EtherType 86DD                                                          |
| 0x8         | Generic L3         | Payload of a frame that is not IPv4 or IPv6, according to the EtherType             |
| 0x9         | TCP/UDP            | IPv4 or IPv6 frames containing UDP or TCP (according to the IP protocol type field) |
| 0xA         | Generic L4         | Payload of IP frames that is not TCP or UDP                                         |

#### 9.5.2.1 Preamble/L2 Header

The preamble/L2 layer consists of the LLID and L2 Ethernet header fields of the received frame. This layer also contains the SNAP headers if they are present. Figure 5 shows the offsets within this layer when the frame does not have SNAP encapsulation.

|                     |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |                      |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
|---------------------|----|----|----|----|----|----|----|------------|----|----|----|----|----|----|----|----------------------|----|----|----|----|----|---|---|----------|---|---|---|---|---|---|---|
| 31                  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23         | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15                   | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7        | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved (Unknown)  |    |    |    |    |    |    |    | LLID Value |    |    |    |    |    |    |    |                      |    |    |    |    |    |   |   | Reserved |   |   |   |   |   |   |   |
| Reserved (Always 0) |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | L2 DA [47:32]        |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| L2 DA [31:0]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |                      |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| L2 SA [47:16]       |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |                      |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| L2 SA [15:0]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | L2 Type Field [15:0] |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |

**Figure 5 - Preamble/L2 without SNAP**

Figure 6 shows the offsets into this layer when the frame has SNAP encapsulation.

|                     |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |                        |    |    |    |    |    |   |   |             |   |   |   |   |   |   |   |
|---------------------|----|----|----|----|----|----|----|------------|----|----|----|----|----|----|----|------------------------|----|----|----|----|----|---|---|-------------|---|---|---|---|---|---|---|
| 31                  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23         | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15                     | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7           | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved (Unknown)  |    |    |    |    |    |    |    | LLID Value |    |    |    |    |    |    |    |                        |    |    |    |    |    |   |   | Reserved    |   |   |   |   |   |   |   |
| Reserved (Always 0) |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | L2 DA [47:32]          |    |    |    |    |    |   |   |             |   |   |   |   |   |   |   |
| L2 DA [31:0]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |                        |    |    |    |    |    |   |   |             |   |   |   |   |   |   |   |
| L2 SA [47:16]       |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |                        |    |    |    |    |    |   |   |             |   |   |   |   |   |   |   |
| L2 SA [15:0]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | L2 Length Field [15:0] |    |    |    |    |    |   |   |             |   |   |   |   |   |   |   |
| DSAP [7:0]          |    |    |    |    |    |    |    | SSAP [7:0] |    |    |    |    |    |    |    | CTL [7:0]              |    |    |    |    |    |   |   | OUI [23:16] |   |   |   |   |   |   |   |
| OUI [15:0]          |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | L2 Type Field [15:0]   |    |    |    |    |    |   |   |             |   |   |   |   |   |   |   |

**Figure 6 - Preamble/L2 with SNAP**

### 9.5.2.2 [802.1ah]

The [802.1ah] layer consists of the [802.1ah] "MAC-in-MAC" encapsulation header, including the B-DA, B-SA, and I-Tag fields. This layer exists only in [802.1ah] encapsulated frames, as determined by the presence of the I-Tag (a TPID value of 0x88E7 immediately following the SA).

|                     |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |              |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
|---------------------|----|----|----|----|----|----|----|------------|----|----|----|----|----|----|----|--------------|----|----|----|----|----|---|---|----------|---|---|---|---|---|---|---|
| 31                  | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23         | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15           | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7        | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved (Unknown)  |    |    |    |    |    |    |    | LLID Value |    |    |    |    |    |    |    |              |    |    |    |    |    |   |   | Reserved |   |   |   |   |   |   |   |
| Reserved (Always 0) |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | B-DA [47:32] |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| B- DA [31:0]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |              |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| B-SA [47:16]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    |              |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| B- SA [15:0]        |    |    |    |    |    |    |    |            |    |    |    |    |    |    |    | I-Tag TPID   |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |
| Reserved (Always 0) |    |    |    |    |    |    |    | I-SID      |    |    |    |    |    |    |    |              |    |    |    |    |    |   |   |          |   |   |   |   |   |   |   |

**Figure 7 - [802.1ah] Layer**

### 9.5.2.3 EtherType

The EtherType layer consists only of the 16-bit EtherType value, wherever it may be located in the source frame. Note that a Length value in an [802.3] format frame is not considered an EtherType value. Ethernet II versus [802.3] format can be tested by testing the existence of the EtherType.

|                    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                   |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |
|--------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------------------|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| 31                 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15                | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved (Unknown) |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Layer 2 EtherType |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |

**Figure 8 - EtherType Layer**

### 9.5.2.4 S-VLAN Tags

The S-VLAN tag layers consist of all S-VLAN tags identified in the frame. An S-VLAN tag is defined by the TPID seen by the parser, which includes the [802.1ad] value 0x88A8 as well as the additional S-VLAN TPID value, if that value has been defined.

|        |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |    |       |    |    |   |   |   |   |   |   |   |   |   |   |  |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|----|----|-------|----|----|---|---|---|---|---|---|---|---|---|---|--|
| 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15  | 14 | 13 | 12    | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |  |
| TPID 0 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | PRI |    | C  | VID 0 |    |    |   |   |   |   |   |   |   |   |   |   |  |
| TPID 1 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | PRI |    | C  | VID 1 |    |    |   |   |   |   |   |   |   |   |   |   |  |
| TPID 2 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | PRI |    | C  | VID 2 |    |    |   |   |   |   |   |   |   |   |   |   |  |
| ..     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |    |       |    |    |   |   |   |   |   |   |   |   |   |   |  |

**Figure 9 - S-VLAN Layer****9.5.2.5 C-VLAN Tags**

The C-VLAN tag layers consist of all C-VLAN tags identified in the frame. A "C-VLAN tag" is defined by the TPID seen by the parser, which includes the [802.1Q] value 0x8100, as well as the Additional C-VLAN TPID value, if that value has been defined.

|        |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |    |       |    |    |   |   |   |   |   |   |   |   |   |   |  |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|----|----|-------|----|----|---|---|---|---|---|---|---|---|---|---|--|
| 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15  | 14 | 13 | 12    | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |  |
| TPID 0 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | PRI |    | C  | VID 0 |    |    |   |   |   |   |   |   |   |   |   |   |  |
| TPID 1 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | PRI |    | C  | VID 1 |    |    |   |   |   |   |   |   |   |   |   |   |  |
| TPID 2 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | PRI |    | C  | VID 2 |    |    |   |   |   |   |   |   |   |   |   |   |  |
| ..     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |    |       |    |    |   |   |   |   |   |   |   |   |   |   |  |

**Figure 10 - C-VLAN Layer****9.5.2.6 MPLS LSEs**

The MPLS LSEs layer consists of all MPLS LSEs identified in the frame, including the Label, Traffic Class (TC), Bottom of the Stack (S), and Time to Live (TTL) fields present in the given MPLS LSE instance, as defined in [RFC 5462].

|         |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |    |   |   |       |   |   |   |   |   |   |   |
|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------|----|---|---|-------|---|---|---|---|---|---|---|
| 31      | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11   | 10 | 9 | 8 | 7     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Label 0 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | TC 0 |    |   | S | TTL 0 |   |   |   |   |   |   |   |
| Label 1 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | TC 1 |    |   | S | TTL 1 |   |   |   |   |   |   |   |
| Label 2 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | TC 2 |    |   | S | TTL 2 |   |   |   |   |   |   |   |

**Figure 11 - MPLS LSEs Layer****9.5.2.7 IPv4**

The IPv4 layer only exists in frames with EtherType 0x0800, and consists of the 40 bytes of standard IPv4 header, followed by any IPv4 options. Note the bit ordering in this layer is consistent with the other layers in this specification, but is the reverse of IETF documentation.

|                           |    |    |    |         |    |    |    |                 |    |    |    |    |    |    |    |                    |    |    |    |                 |    |   |   |   |   |   |   |   |   |   |   |
|---------------------------|----|----|----|---------|----|----|----|-----------------|----|----|----|----|----|----|----|--------------------|----|----|----|-----------------|----|---|---|---|---|---|---|---|---|---|---|
| 31                        | 30 | 29 | 28 | 27      | 26 | 25 | 24 | 23              | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15                 | 14 | 13 | 12 | 11              | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Version                   |    |    |    | Hdr Len |    |    |    | Type of Service |    |    |    |    |    |    |    | Length of datagram |    |    |    |                 |    |   |   |   |   |   |   |   |   |   |   |
| Identification            |    |    |    |         |    |    |    |                 |    |    |    |    |    |    |    | Flags              |    |    |    | Fragment Offset |    |   |   |   |   |   |   |   |   |   |   |
| Time to Live              |    |    |    |         |    |    |    | Protocol        |    |    |    |    |    |    |    | Header Checksum    |    |    |    |                 |    |   |   |   |   |   |   |   |   |   |   |
| Source IP Address         |    |    |    |         |    |    |    |                 |    |    |    |    |    |    |    |                    |    |    |    |                 |    |   |   |   |   |   |   |   |   |   |   |
| Destination IP Address    |    |    |    |         |    |    |    |                 |    |    |    |    |    |    |    |                    |    |    |    |                 |    |   |   |   |   |   |   |   |   |   |   |
| IP Options (if any)..<br> |    |    |    |         |    |    |    |                 |    |    |    |    |    |    |    |                    |    |    |    |                 |    |   |   |   |   |   |   |   |   |   |   |

**Figure 12 - IPv4 Layer****9.5.2.8 IPv6**

The IPv6 layer only exists in frames with EtherType 0x86DD, and consists of the 40 bytes of base IPv6 header, followed by extension headers. Note the bit ordering in this layer is consistent with the other layers in this specification, but is the reverse of IETF documentation.

|                     |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
|---------------------|----|---------------|----|----|----|----|----|----|----|----|----|------------|-------------|----|----|----|----|----|----|----|----|-----------|---|---|---|---|---|---|---|---|---|
| 31                  | 30 | 29            | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19         | 18          | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9         | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Version             |    | Traffic Class |    |    |    |    |    |    |    |    |    | Flow Label |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Payload Length      |    |               |    |    |    |    |    |    |    |    |    |            | Next Header |    |    |    |    |    |    |    |    | Hop Limit |   |   |   |   |   |   |   |   |   |
| Source Address      |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Source Address      |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Source Address      |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Source Address      |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Destination Address |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Destination Address |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Destination Address |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |
| Destination Address |    |               |    |    |    |    |    |    |    |    |    |            |             |    |    |    |    |    |    |    |    |           |   |   |   |   |   |   |   |   |   |

**Figure 13 - IPv6 Layer****9.5.2.9 Generic L3**

The Generic L3 layer consists of all bytes after the VLAN or MPLS layers in frames that are not IP frames; that is, those frames with EtherType other than 0x0800 or 0x86DD. Rules that match custom fields in the Generic L3 layer likely need also to match the EtherType to ensure that the frame contains the expected protocol.

**9.5.2.10 TCP/UDP**

The TCP/UDP layer consists of the bytes of the standard TCP or UDP header, if the frame is an IP frame (v4 or v6), and if the IP Protocol type indicates UDP or TCP.

|             |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |                  |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |
|-------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|------------------|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| 31          | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15               | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Source Port |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Destination Port |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |

**Figure 14 - Layer TCP/UDP****9.5.2.11 Generic L4**

The Generic L4 layer consists of all bytes after the IP header (v4 or v6) if the IP protocol type is not UDP and not TCP. Rules that match custom fields in the Generic L4 layer likely need also to match the IP protocol type field to ensure that the frame contains the expected protocol.

**9.5.3 C-VLAN TPID (0xD7/0x0503)**

Objects: Network Port, User Port

This attribute represents an alternate EtherType value that is used to identify a C-VLAN tag in a frame, in addition to the standard IEEE value of 0x8100. D-ONUs with an alternate C-VLAN TPID will accept either the alternate value or 0x8100 as indicating a C-VLAN tag. C-VLAN tags added by a D-ONU are always added with the standard value of 0x8100 by default. If the "Insert This TPID" field is set to TRUE (1), then this alternate TPID will be used for all tags inserted by the D-ONU instead.

**Table 134 - C-VLAN TPID**

| Size | Description           | Units   | Default | Min | Max    |
|------|-----------------------|---------|---------|-----|--------|
| 2    | Alternate C-VLAN TPID | -       | 0x8100  | 0   | 0xFFFF |
| 1    | Insert This TPID      | Boolean | 0       | 0   | 1      |

**9.5.4 S-VLAN TPID (0xD7/0x0504)**

Objects: Network Port, User Port

This attribute represents an alternate EtherType value that is used to identify an S-VLAN tag in a frame, in addition to the standard IEEE value of 0x88A8. D-ONUs with an alternate S-VLAN TPID will accept either the alternate

value or 0x88A8 as indicating an S-VLAN tag. VLAN tags added by a D-ONU are always added with the standard value of 0x88A8 by default. If the "Insert This TPID" field is set to TRUE (1), then this alternate TPID will be used for all tags inserted by the D-ONU instead.

**Table 135 - S-VLAN TPID**

| Size | Description           | Units   | Default | Min | Max    |
|------|-----------------------|---------|---------|-----|--------|
| 2    | Alternate S-VLAN TPID |         | 0x88A8  | 0   | 0xFFFF |
| 1    | Insert This TPID      | Boolean | 0       | 0   | 1      |

### 9.5.5 Reserved (0xD7/0x0505)

### 9.5.6 I- TPID (0xD7/0x0506)

Objects: Network Port, User Port

This attribute represents an alternate I-TPID value that is used to identify an I-Tag in a frame, in addition to the value of 0x88E7 as defined in [802.1Q]. D-ONUs with an alternate I-TPID will accept either the alternate value or 0x88E7 as indicating an I-Tag. I-Tags added by a D-ONU are always added with the standard value of 0x88E7 by default. If the "Insert This TPID" field is set to TRUE (1), then this alternate I-TPID will be used for all I-Tags inserted by the D-ONU instead.

**Table 136 - I-TPID**

| Size | Description       | Units   | Default | Min | Max    |
|------|-------------------|---------|---------|-----|--------|
| 2    | Alternate I- TPID |         | 0x88E7  | 0   | 0xFFFF |
| 1    | Insert This TPID  | Boolean | 0       | 0   | 1      |

### 9.5.7 B-TPID (0xD7/0x0507)

Objects: Network Port, User Port

This attribute represents an alternate EtherType value that is used to identify a B-Tag in a frame, in addition to the value of 0x88A8 as defined in [802.1Q]. D-ONUs with an alternate B-TPID will accept either the alternate value or 0x88A8 as indicating a B-Tag. B-Tags added by a D-ONU are always added with the standard value of 0x88A8 by default. If the "Insert This TPID" field is set to TRUE (1), then this alternate B-TPID will be used for all B-Tags inserted by the D-ONU instead.

**Table 137 - B-TPID**

| Size | Description      | Units   | Default | Min | Max    |
|------|------------------|---------|---------|-----|--------|
| 2    | Alternate B-TPID |         | 0x88A8  | 0   | 0xFFFF |
| 1    | Insert This TPID | Boolean | 0       | 0   | 1      |

### 9.5.8 Clear Port Ingress Rules (0xD9/0x0501)

Objects: Network Port, User Port

This action deletes all ingress frame processing rules of the current port.

### 9.5.9 Add Port Ingress Rule (0xD9/0x0502)

Objects: Network Port, User Port

This action adds the Port Ingress Rule, which preceded this TLV to the port in context.

### 9.5.10 Delete Port Ingress Rule (0xD9/0x0503)

Objects: Network Port, User Port

This action deletes the Port Ingress Rule, which preceded this TLV to the port in context.

## 9.6 Service Level Agreements

### 9.6.1 Broadcast Rate Limit (0xD7/0x0601)

Objects: User Port

This attribute represents a limit on the number of broadcast frames that can be received through the Ethernet interface. The rates refer to packet counts in a second. Once the count is exceeded, the discard result will be set for the packet at precedence 1. D-ONU rules can override the discard with a forward result at higher precedence. When set to 0xFF-FF-FF-FF, the broadcast rate filtering is disabled.

**Table 138 - Broadcast Rate Limit**

| Size | Description                                                                         | Units            | Default | Min | Max           |
|------|-------------------------------------------------------------------------------------|------------------|---------|-----|---------------|
| 4    | The maximum number of broadcast packets allowed from context user port in 1 second. | packets / second | 20 0000 | 0   | 0xFF-FF-FF-FF |

### 9.6.2 Obsolete (0xD7/0x0602)

This attribute is deprecated in DPoEv2.0.

### 9.6.3 Obsolete (0xD7/0x0603)

This attribute is deprecated in DPoEv2.0.

### 9.6.4 Queue Committed Information Rate (0xD7/0x0604)

Objects: Queue

This attribute represents the CIR rate for output from a queue.

**Table 139 - Queue CIR**

| Size | Description                         | Units     | Default | Min | Max         |
|------|-------------------------------------|-----------|---------|-----|-------------|
| 2    | Committed Burst Size (0 to disable) | 256 Bytes | 0       | 0   | 0xFFFF      |
| 4    | Committed Information Rate          | 1 Kbps    | 0       | 0   | 0xFFFF FFFF |

### 9.6.5 FEC Mode (0xD7/0x0605)

Objects: Network Port, Unicast Logical Link, Multicast Logical Link

This attribute represents the current FEC mode.

For any PX type device, operating at the effective data rate of 1 Gbit/s in downstream and upstream directions, the upstream and downstream links support values as shown in Table 128, both for reading and writing.

For any PRX type device, operating at the effective data rate of 10 Gbit/s downstream and 1 Gbit/s upstream, the upstream link supports values as shown in Table 140 for the "The D-ONU tx/upstream FEC" attribute, while the downstream link supports only the value "FEC is ON" for the "The D-ONU rx/downstream FEC" attribute. On read, the ONU returns the value of "FEC is ON" for the "The D-ONU tx/upstream FEC" attribute. Any attempt to write any value other than "FEC is ON" into the "The D-ONU rx/downstream FEC" attribute is ignored.

For any PR type device, operating at the effective data rate of 10 Gbit/s in downstream and upstream directions, only the value "FEC is ON" is supported for both downstream and upstream links. On read, the ONU returns the value of "FEC is ON" for the "The D-ONU rx/downstream FEC" attribute and the "The D-ONU tx/upstream FEC" attribute. Any attempt to write any value other than "FEC is ON" into the "The D-ONU rx/downstream FEC" attribute and the "The D-ONU tx/upstream FEC" attribute is ignored.

If the object context is the Multicast Logical Link, "The D-ONU tx/upstream FEC" attribute should be ignored at the reception at both the D-ONU and DPoE System.

**Table 140 - FEC Mode**

| Size | Description                                                         | Units | Default | Min | Max |
|------|---------------------------------------------------------------------|-------|---------|-----|-----|
| 1    | The D-ONU rx/downstream FEC<br>0: Off – No FEC<br>1: On – FEC is ON | enum  | 0       | 0   | 1   |
| 1    | The D-ONU tx/upstream FEC<br>0: Off – No FEC<br>1: On – FEC is ON   | enum  | 0       | 0   | 1   |

**9.6.6 Queue Excess Information Rate (0xD7/0x0606)**

Objects: Queue

This attribute represents the EIR rate for output from a queue.

**Table 141 - Queue EIR**

| Size | Description                      | Units     | Default | Min | Max         |
|------|----------------------------------|-----------|---------|-----|-------------|
| 2    | Excess Burst Size (0 to disable) | 256 Bytes | 0       | 0   | 0xFFFF      |
| 4    | Queue EIR                        | 1 Kbps    | 0       | 0   | 0xFFFF FFFF |

**9.6.7 Queue Color Marking (0xD7/0x0607)**

Objects: Queue

This attribute represents the method of marking frames according to particular shaper results, usually described as "color" values. When color marking is enabled, the field indicated in this attribute will be overwritten before frame egress with the green or yellow color value according to the rate limiter results for that frame.

**Table 142 - Queue Color Marking**

| Size | Description          | Units           | Default | Min | Max  |
|------|----------------------|-----------------|---------|-----|------|
| 1    | Enable Color Marking | Boolean         | 0       | 0   | 1    |
| 1    | Field Code           | (See Table 121) | 0       | 0   | 0xFF |
| 1    | Field Instance       |                 | 0       | 0   | 0xFF |
| 1    | MSB Mask             |                 | 0       | 0   | 0xFF |
| 1    | LSB Mask             |                 | 0       | 0   | 0xFF |
| 1    | Green Value          |                 | 0       | 0   | 0xFF |
| 1    | Yellow Value         |                 | 0       | 0   | 0xFF |

**9.6.8 Queue Rate Limiter Capabilities (0xD7/0x0608) R**

Objects: D-ONU

This capabilities attribute describes support for the rate limiting function in the D-ONU hardware. The "Number of Rate Limiters" fields indicates how many instances of hardware exist; that is, how many different services can be independently controlled with this feature. A value of 0 indicates the feature is not supported.

"Min Increments" for rate limits indicate the smallest multiple of the field units (256 bytes / 1Kbps) which can actually be enforced. For example, hardware that can rate limit only to multiples of 64 Kbps would have a CIR Min Increment of 64.

"Color Aware?" indicates whether the function is sensitive to incoming color marking. "Coupling Configurable?" indicates whether the CIR+EIR coupling behavior for yellow frames can be changed. When Coupling Configurable? is FALSE, "Coupling Behavior Default" indicates the coupling behavior that is always present. "Color Marking Support?" indicates whether the hardware can alter egress frames to show the results from the rate limiter function. "Smart Color Drop?" indicates whether the hardware is capable of considering the color of a frame when making decisions to drop frames from a queue.

**Table 143 - Queue Rate Limiter Capabilities**

| Size | Description               | Units     | Default | Min | Max     |
|------|---------------------------|-----------|---------|-----|---------|
| 2    | Number of Rate Limiters   | Instances | 0       | 0   | 0xFF FF |
| 2    | CBS Min Increment         | 256 bytes | 1       | 0   | 0xFF FF |
| 2    | CIR Min Increment         | 1K bps    | 1       | 0   | 0xFF FF |
| 2    | EBS Min Increment         | 256 bytes | 1       | 0   | 0xFF FF |
| 2    | EIR Min Increment         | 1K bytes  | 1       | 0   | 0xFF FF |
| 1    | Color Aware?              | Boolean   | 0       | 0   | 1       |
| 1    | Coupling Configurable?    | Boolean   | 0       | 0   | 1       |
| 1    | Coupling Behavior Default | Boolean   | 0       | 0   | 1       |
| 1    | Color Marking Support?    | Boolean   | 0       | 0   | 1       |
| 1    | Smart Color Drop?         | Boolean   | 0       | 0   | 1       |

### 9.6.9 Coupling Flag (0xD7/0x0609)

Objects: Queue

Indicates the value of the MEF coupling flag for joint behavior of the CIR/EIR shapers.

**Table 144 - Coupling Flag**

| Size | Description   | Units   | Default | Min | Max |
|------|---------------|---------|---------|-----|-----|
| 1    | Coupling Flag | Boolean | 0       | 0   | 1   |

### 9.6.10 Enable User Traffic (0xD9/0x0601)

Objects: D-ONU, Unicast Logical Link

Enable user data traffic for the object in context. If the object is Unicast Logical Link, this enables user traffic for the link only. If the object is D-ONU, traffic for all logical links is enabled. The Disable User Traffic message stops this traffic. D-ONUs boot with user data traffic disabled. If a link deregisters and then re-registers, the traffic is disabled.

### 9.6.11 Disable User Traffic (0xD9/0x0602)

Objects: D-ONU, Unicast Logical Link

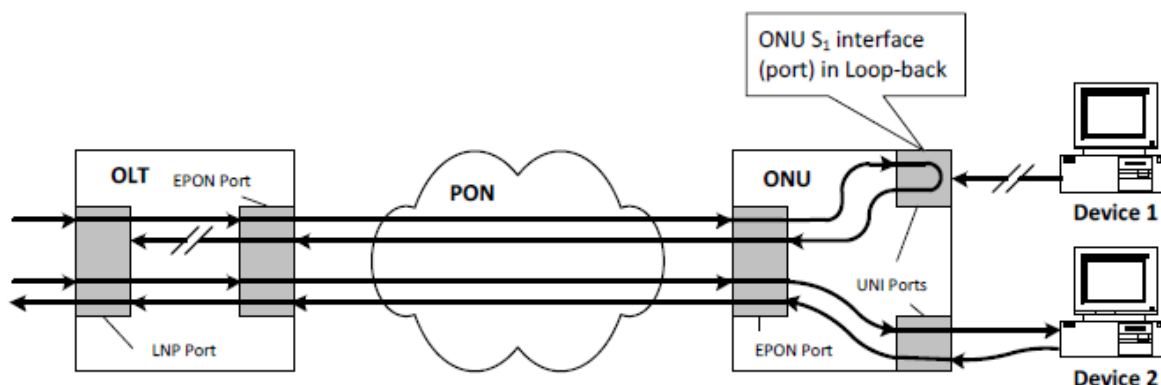
The Disable message causes the D-ONU to disable all user data traffic for the object in context. If the object is Unicast Logical Link, this disables user traffic for the link only. If the object is D-ONU, traffic for all logical links is disabled OAM and MPCP traffic remains intact. The Enable User Traffic message restores the user traffic. D-ONUs boot with user traffic disabled. If a link deregisters and then re-registers, the traffic is disabled.

### 9.6.12 Loopback Enable (0xD9/0x0603)

Objects: Unicast Logical Link, User Port

The D-ONU MUST implement logical link loopback as per [802.3]. The D-ONU implements loopback at the S interface using this action.

This attribute enables MAC or PHY loopback at the specified D-ONU S interface (port). Figure 15 below is an example of Set Loopback for a D-ONU S interface (port). When a D-ONU S interface (port) is in loopback, packets sent upstream to the UNI port will be dropped. Packets sent downstream are looped back upstream and transmitted out the TU interface port of the D-ONU. Traffic flowing to other ports will not be affected. This loopback message tests a path through the entire D-ONU, in contrast to the [802.3] link loopback, which occurs at the TU interface side of the D-ONU.



**Figure 15 - Set Loopback for D-ONU S Interface**

**Table 145 - Loopback Enable**

| Size | Description                                           | Units | Default | Min | Max |
|------|-------------------------------------------------------|-------|---------|-----|-----|
| 1    | Location (0 = PHY, 1 = MAC, 2 = unicast logical link) |       | 0       | 0   | 2   |

### 9.6.13 Loopback Disable (0xD9/0x0604)

Objects: Unicast Logical Link, User Port

This attribute takes the specified entity out of loopback. If the given entity is not in loopback, this message is ignored.

**Table 146 - Loopback Disable**

| Size | Description                                   | Units | Default | Min | Max |
|------|-----------------------------------------------|-------|---------|-----|-----|
| 1    | Location (0 = PHY, 1 = MAC, 2 = logical link) | enum  | 0       | 0   | 2   |

The procedure for initiating a loopback is to send an Enable Loopback command with the port label of the port on which the loopback is to be established. After the loopback has been set, an autonomous loopback alarm message will be sent to the host. In accordance with [802.3] Clause 57, the DPoE System will start a countdown timer with the value from the Get Loopback Timeout Host Interface message. If the loopback is not cleared by the Host within the period specified (Scenario 1 in Figure 16 below), the Loopback will be cleared automatically by the DPoE System (Scenario 2 in Figure 16 below). An autonomous alarm report will then be sent to the host, indicating that the loopback has been cleared.

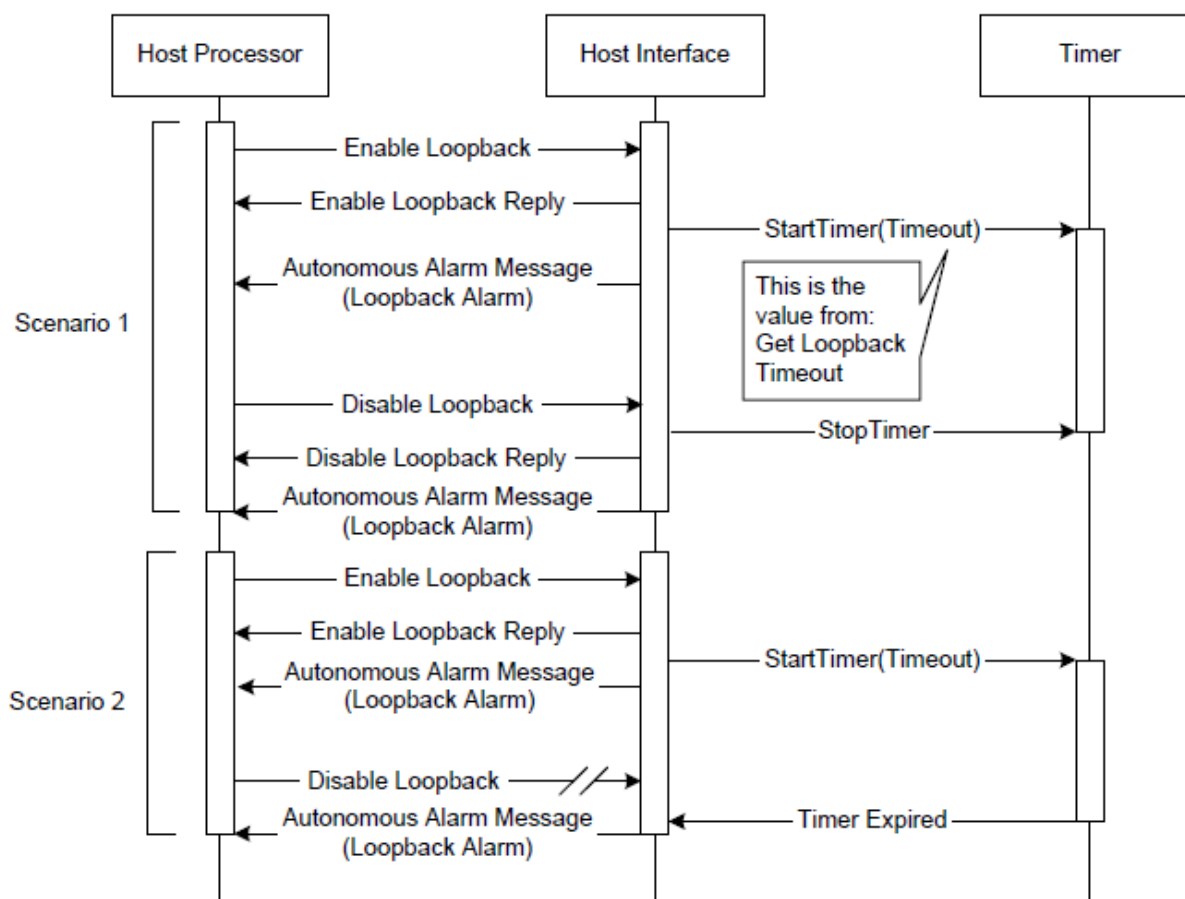


Figure 16 - Enable/Disable Loopback

#### 9.6.14 Laser Tx Power Off (0xD9/0x0605)

Objects: Network Port

This attribute turns off the laser Tx for specified time for diagnostic purposes. Note that this message can also instruct a D-ONU to permanently remove itself from the network. Setting the power off time to 0 enables the laser power again, bringing an D-ONU back onto the network without waiting for an earlier timer to expire.

Table 147 - Laser Tx Power Off

| Size | Description  | Units        | Default | Min                  | Max                             |
|------|--------------|--------------|---------|----------------------|---------------------------------|
| 2    | Disable time | milliseconds | -       | 0<br>(turn laser on) | 0xFFFF<br>(disable permanently) |

## 9.7 Clock Transport

### 9.7.1 Clock Transport Capabilities (0xD7/0x0701) R

Objects: User Port

This attribute represents the capability of the given user port on the D-ONU to support the 1PPS+TOD or [1588v2] timing interfaces.

**Table 148 - Clock Transport Capabilities**

| Size | Description            | Units   | Default         | Min | Max |
|------|------------------------|---------|-----------------|-----|-----|
| 1    | 1PPS Pulse Support     | Boolean | 0 (unsupported) | 0   | 1   |
| 1    | TOD String Support     | Boolean | 0 (unsupported) | 0   | 1   |
| 1    | [1588v2] Frame Support | Boolean | 0 (unsupported) | 0   | 1   |

**9.7.2 Enable Clock Transport (0xD7/0x0702)**

Objects: User Port

This attribute enables the selected type of clock transport interface on the given user port on the D-ONU.

**Table 149 - Clock Transport Enable**

| Size | Description           | Units   | Default      | Min | Max |
|------|-----------------------|---------|--------------|-----|-----|
| 1    | 1PPS Pulse Output     | Boolean | 0 (disabled) | 0   | 1   |
| 1    | TOD String Output     | Boolean | 0 (disabled) | 0   | 1   |
| 1    | [1588v2] Frame Output | Boolean | 0 (disabled) | 0   | 1   |

**9.7.3 Time Transfer (0xD7/0x0703)**

Objects: D-ONU

If at least one [1588v2] interface is enabled on the D-ONU, this attribute sets the time for the next ToD synchronization event on the D-ONU, indicating a reference MPCP clock time and the ToD value when the local D-ONU MPCP clock reaches the value carried in the 'MPCP Reference Point' field.

When at least one 1PPS+TOD interface is enabled on the D-ONU, this attribute sets the MPCP time for the next 1PPS pulse for the clock transport function. The value carried in the 'MPCP Reference Point' is the time for the next 1PPS pulse. The value carried in the 'TOD String' field represents the reference TOD value at the time of the 1PPS pulse. This value is variable length binary data, and may contain embedded NULs (ASCII 0) or other non-printable ASCII, depending on the TOD format in use for the particular DPoE Network.

**Table 150 - Time Transfer**

| Size   | Description          | Units    | Default | Min | Max         |
|--------|----------------------|----------|---------|-----|-------------|
| 4      | MPCP Reference Point | 16 ns TQ | -       | 0   | 0xFFFF FFFF |
| Varies | TOD String           | -        | -       | -   | -           |

**9.7.4 Propagation Parameters (0xD7/0x0704)**

Objects: D-ONU

These values represent the refractive index of the fiber connected to this D-ONU in the upstream and downstream wavelengths, multiplied by the coefficient of  $2^{24}$ . (That is, there is an implied radix point after the most significant 8 bits of this value.)

**Table 151 - Propagation Parameters**

| Size | Description | Units         | Default    | Min | Max         |
|------|-------------|---------------|------------|-----|-------------|
| 4    | ndown       | dimensionless | 0x01999999 | 0   | 0xFFFF FFFF |
| 4    | nup         | dimensionless | 0x01999999 | 0   | 0xFFFF FFFF |

**9.7.5 RTT (0xD7/0x0705)**

Objects: D-ONU

This attribute represents the latest value of the round-trip time (RTT) measured by the DPoE System for the given D-ONU, using the mechanisms defined in [802.3] for EPON.

**Table 152 - RTT**

| Size | Description | Units    | Default | Min | Max         |
|------|-------------|----------|---------|-----|-------------|
| 4    | RTT         | 16 ns TQ | -       | 0   | 0xFFFF FFFF |

## 9.8 DEMARC Automatic Configuration

This functionality is no longer defined.

### 9.8.1 Reserved (0xD7/0x0800)

### 9.8.2 Reserved (0xD7/0x0801)

### 9.8.3 Reserved (0xD7/0x0802)

### 9.8.4 Reserved (0xD7/0x0803)

## 9.9 UNI management

### 9.9.1 Energy Efficient Ethernet (EEE) status (0xD7/0x0820)

**Objects: User Port**

This attribute allows the operator to control the status of the Energy Efficient Ethernet (EEE) function on the given UNI port. When the auto-negotiation function on the given UNI port is enabled, setting the EEE status to *enabled* or *disabled* does not have any effect.

**Table 153 - EEE Status**

| Size | Description | Default | Min  | Max  | Values                                                                |
|------|-------------|---------|------|------|-----------------------------------------------------------------------|
| 1    | EEE status  | 0x00    | 0x00 | 0xFF | 0x00 = disabled (default)<br>0x01 = enabled<br>0x02 - 0xFF = reserved |

### 9.9.2 Power over Ethernet (PoE) status (0xD7/0x0821)

**Objects: User Port**

This attribute allows the operator to control the status of the Power over Ethernet (PoE) function on the given UNI port. Setting the status of the PoE function on the UNI that does not support PoE has no effect on the operation of the given UNI.

**Table 154 - PoE Status**

| Size | Description | Default | Min  | Max  | Values                                                                |
|------|-------------|---------|------|------|-----------------------------------------------------------------------|
| 1    | PoE status  | 0x00    | 0x00 | 0xFF | 0x00 = disabled<br>0x01 = enabled (default)<br>0x02 - 0xFF = reserved |

### 9.9.3 Media Type (0xD7/0x0822)

**Objects: User Port**

This attribute allows the operator to control the type of media used on a selectable-media port. Setting the media type on a UNI port that does not support selectable-media has no effect on the operation of the given UNI.

**Table 155 - Media Type**

| Size | Description | Default | Min  | Max  | Values                                                                      |
|------|-------------|---------|------|------|-----------------------------------------------------------------------------|
| 1    | Media Type  | 0x01    | 0x00 | 0xFF | 0x00 = SFP media<br>0x01 = BASE-T media (default)<br>0x02 - 0xFF = reserved |

## 9.10 Optical Link Protection R

### 9.10.1 ONU Protection Capability (0xD7/0x09-00)

See [1904.1A], subclause 14.4.3.9.1.

### 9.10.2 ONU Protection Configuration (0xD7/0x09-01)

See [1904.1A], subclause 14.4.3.9.2.

### 9.10.3 PON Interface Administrative (0xD7/0x09-02)

See [1904.1A], subclause 14.4.3.9.3.

### 9.10.4 ONU Config Holdover Period (0xD7/0x09-03)

See [1904.1A], subclause 14.4.3.9.4.

## 9.11 Power Saving

### 9.11.1 ONU Power Saving Capabilities aOnuPwrSavingCap (0xD7/0xFFFF)

See [1904.1A], subclause 14.4.3.8.1.

## 10 MULTICAST LOGICAL LINK REGISTRATION

DPoE multicast architecture defined in IEEE [1904.1A], TBD pending SIEPON finalizing 1904.1A update.

## 11 SECURITY

See the [DPoE-SECv2.0] document for details of encryption, key exchange, authentication, and other requirements related to security and authentication.

### 11.1 Key Exchange

DPoE OAM extensions include a key exchange protocol. This can be used to synchronize keys between the DPoE System and D-ONU. The Key Exchange PDU begins with a subtype code to distinguish PDU types used in the key exchange protocol.

The Key Assignment PDU is used to transmit a key value to the network peer.

**Table 156 - Key Assignment**

| Width (Octets) | Field                | Value (hex)                                                                                 |
|----------------|----------------------|---------------------------------------------------------------------------------------------|
| 1              | Key Exchange Subtype | 0: Key Assignment                                                                           |
| 2              | LLID                 | LLID value, as in frame preamble, for the logical link to which this message applies        |
| 1              | Key Number           | 0..1; indicates key phase                                                                   |
| 1              | Key Length           | Number of bytes of key data (16 for 128-bit AES)                                            |
| Varies         | Key                  | Random data equal to Length bytes. The first byte is the most significant byte of key data. |

The Key Assignment Acknowledgement PDU is sent in some applications of the protocol after a Key Assignment PDU is received.

**Table 157 - Key Assignment Ack**

| Width (Octets) | Field                | Value (hex)                                                                          |
|----------------|----------------------|--------------------------------------------------------------------------------------|
| 1              | Key Exchange Subtype | 1: Key Assignment Acknowledgement                                                    |
| 2              | LLID                 | LLID value, as in frame preamble, for the logical link to which this message applies |
| 1              | Key Number           | 0..1; indicates key phase                                                            |

## 12 FILE TRANSFER

DPoE extensions enable D-ONUs to download new firmware upgrades and other files from the DPoE System using a simple file transfer protocol.

This protocol is a simplified form of TFTP. It has been modified to operate over the [802.3] OAM channel instead of IP. This protocol differs from TFTP in the following ways:

- It includes support for only one data encoding option (binary).
- It supports variable sized frames, to suit the negotiated length of the Ethernet OAM frame and take advantage of the longer MTU.
- It acknowledges next block to receive rather than last block received, to avoid the Sorcerer's Apprentice problem without extra timers.
- It replaces the file pathname string with a numeric file type identifier.

To maximize interoperability, the contents of D-ONU files are considered to be opaque to the DPoE System and management system. There is intentionally no standardized header that all D-ONU models must support. An EMS might well add headers to binary files for D-ONUs for its own purposes of storage and tracking, but these headers would be removed before sending the data to the D-ONU. Conversely, any information which a particular D-ONU needs for its own purposes for storage and validation must be included in the D-ONU file; the exact format of this data is up to the D-ONU vendor so long as the file format meets the requirements of this section. The DPoE System does not parse into the contents of files for the D-ONU, but only acts as a gateway to transfer the files.

### 12.1 File Transfer PDU Header

File Transfer PDUs have a common header, shown below.

**Table 158 - File Transfer PDU Header**

| Width (Octets) | Field                  | Value (hex)                                            |
|----------------|------------------------|--------------------------------------------------------|
| 6              | Ethernet DA            | 0x01:80:C2:00:00:02<br>([802.3] OAM multicast address) |
| 6              | Ethernet SA            | As per sending MAC                                     |
| 2              | Ethernet Type          | 0x8809 (Ethernet Slow Protocol)                        |
| 1              | Subtype                | 0x03 ([802.3]OAM)                                      |
| 2              | Flags                  | As per [802.3]                                         |
| 1              | Opcode                 | FE (Vendor extended)                                   |
| 3              | OUI                    | 0x001000 (DPoE EPON)                                   |
| 1              | DPoE Opcode            | 0x09 (File Transfer)                                   |
| 1              | File Transfer Opcode   | See Table 159                                          |
| varies         | File Transfer PDU body | As per each PDU type, defined below                    |

**Table 159 - File Transfer PDU Opcodes**

| File Transfer PDU Opcode | Value (hex) |
|--------------------------|-------------|
| Reserved                 | 0x0         |
| Write Request            | 0x1         |
| File Transfer Data       | 0x2         |
| File Transfer Ack        | 0x3         |

#### 12.1.1 File Transfer Write Request

The File Transfer Write Request OAM PDUs indicates a request to initiate a file transfer from the DPoE System to the D-ONU, including the target DPoE ONU firmware file name, transferred in the format of a null-terminated ASCII string. The recipient prepares to receive a file.

The response to a File Transfer Request is a File Transfer Ack message. The error code of the Ack is either zero (Ok), allowing the transfer to proceed, or non-zero, indicating the reason that the transfer cannot take place.

**Table 160 - File Transfer Write Request**

| Width (Octets) | Field        | Value (hex)                  |
|----------------|--------------|------------------------------|
| varies         | OSS Filename | Null-terminated ASCII string |

### 12.1.2 File Transfer Data

File Transfer Data PDUs contain the data for the current file. Each PDU carries a sequence number and size field, specifying the number of file data bytes to follow. Data PDUs are sent one block at a time in sequential order. Each block is acknowledged by the recipient before the next block is sent. (This is a "stop and wait" protocol.) The first block of a file has sequence number 0.

The response to a Transfer Request is a File Transfer Ack message. The error code of the Ack is either zero (Ok), allowing the transfer to proceed, or non-zero, indicating the reason that the transfer was aborted. The Ack also contains the block number of the next block the recipient expects to receive.

Once the file transfer begins, at least one Data PDU must be sent every second. If the recipient fails to receive a Data PDU every second, a timeout is counted and the recipient sends a File Transfer Ack. This message contains the timeout error code and the sequence number indicating the desired block. Three successive timeouts will abort the file transfer process. In this case, the file on the recipient is unchanged.

A Data PDU may be sent with a size of zero. This resets the block reception timer on the recipient to prevent a timeout. It does not advance the block sequence number or the state of the received file. This feature can be used to keep a transfer alive in the event of an unanticipated delay at the sender.

**Table 161 - File Transfer Data**

| Width (Octets) | Field                | Value (hex) |
|----------------|----------------------|-------------|
| 2              | Block Number         | Increments  |
| 2              | Block Width (Octets) | Varies      |
| (Size)         | File data            | Varies      |

### 12.1.3 File Transfer Ack

The Acknowledgement PDUs contain a sequence number and an error code. The sequence number is the number of the next block expected by the recipient. The error code indicates the status of the transfer. A non-zero error code aborts the file transfer and leaves the files on the recipient unchanged.

To signal the end of a file transfer, the sender sends an Ack PDU. This PDU contains sequence number 0 and a code indicating the status of the transfer. (The transfer status indicated is assessed by the sender, not the recipient.) A zero status instructs the recipient to commit the file to permanent storage. A non-zero status instructs the recipient to discard the file, even if the transfer appears successful to the recipient. This Ack is the only Ack sent by the sender in this protocol.

The final Ack from the sender is acknowledged by a final Ack from the recipient. The recipient sends the Ack after it has committed the file or discarded it. Committing a file to flash requires more time than processing a single data frame. Therefore, the timeout for the final Ack response from the recipient should be at least 15 seconds.

**Table 162 - File Transfer Ack**

| Width (Octets) | Field         | Value (hex)                                            |
|----------------|---------------|--------------------------------------------------------|
| 2              | Block Number  | Increments                                             |
| 1              | Response Code | As per File Acknowledgement Response Code table, below |

**Table 163 - File Acknowledgement Response Code**

| Ack Response Code | Meaning                                                                                                        | Value (hex) |
|-------------------|----------------------------------------------------------------------------------------------------------------|-------------|
| OK                | No errors                                                                                                      | 0x0         |
| Undefined         | Unknown error, or one not covered elsewhere                                                                    | 0x1         |
| Not Found         | Read requested file that is not available                                                                      | 0x2         |
| No Access         | Access permissions do not allow the requested read/write                                                       | 0x3         |
| Full              | Storage is full, and cannot hold the written file                                                              | 0x4         |
| Illegal Operation | Cannot perform requested operation in current state                                                            | 0x5         |
| Unknown ID        | Requested file ID is not supported by this device                                                              | 0x6         |
| Bad Block         | Block received in error                                                                                        | 0x7         |
| Timeout           | No block received before timer expiration                                                                      | 0x8         |
| Busy              | Cannot perform requested action due to other activity                                                          | 0x9         |
| Incompatible File | Received file is incompatible with this device. File incompatibility is determined by the device vendor.       | 0xA         |
| Corrupted File    | File was received corrupted and is unusable by this device. File integrity is determined by the device vendor. | 0xB         |

## Appendix I Branch/Leaf Code Reference (Informative)

### I.1 [802.3] Clause 30 Attributes (Branch 0x07)

The following table lists attributes as defined in [802.3] Clause 30. They are repeated here for ease of reference. These attributes can also appear in DPoE OAM PDUs to avoid the need to send separate PDUs to query both [802.3] and DPoE attributes.

**Table 164 - [802.3] Clause 30 Attributes (Branch 07)**

| Leaf (HEX)                       | Attribute                     | Read/ Write | Description                                                                 |
|----------------------------------|-------------------------------|-------------|-----------------------------------------------------------------------------|
| MAC                              |                               |             |                                                                             |
| 0x00 01                          | MAC ID                        | R           | ID for this MAC in this device                                              |
| 0x00 02                          | Frames Tx OK                  | R           | Frames transmitted                                                          |
| 0x00 03                          | Single Collision Frames       | R           | Frames suffering a single collision                                         |
| 0x00 04                          | Multiple Collision Frames     | R           | Frames suffering multiple collisions                                        |
| 0x00 05                          | Frames Rx OK                  | R           | Frames received with no errors                                              |
| 0x00 06                          | FCS Err                       | R           | Frames received with FCS errors                                             |
| 0x00 07                          | Alignment Error               | R           | Alignment errors                                                            |
| 0x00 08                          | Octets Tx OK                  | R           | Octets transmitted in frames with no errors                                 |
| 0x00 09                          | Frames Deferred               | R           | Deferred due to collisions                                                  |
| 0x00 0A                          | Late Collisions               | R           | Collisions after frame in progress                                          |
| 0x00 0B                          | Excessive Collisions          | R           | Frames dropped due to too many collisions                                   |
| 0x00 0C                          | Lost MAC Tx Err               | R           | Frames lost due to MAC transmission error                                   |
| 0x00 0E                          | Octets Rx OK                  | R           | Octets received in good frames                                              |
| 0x00 0F                          | Frames Lost MAC Rx Error      | R           | Frames lost due to MAC receive error                                        |
| 0x00 12                          | Multicast Frames Tx           | R           | Frames transmitted with a multicast address                                 |
| 0x00 13                          | Broadcast Frames Tx           | R           | Frames transmitted with a broadcast address                                 |
| 0x00 14                          | Frames Excessive Deferral     | R           | Frames dropped due to too many backoff retries                              |
| 0x00 15                          | Multicast Frames Rx           | R           | Frames received with multicast address                                      |
| 0x00 16                          | Broadcast Frames Rx           | R           | Frames received with broadcast address                                      |
| 0x00 17                          | In Range Length Error         | R           | [802.3] format frames received with actual length not equal to length field |
| 0x00 18                          | Out of Range Length Error     | R           | Frames received out of allowed length (short or long)                       |
| 0x00 19                          | Frame Too Long                | R           | Frames received longer than the maximum permitted                           |
| 0x00 1A                          | MAC Enable Status             | R/W         | Port enabled or disabled                                                    |
| 0x00 1D                          | MAC Address                   | R           | MAC Address of the port                                                     |
| PHY                              |                               |             |                                                                             |
| 0x00 20                          | PHY Type                      | R           | Type of PHY for this port                                                   |
| 0x00 23                          | PHY Symbol Err During Carrier | R           | Transmission errors detected                                                |
| 0x00 25                          | PHY Admin State               | R/W         | PHY enabled or disabled                                                     |
| MAU                              |                               |             |                                                                             |
| 0x00 47                          | MAU Media Available           | R           |                                                                             |
| Auto-negotiation - See 0xD7/0105 |                               |             |                                                                             |
| 0x00 4E                          | Obsolete                      | R           |                                                                             |
| 0x00 4F                          | Obsolete                      | R/W         |                                                                             |

| Leaf (HEX)    | Attribute                    | Read/ Write | Description |
|---------------|------------------------------|-------------|-------------|
| 0x00 50       | Obsolete                     | R           |             |
| 0x00 51       | Obsolete                     | R           |             |
| 0x00 52       | Obsolete                     | R/W         |             |
| 0x00 53       | Obsolete                     | R/W         |             |
| 0x00 54       | Obsolete                     | R           |             |
| 0x00 55       | Obsolete                     | R           |             |
| 0x00 56       | Obsolete                     | R           |             |
| 0x00 57       | Obsolete                     | R           |             |
| MAC           |                              |             |             |
| 0x00 5A       | Duplex Status                | R/W         |             |
| MAC Control   |                              |             |             |
| 0x00 5D       | MAC Ctrl Functions Supported | R           |             |
| 0x00 5E       | MAC Ctrl Frames Tx           | R           |             |
| 0x00 5F       | MAC Ctrl Frames Rx           | R           |             |
| 0x00 60       | MAC Ctrl Unsupported Op Rx   | R           |             |
| 0x00 61       | MAC Ctrl Pause Delay         | R           |             |
| 0x00 62       | MAC Ctrl Pause Tx            | R           |             |
| 0x00 63       | MAC Ctrl Pause Rx            | R           |             |
| OMP Emulation |                              |             |             |
| 0x01 18       | MPCP Frames Tx               | R           |             |
| 0x01 19       | MPCP Frames Rx               | R           |             |
| 0x01 20       | MPCP Tx Discovery            | R           |             |
| 0x01 22       | MPCP Disc Timeout            | R           |             |
| FEC           |                              |             |             |
| 0x01 24       | FEC Corrected Blocks         | R           |             |
| 0x01 25       | FEC Uncorrectable Blocks     | R           |             |
| 0x01 39       | FEC Ability                  | R/W         |             |
| 0x01 3A       | FEC Mode                     | R/W         |             |
| OMP Emulation |                              |             |             |
| 0x01 3B       | MPCP Tx Gate                 | R           |             |
| 0x01 3C       | MPCP Tx Reg Ack              | R           |             |
| 0x01 3D       | MPCP Tx Register             | R           |             |
| 0x01 3E       | MPCP Tx Reg Req              | R           |             |
| 0x01 3F       | MPCP Tx Report               | R           |             |
| 0x01 40       | MPCP Rx Gate                 | R           |             |
| 0x01 41       | MPCP Rx Reg Ack              | R           |             |
| 0x01 42       | MPCP Rx Register             | R           |             |
| 0x01 43       | MPCP Rx Reg Req              | R           |             |
| 0x01 44       | MPCP Rx Report               | R           |             |

## I.2 DPoE Attributes (Branch 0xD7)

The table below lists attributes defined for managing extended features with DPoE OAM. See Section 9 for Branch D7 attribute details.

**Table 165 - DPoE Attributes (Branch D7)**

| Leaf (HEX)              | Attribute                          | Read/ Write | Description                                                                                  |
|-------------------------|------------------------------------|-------------|----------------------------------------------------------------------------------------------|
| <b>D-ONU Management</b> |                                    |             |                                                                                              |
| 0x0002                  | Device ID                          | R           | Lowest (numerically smallest) TU MAC address                                                 |
| 0x0003                  | Firmware info                      | R           | Firmware information                                                                         |
| 0x0004                  | Chipset Info                       | R           | Type of chip used on the D-ONU                                                               |
| 0x0005                  | Date of Manufacture                | R           | Date of Manufacture                                                                          |
| 0x0006                  | Manufacturer Info                  | R           | Manufacturer-specific information                                                            |
| 0x0007                  | Max Logical Links                  | R           | Maximum LLIDs                                                                                |
| 0x0008                  | Number of Network Ports            | R           | Number of TU interface ports on the D-ONU                                                    |
| 0x0009                  | Number of S interfaces             | R           | Number of S interfaces on D-ONU                                                              |
| 0x000A                  | D-ONU Packet Buffer                | R           | Packet buffer capabilities                                                                   |
| 0x000B                  | Report Thresholds                  | R/W         | threshold levels used to generate REPORT MPCPDUs                                             |
| 0x000C                  | Logical Link Forwarding State      | R           | Current traffic state for a logical link                                                     |
| 0x000D                  | OAM Frame Rate                     | R           | Maximum rate at which OAM PDUs are transmitted on a link                                     |
| 0x000E                  | ONU Manufacturer Organization Name | R           | Organization name which manufactured the D-ONU                                               |
| 0x000F                  | Firmware Mfg Time Varying Controls | R           | The firmware CVC and CVS validity times                                                      |
| 0x0010                  | D-ONU Port Type                    | R           | Type of individual ports and devices connected to them (if present)                          |
| 0x0011                  | Vendor Name                        | R           | ONU vendor name                                                                              |
| 0x0012                  | Model Number                       | R           | ONU model number                                                                             |
| 0x0013                  | Hardware Version                   | R           | ONU hardware version                                                                         |
| 0x0014                  | EPON Mode                          | R           | EPON Mode capabilities                                                                       |
| 0x0015                  | Software Bundle                    | R           | Software Bundle Description (augments SW_REV)                                                |
| <b>Bridging</b>         |                                    |             |                                                                                              |
| 0x0101                  | Dynamic Learning Table Size        | R           | Maximum size of the D-ONU MAC address learning table                                         |
| 0x0102                  | Dynamic Address Age Limit          | R/W         | Dynamic MAC learning table age limit                                                         |
| 0x0103                  | Dynamic MAC Table                  | R           | Dynamically learned MAC address rules of one Ethernet port                                   |
| 0x0104                  | Static MAC Table                   | R           | Statically provisioned MAC address table                                                     |
| 0x0105                  | Interface Port Auto-negotiation    | R           | Auto-negotiation advertisement values used by a port                                         |
| 0x0106                  | Source Address Admission Control   | R/W         | MAC Source Address-based admission function operating on the selected upstream DPOE ONU port |
| 0x0107                  | MAC Learning Min Guarantee         | R/W         | Minimum number of MAC addresses that can be learned on an individual UNI port                |
| 0x0108                  | MAC Learning Max Allowed           | R/W         | Maximum allowed number of MAC addresses on an individual S port                              |
| 0x0109                  | MAC Learning Aggregate Limit       | R/W         | Aggregate dynamic MAC address limit for the D-ONU as a whole                                 |
| 0x010A                  | Len Error Discard                  | R/W         | Length Error Discard Enable status of the D-ONU ports                                        |
| 0x010B                  | Flood Unknown                      | R/W         | Flooding control of downstream frames whose destination addresses have not been learned      |
| 0x010C                  | Local Switching                    | R/W         | configuration of a port for local switching                                                  |
| 0x010D                  | Obsolete                           |             | See 0xD7/0x0114 and 0xD7/0x0115                                                              |
| 0x010E                  | Firmware Filename                  | R           | Name of the DPoE ONU firmware file                                                           |
| 0x010F                  | MAC Table Full Behavior            | R/W         | Controls behavior of the D-ONU MAC address learning process                                  |

| Leaf (HEX)              | Attribute                     | Read/ Write | Description                                                                                                                                          |
|-------------------------|-------------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x0110                  | Multicast LLID                | RO          |                                                                                                                                                      |
| 0x0111                  | Obsolete                      |             |                                                                                                                                                      |
| 0x0112                  | ONU Max Frame Size Capability | RO          | Max size of Ethernet frame supported by ONU                                                                                                          |
| 0x0113                  | UNI Max Frame Size Limit      | RW          | Current setting of max Ethernet frame size for the ONU User Port in the upstream direction. (0x0040 to 0xFFFF)                                       |
| 0x0114                  | ONU Port Config               | RW          | Number of LLIDs and User Ports to be enabled in the ONU                                                                                              |
| 0x0115                  | Queue Config                  | RW          | Number of queues to be enabled for a given LLID or UNI port. Queues are specified in order of priority where the first queue is the highest priority |
| Statistics And Counters |                               |             |                                                                                                                                                      |
| 0x0201                  | Rx Frames Green               | R/W         | Count of frames received at one port                                                                                                                 |
| 0x0202                  | Tx Frames Green               | R/W         | Count of frames transmitted from one port                                                                                                            |
| 0x0203                  | Rx Frame Too Short            | R/W         | RxFrameTooShort counter of one port                                                                                                                  |
| 0x0204                  | Rx Frame 64                   | R/W         | RxFrame64 counter of one port                                                                                                                        |
| 0x0205                  | Rx Frame 65_127               | R/W         | RxFrame65_127 counter of one port                                                                                                                    |
| 0x0206                  | RxFrame128_255                | R/W         | RxFrame128_255 counter of one port                                                                                                                   |
| 0x0207                  | Rx Frame 256_511              | R/W         | RxFrame256_511 counter of one port                                                                                                                   |
| 0x0208                  | Rx Frame 512_1023             | R/W         | RxFrame512_1023 counter of one port                                                                                                                  |
| 0x0209                  | Rx Frame 1024_1518            | R/W         | RxFrame1024_1518 counter of one port                                                                                                                 |
| 0x020A                  | Rx Frame 1519 Plus            | R/W         | RxFrame1519Plus counter of one port                                                                                                                  |
| 0x020B                  | Tx Frame 64                   | R/W         | TxFrame64 counter of one port                                                                                                                        |
| 0x020C                  | Tx Frame 65_127               | R/W         | TxFrame65_127 counter of one port                                                                                                                    |
| 0x020D                  | Tx Frame 128_255              | R/W         | TxFrame128_255 counter of one port                                                                                                                   |
| 0x020E                  | Tx Frame 256_511              | R/W         | TxFrame256_511 counter of one port                                                                                                                   |
| 0x020F                  | Tx Frame 512_1023             | R/W         | TxFrame512_1023 counter of one port                                                                                                                  |
| 0x0210                  | Tx Frame 1024_1518            | R/W         | TxFrame1024_1518 counter of one port                                                                                                                 |
| 0x0211                  | Tx Frame 1519 Plus            | R/W         | TxFrame1519Plus counter of one port                                                                                                                  |
| 0x0212                  | Queue Delay Threshold         | R/W         | Threshold for Delay that causes Bytes Delayed counter to increment for a queue                                                                       |
| 0x0213                  | Queue Delay                   | R/W         | Maximum Frame Delay experienced since statistic reset for a queue                                                                                    |
| 0x0214                  | Frames Dropped                | R/W         | Frames dropped due to queue overflow or rate control discard                                                                                         |
| 0x0215                  | Bytes Dropped                 | R/W         | Bytes dropped due to queue overflow or rate control discard                                                                                          |
| 0x0216                  | Bytes Delayed                 | R/W         | Bytes in frames with a D-ONU queue residency time greater than DelayThreshold for a queue                                                            |
| 0x0217                  | Tx Bytes Unused               | R/W         | Bytes granted to the Unicast Logical Link but not filled with transmitted data                                                                       |
| 0x021D                  | Optical Mon Temperature       | R/W         | Optical module temperature                                                                                                                           |
| 0x021E                  | Optical Mon Vcc               | R/W         | Optical module Vcc                                                                                                                                   |
| 0x021F                  | Optical Mon Tx Bias Current   | R/W         | Current optical module Tx bias current                                                                                                               |
| 0x0220                  | Optical Mon Tx Power          | R/W         | Current optical module Tx power                                                                                                                      |
| 0x0221                  | Optical Mon Rx Power          | R/W         | Current optical module Rx power                                                                                                                      |
| 0x0222                  | Rx Frames Yellow              | R/W         | Frames received at one port                                                                                                                          |
| 0x0223                  | Tx Frames Yellow              | R/W         | Frames transmitted from one port                                                                                                                     |
| 0x0224                  | Tx Bytes Green                | R/W         | Bytes in green frames transmitted from one port                                                                                                      |
| 0x0225                  | Rx Bytes Yellow               | R/W         | Bytes in yellow frames received at one port                                                                                                          |
| 0x0226                  | Rx Bytes Green                | R/W         | Bytes in green frames received at one port                                                                                                           |

| Leaf (HEX)               | Attribute                          | Read/ Write | Description                                                                    |
|--------------------------|------------------------------------|-------------|--------------------------------------------------------------------------------|
| 0X0227                   | Tx Bytes Yellow                    | R/W         | Bytes in yellow frames transmitted from one port                               |
| 0X0228                   | Tx Frames Unicast                  | R/W         | Frames transmitted with a unicast L2 DA                                        |
| 0X0229                   | Tx Frames Multicast                | R/W         | Frames transmitted with a multicast L2 DA                                      |
| 0X022A                   | Tx Frames Broadcast                | R/W         | Frames transmitted with the broadcast L2 DA                                    |
| 0X022B                   | Rx Frames Unicast                  | R/W         | Frames received with a L2 unicast DA                                           |
| 0X022C                   | Rx Frames Multicast                | R/W         | Frames received with a multicast L2 DA                                         |
| 0X022D                   | Rx Frames Broadcast                | R/W         | Frames received with the broadcast L2 DA                                       |
| 0X022E                   | Number of Programmable Counters    | R           | Programmable frame/byte counters supported                                     |
| 0X022F                   | L2CP Frames Rx                     | R/W         | Layer 2 control protocol frames received                                       |
| 0X0230                   | L2CP Octets Rx                     | R/W         | Layer 2 control protocol frames received                                       |
| 0X0231                   | L2CP Frames Tx                     | R/W         | Layer 2 control protocol frames transmitted                                    |
| 0X0232                   | L2CP Octets Tx                     | R/W         | Layer 2 control protocol frames transmitted                                    |
| 0X0233                   | L2CP Frames Discarded              | R/W         | Layer 2 control protocol frames discarded                                      |
| 0X0234                   | L2CP Octets Discarded              | R/W         | Layer 2 control protocol frames discarded                                      |
| 0X0235                   | Tx L2 Errors                       | R/W         | Frames that failed to transmit because of an error in the data link layer      |
| 0X0236                   | Rx L2 Errors                       | R/W         | Frames discarded due to errors in the frame                                    |
| Alarms                   |                                    |             |                                                                                |
| 0X0301                   | Port Stat Threshold                | R/W         | Port statistics counter threshold                                              |
| 0X0302                   | Link Stat Threshold                | R/W         | Link statistics counter threshold                                              |
| 0X0303                   | Suspend/Resume Alarm Reporting     | R/W         | Enable or disable transmission alarms                                          |
| Security                 |                                    |             |                                                                                |
| 0X0401                   | Encryption Key Expiry Time         | R/W         | Timeout value for encryption keys                                              |
| 0X0402                   | Encryption Mode                    | R/W         | Encryption method to be used on a particular logical link                      |
| Frame Processing         |                                    |             |                                                                                |
| 0X0501                   | Port Ingress Rule                  | R/W         | A rule in the ingress table of the current port                                |
| 0X0502                   | Custom Field                       | R/W         |                                                                                |
| 0X0503                   | C-VLAN TPID                        | R/W         | Alternate EtherType value (C-VLAN)                                             |
| 0X0504                   | S-VLAN TPID                        | R/W         | alternate EtherType (S-VLAN)                                                   |
| 0X0505                   | IPMC Forwarding Rule Configuration | R/W         | A unique IP multicast group                                                    |
| 0X0506                   | I- TPID                            | R/W         | Alternate I-TPID (I-Tag)                                                       |
| 0X0507                   | B- TPID                            | R/W         | Alternate B-TPID (B-Tag)                                                       |
| Service Level Agreements |                                    |             |                                                                                |
| 0X0601                   | Broadcast Rate Limit               | R/W         | Number of broadcast frames that can be received through the Ethernet interface |
| 0X0602                   | Reserved                           |             | Deprecated in DPoE 2.0                                                         |
| 0X0603                   | Reserved                           |             | Deprecated in DPoE 2.0                                                         |
| 0X0604                   | Queue Committed Information Rate   | R/W         | CIR output rate from a queue                                                   |
| 0X0605                   | FEC Mode                           | R/W         | Current FEC mode                                                               |
| 0X0606                   | Queue Excess Information Rate      | R/W         | EIR output rate from a queue                                                   |
| 0X0607                   | Queue Color Marking                | R/W         | Frame marking method                                                           |
| 0X0608                   | Queue Rate Limiter Capabilities    | R           | Rate limiting method                                                           |

| Leaf (HEX)      | Attribute                              | Read/ Write | Description                                                      |
|-----------------|----------------------------------------|-------------|------------------------------------------------------------------|
| 0X0609          | Coupling Flag                          | R/W         | MEF coupling flag for joint behavior of the CIR/EIR shapers      |
| Clock Transport |                                        |             |                                                                  |
| 0X0701          | Clock Transport Capabilities           | R           | Port capability to support 1 PPS+TOD or 1588v2 timing interfaces |
| 0X0702          | Enable Clock Transport                 | R/W         | Enables the selected type of clock transport                     |
| 0X0703          | Time Transfer                          | R/W         | Sets the time for the next ToD synchronization event             |
| 0X0704          | Propagation Parameters                 | R/W         | Refractive index of the fiber                                    |
| 0X0705          | RTT                                    | R/W         | Round-trip time (RTT) measured by the DPoE System                |
| Reserved        |                                        |             |                                                                  |
| 0X0800          | Reserved                               |             | Deprecated in DPoE 2.0                                           |
| 0X0801          | Reserved                               |             | Deprecated in DPoE 2.0                                           |
| 0X0802          | Reserved                               |             | Deprecated in DPoE 2.0                                           |
| 0X0803          | Reserved                               |             | Deprecated in DPoE 2.0                                           |
| UNI Management  |                                        |             |                                                                  |
| 0X0820          | Energy Efficient Ethernet (EEE) status | R/W         | Energy Efficient Ethernet for UNI port                           |
| 0X0821          | Power over Ethernet (PoE) status       | R/W         | POE for UNI Port                                                 |
| 0X0822          | Media Type                             | R/W         | Media used on a selectable-media port                            |
| Link Protection |                                        |             |                                                                  |
| 0X0900          | ONU Protection Capability              | R/W         | See [1904.1A] subclause 14.4.3.9.1                               |
| 0X0901          | ONU Protection Configuration           | R/W         | See [1904.1A], subclause 14.4.3.9.2                              |
| 0X0902          | PON Interface Administrative           | R/W         | See [1904.1A], subclause 14.4.3.9.3                              |
| 0X0902          | Config HoldOver                        | R/W         | See [1904.1A], subclause 14.4.3.9.4                              |
| Power Saving    |                                        |             |                                                                  |
| 0xFFFF          | Power Saving Capabilities              | R           | See [1904.1A], subclause 14.4.3.8.1                              |

### I.3 [802.3] Clause 30 Actions (Branch 09) (Informative)

These actions are defined in [802.3] Clause 30, and are repeated here for ease of reference.

**Table 166 - [802.3] Clause 30 Actions (Branch 09)**

| Leaf (HEX) | Attribute            | Description             |
|------------|----------------------|-------------------------|
| 0x00 05    | PHY Admin Control    | Enable/disable PHY      |
| 0x00 0B    | Auto Neg Renegotiate | Force renegotiation     |
| 0x00 0C    | Auto Neg Admin Ctrl  | Auto Neg enable/disable |

### I.4 DPoE Actions (Branch 0xD9)

An action is identified by a Variable Container. Action parameters, if any, are included in the data portion of the container in the Set Request OAM PDU. Actions with no parameters have a zero length Container (Width code 0x80).

Responses to an action in the Set Response OAM PDU similarly have a list of Containers. Typically the response is just the result code (0x80, No Error, or a failure code). A response could return a result in the data portion of the container.

See Sections 9.6.6 through 9.6.14 for DPoE OAM PDUs for Branch D9.

## Appendix II Example PDUs (Informative)

This informative-only appendix shows examples of DPoE OAM PDUs to illustrate the format and usage of these messages.

### II.1 Get and Get Response

This example shows the use of the Object ID in a complex Get message that requests attributes from several objects. The Get message received from the DPoE System is shown on the left, with the corresponding D-ONU response on the right. The frame begins with some attribute TLVs (branch 7, D7), both standard and DPoE, without an object context. These attributes by definition refer to the default object, which is the EPON port and logical link on which the message was received. The D-ONU responds to an Object ID simply by echoing the TLV back in the Get Response. For each Variable Descriptor in the Get message, the D-ONU creates a matching Variable Container. Note that there is one response indicating an error code. All errors designate a length of 0 bytes, so there is no data field. As in the [802.3] standard, a branch value of zero terminates the list of TLVs. This null terminator is always in the message; it is not padding.

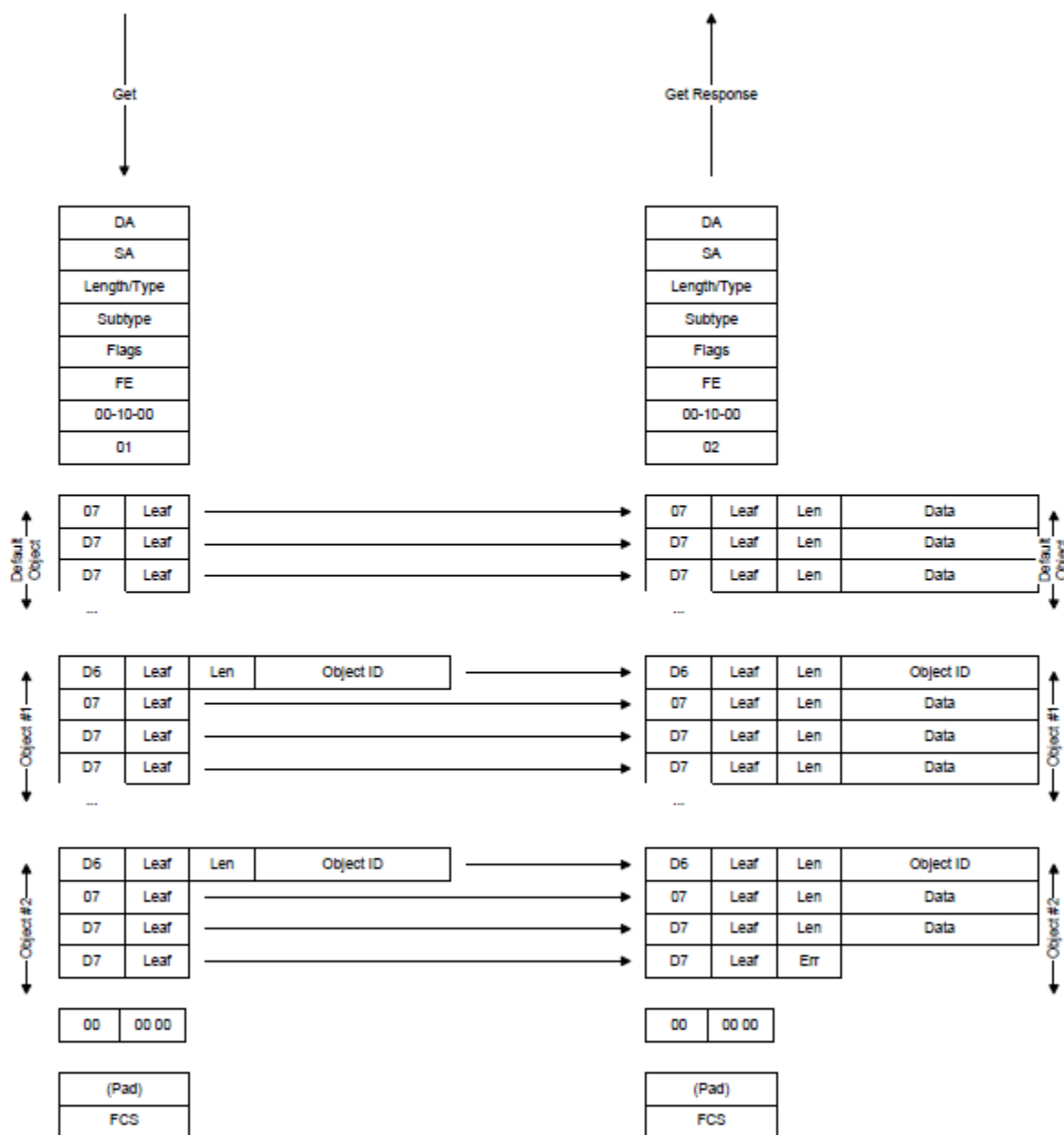


Figure 17 - Get and Get Response

## II.2 Set and Set Response

This example shows a Set message, including a change in Object ID. Note that both standard and extended attributes can be set in a single message. Set messages have Variable Containers rather than Descriptors in the Get, because to set an attribute, you must specify both the attribute and its new value. The response to a Set is a TLV with a return code (usually RcOk, but perhaps an error) indicating zero data. Actions (branch codes 0x09, 0xD9) can also be included in a set message. Actions often have parameters (ex: Add MAC address (M1)), so they are also Variable Containers. For consistency in parsing, even actions with no parameters, such as D-ONU Reset, use the Variable Container format with a length of zero.

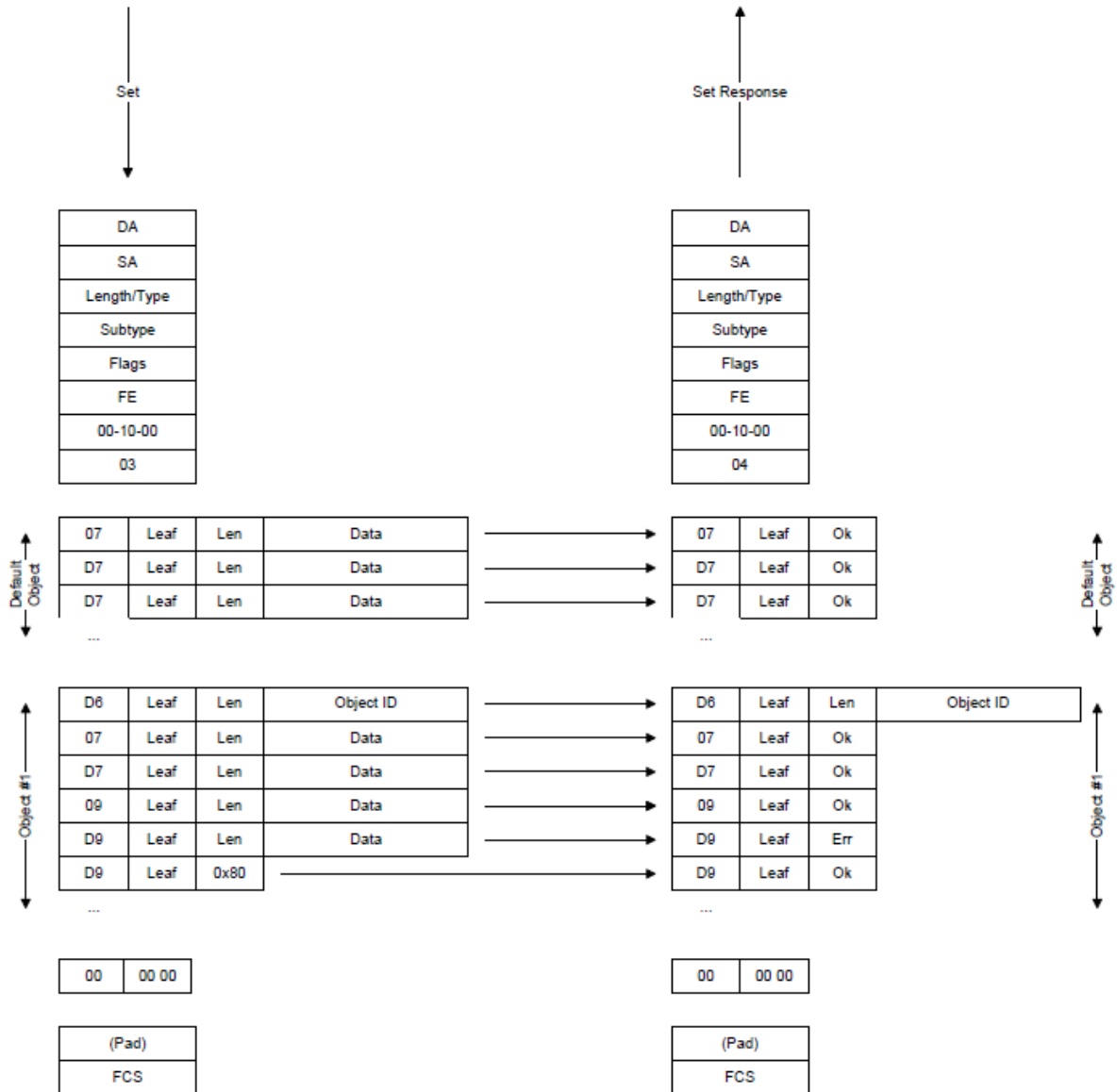
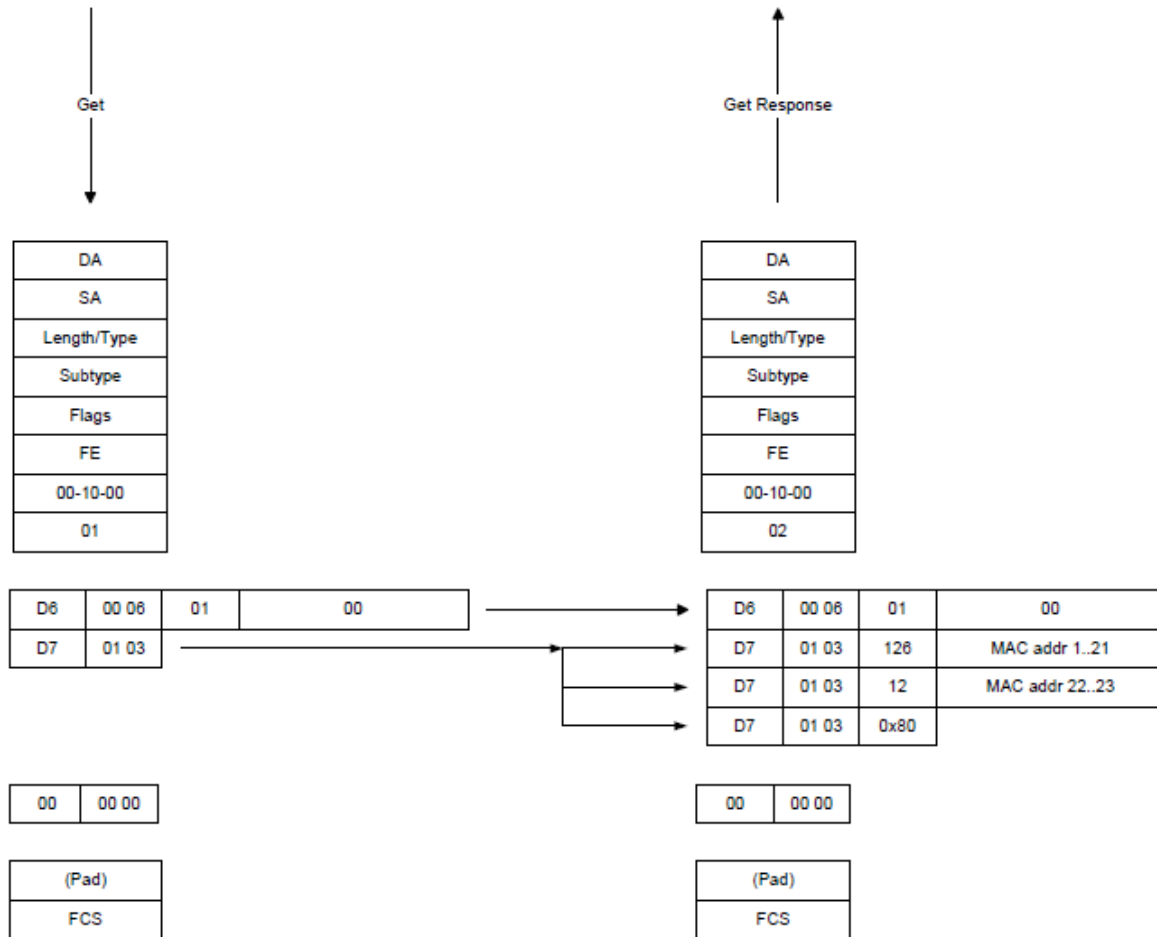


Figure 18 - Set and Set Response

### II.3 Large Attribute Values

This example illustrates the format for a large return value, in this case the MAC address table for a particular UNI port. The Get Request PDU contains a single attribute, but the reply is larger than 128 bytes, and so requires several containers for the response.



**Figure 19 - Large Attribute Values**

## II.4 Multi-Part Replies

The following diagram illustrates the use of the sequence number attribute in a two-part reply to a single Get PDU. For the sake of example, the reply is assumed to be a single attribute, an extremely large MAC address table, as in the previous example. A multi-part reply also might be generated in response to a long list of small attributes.

Note that the large attribute is not terminated in the first frame as it is not yet complete, but is terminated only in the second frame.

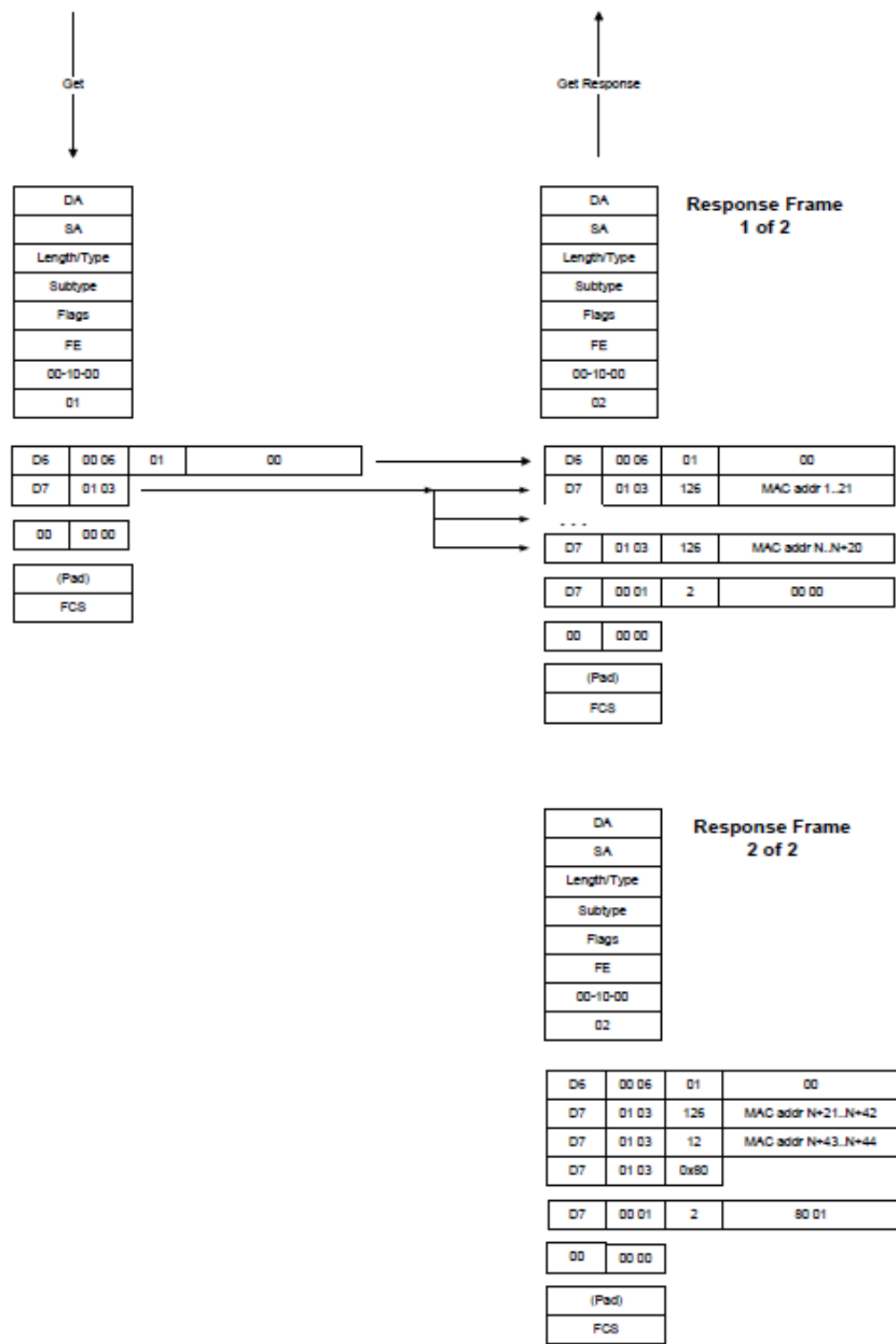
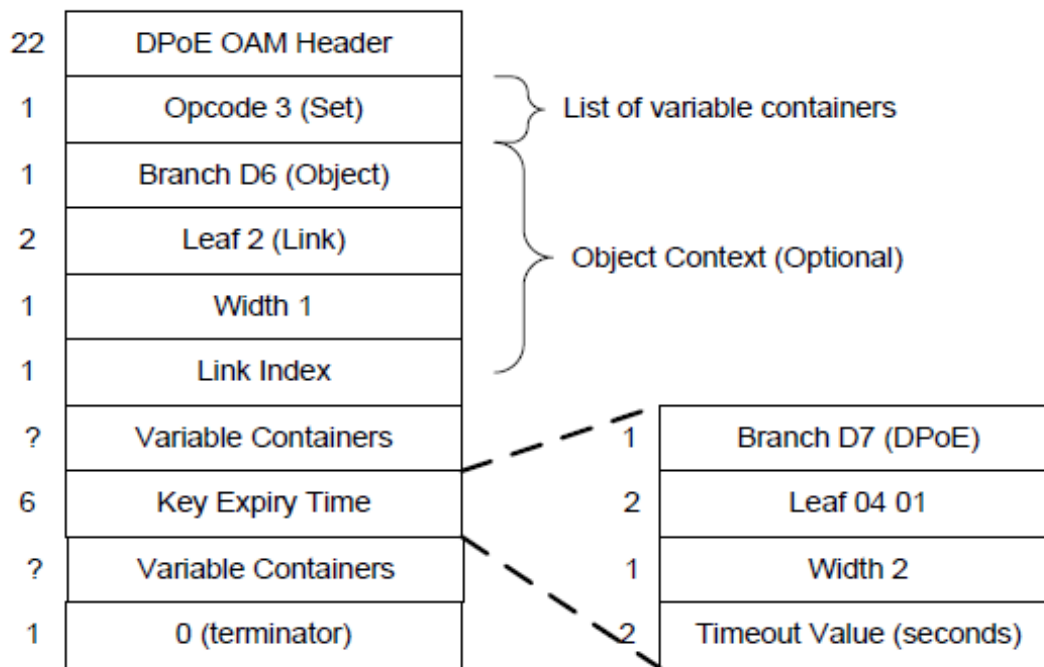


Figure 20 - Multi-Part Replies

## II.5 Encryption and Key Exchange Messages

This PDU is used to set the key exchange interval on the D-ONU.

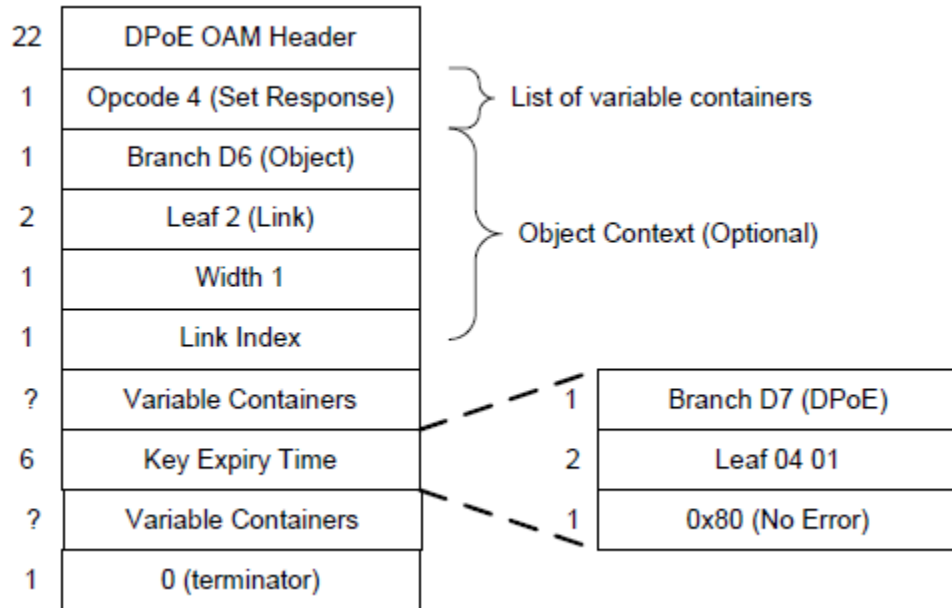


**Figure 21 - Set Key Exchange Timer Request PDU**

```
+ Ethernet Frame
DA.....01 80 c2 00 00 02
SA.....54 4b 37 21 00 00
EtherType.....88 09 (Slow Protocol)
SubType.....03 (OAM)
+ OAM PDU
Flags.....00 10
Code.....fe (Organization Specific)
OUI.....00 10 00 (DPoE)
+ DPoE PDU
OpCode.....03 (Set)
+ TLV
Branch.....d6 (Object Context)
Leaf.....00 02 (LLID)
Width.....02
Value.....00 00 (LLID Index 0)
+ TLV
Branch.....d7 (DPoE attribute)
Leaf.....04 01 (Encryption Key Expiry Time)
Width.....02
Value.....00 3c (60 seconds)
+ TLV
Branch.....00 (Branch null (terminator))
Leaf.....00 00 (Leaf null (terminator))
+ PAD
+ FCS
```

### II.5.1 Set Key Exchange Timer Response PDU

This PDU is returned to inform the DPoE System if the D-ONU was successfully configured (or not successfully configured) with the Key Exchange Timer value specified in a Set Request Message.

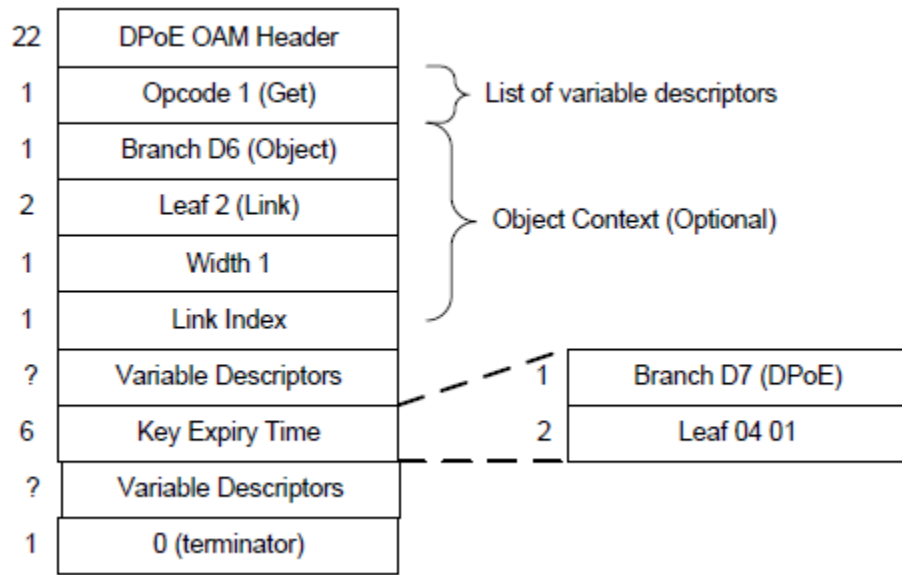


**Figure 22 - Set Key Exchange Timer Response PDU**

```
+ Ethernet Frame
DA.....01 80 c2 00 00 02
SA.....54 4b 37 01 00 ab
EtherType.....88 09
SubType.....03 (OAM)
+ OAM PDU
  Flags.....00 50
  Code.....fe (Organization Specific)
  OUI.....00 10 00 (DPoE)
+ DPoE PDU
  OpCode.....04 (Set Response)
+ TLV
  Branch.....d6 (Object)
  Leaf.....00 02 (LLID)
  Width.....02
  Value.....00 00 (LLID Index)
+ TLV
  Branch.....d7 (DPoE Attribute)
  Leaf.....04 01 (Encryption Key Expiry Time)
  Width/Code..80 (No Error)
+ TLV
  Branch.....00 (Branch null (terminator))
  Leaf.....00 00 (Leaf terminator)
+ PAD
+ FCS
```

### II.5.2 Get Key Exchange Timer PDU

This PDU may be used by the DPoE System to query the D-ONU to determine the currently specified Key Exchange Timer value used by one of the D-ONU's links.



**Figure 23 - Get Key Exchange Timer PDU**

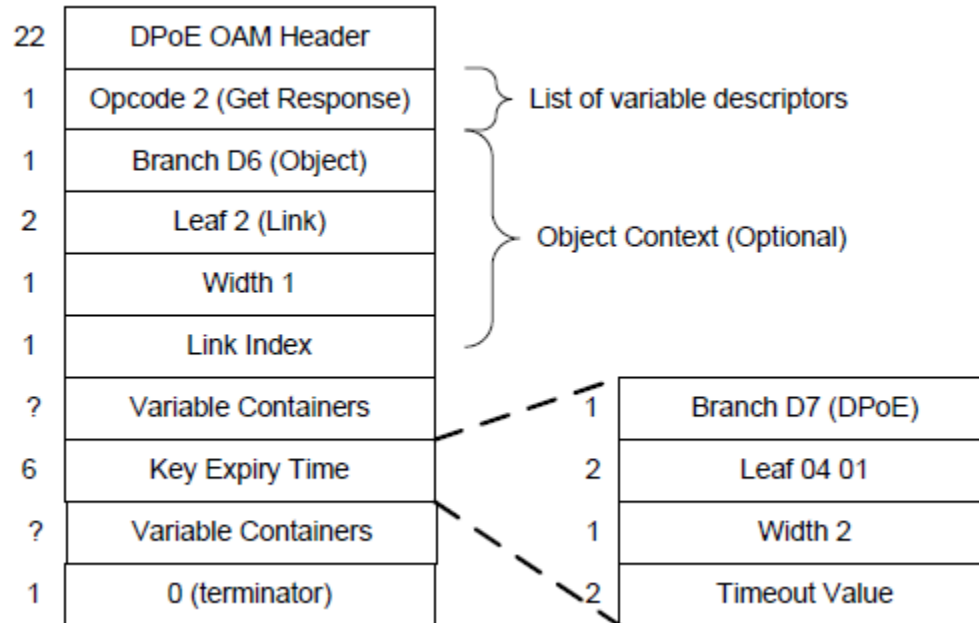
```

+ Ethernet Frame
  DA.....01 80 c2 00 00 02
  SA.....54 4b 37 21 00 00
  EtherType.....88 09 (Slow Protocol)
  SubType.....03 (OAM)
+ OAM PDU
  Flags.....00 10
  Code.....fe (Organization Specific)
  OUI.....00 10 00 (DPoE)
+ DPoE PDU
  OpCode.....01 (Get)
+ TLV
  Branch.....d6 (Object Context)
  Leaf.....00 02 (Link)
  Width.....02
  Value.....00 00 (LLID Index 0)
+ TLV
  Branch.....d7 (DPoE Attribute)
  Leaf.....04 01 (Key Exchange Expiry Time)
+ TLV
  Branch.....00 (Branch null (terminator))
+ PAD
+ FCS

```

### II.5.3 Get Key Exchange Timer Response PDU

All D-ONU implementations respond either with the provisioned Key Exchange Timer Value or an appropriate error Container Value if queried by the DPoE System.



**Figure 24 - Get Key Exchange Timer Response PDU**

```

+ Ethernet Frame
  DA.....01 80 c2 00 00 02
  SA.....54 4b 37 01 00 ab
  SubType.....88 09 (Slow Protocol)
  Flags.....03 (OAM)
+ OAM PDU
  Flags.....00 50
  Code.....fe (Organization Specific)
  OUI.....00 10 00 (DPoE)
+ DPoE PDU
  OpCode.....02 (Get Response)
+ TLV
  Branch.....d6 (Object Context)
  Leaf.....00 02 (Link)
  Length.....02
  Value.....00 00 (LLID Index 0)
+ TLV
  Branch.....d7 (DPoE attribute)
  Leaf.....04 01 (Key Exchange Expiry Timer)
  Width.....02
  Value.....00 3c
+ TLV
  Branch.....00 (Branch null (terminator))
+ PAD
+ FCS

```

## II.6 Key Exchange Message

This message is example showing the key value being the D-ONU to DPoE System.

```

+ Ethernet Frame
  DA.....01 80 c2 00 00 02
  SA.....54 4b 37 01 00 ab
  EtherType.....88 09 (Slow Protocol)
  SubType.....03 (OAM)
+ OAM PDU

```

```

Flags.....00 50
Code.....fe (Organization Specific)
OUI.....00 10 00 (DPoE)
+ DPoE PDU
  OpCode.....08 (Key Exchange)
  KeyNumber.....00
  KeySize.....10
  Key.....04 b9 98 48 04 a2 72 41
              d1 a0 5a 36 67 db 85 66
+ PAD
+ FCS

```

## II.7 Example 1Down Key Exchange Sequence

Set Key Exchange Timer (60 seconds)

```

-----
01 80 c2 00 00 02 54 4b 37 21 00 00 88 09 03 00
10 fe 00 10 00 03 d7 04 01 02 00 3c 00 00 00 ...

```

Set Key Exchange Timer Response

```

-----
01 80 c2 00 00 02 54 4b 37 01 00 ab 88 09 03 00
50 fe 00 10 00 04 d7 04 01 80 00 00 ...

```

Get Key Exchange Timer

```

-----
01 80 c2 00 00 02 54 4b 37 21 00 00 88 09 03 00
10 fe 00 10 00 01 d7 04 01 00 00 00 ...

```

Get Key Exchange Timer Response

```

-----
01 80 c2 00 00 02 54 4b 37 01 00 ab 88 09 03 00
50 fe 00 10 00 02 d7 04 01 02 00 3c 00 00 ...

```

Key Exchange Message

```

-----
01 80 c2 00 00 02 54 4b 37 01 00 ab 88 09 03 00
50 fe 00 00 10 00 01 10 ad b5 01 ab cc a8 12 68
eb 94 35 7d ec 08 3c 65 00 00 00 ...

```

Key Exchange Message

```

-----
01 80 c2 00 00 02 54 4b 37 01 00 ab 88 09 03 00
50 fe 00 10 00 08 00 10 94 cb 49 59 38 d1 5b a3
d2 7d e6 ca fd 00 9f 1f 00 00 00 ...

```

Key Exchange Message

```

-----
01 80 c2 00 00 02 54 4b 37 01 00 ab 88 09 03 00
50 fe 00 10 00 08 01 10 80 52 4c cc 21 9d 08 ea
4e 18 f5 fb 24 48 79 d6 00 00 ...

```

## II.8 LLID and Queue Configuration TLV

The following example shows the contents of a Link and Queue Configuration TLV that configures two links and two UNI ports as follows

- Upstream Configuration: N (number of links) = 2
- LLID 0 configuration: [M=2, (Queue 0 Size=10, Queue 1 size=10)]
- LLID 1 configuration: [M=1, (Queue 0 Size = 5)]
- Downstream Configuration: P (number of ports) = 2
- Port 0 (i.e., UNI port 1) configuration: [J=2, (Queue 0 Size=5, Queue 1 Size=5)]
- Port 1 (i.e., UNI port 2) configuration: [J=1, (Queue 0 Size=8)]

```

D7 01 0D 0C          ; branch/leaf for LLID/Queue Config TLV; length 12 bytes
02                   ; 2 LLIDs
    02               ; LLID 0 has 2 queues
        0A           ; LLID 0 queue 0 is size 40 KB
        0A           ; LLID 0 queue 1 is size 40 KB
    01               ; LLID 1 has 1 queue
        05           ; LLID 1 queue 0 is size 20 KB
02                   ; 2 User Ports
    02               ; Port 0 has 2 queues
        05           ; Port 0 queue 0 is size 20 KB
        05           ; Port 0 queue 1 is size 20 KB
    01               ; Port 1 has 1 queue
        08           ; Port 1 queue 0 is size 32 KB

```

## Appendix III Life Cycle of a Unicast Logical Link (Informative)

The diagram below illustrates typical events in the OAM sequence for a unicast logical link. As a merely informative example, this diagram does not require a particular order of operation or set of messages. Any such requirements appear elsewhere in the DPoE specifications. Figure 25 is intended as an aid to overall comprehension only.

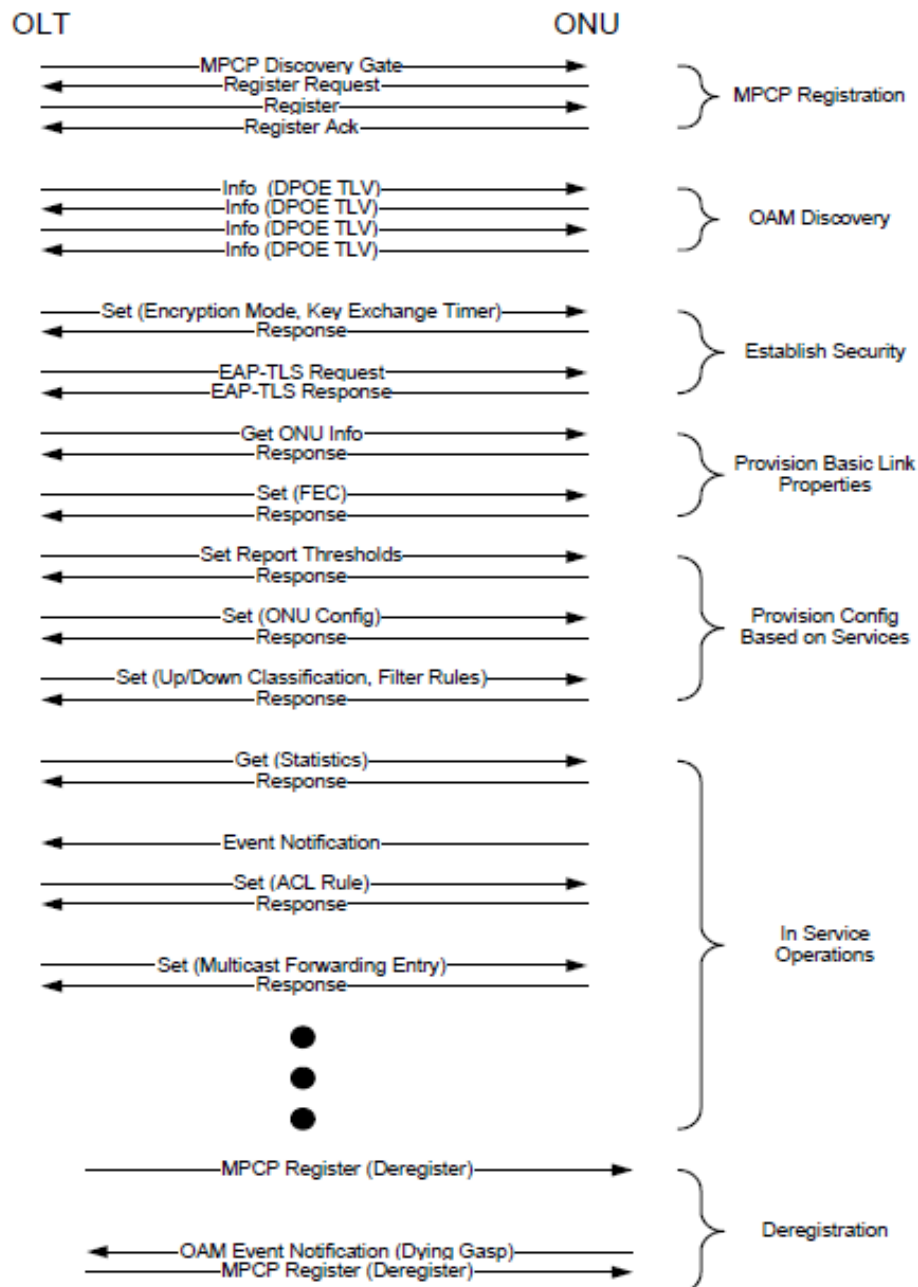


Figure 25 - Unicast Logical Link Life Cycle

### III.1 MPCP Registration

Initial detection of a logical link occurs by MPCP registration as specified in [802.3] Clause 64 and Clause 77. Range to the D-ONU and MAC address of the logical link are first available at this point.

### III.2 OAM Discovery

As per [802.3] Clause 57, OAM Discovery occurs immediately after registration. DPoE Networks all support OAM. Support for this extension is indicated by including a DPoE Info TLV in each Info PDU during discovery. As the active device, the DPoE System always transmits the first OAM PDU. The D-ONU begins transmitting its own Info PDUs once it receives a PDU from the DPoE System. (Note that the ONU PDU is not strictly a response to the DPoE System; these PDUs are sent based on a local timer, but that timer does not start until the first PDU arrives from the DPoE System.) The state machine in [802.3] Clause 57 requires two PDUs from each side to progress to the in-service state. It would be unusual for more than two PDUs to be required, as there is not a lot of negotiation to be carried out in this step.

### III.3 Establish Discovery

It is desirable to establish encryption and authenticate the newly-discovered D-ONU as soon as possible, and before user data traffic is allowed to pass the D-ONU. These processes are carried out as defined by the DPoE specifications. Other OAM should be postponed until encryption has been established and the D-ONU has been authenticated.

### III.4 Provision Basic Link Properties

The D-ONU Device ID and capabilities for the newly-discovered link would normally be queried early in the lifetime of a link. Any basic link properties necessary to operate the link might be provisioned first. For example, FEC for the link might be enabled.

### III.5 Provision Configuration Based on Services

Once the identity of the D-ONU has been established and the link has been configured, the DPoE System can consult its database and configure the D-ONU as required to support the services authorized for this user. Commands might be sent to the D-ONU to establish its basic configuration (number of logical links, queues, and classification scheme); MPCP report thresholds would be established as appropriate for the SLA for the logical link; filter rules for the link might be established.

The first link registered from a physical D-ONU is likely to see more activity than others, as the DPoE System would provision configuration global to the entire D-ONU on this link, but not repeat that provisioning for later links.

### III.6 In Service Operations

Periodic activity can be expected on a logical link once it is in service and basic provisioning has been established. For example, statistics might be regularly polled on the D-ONU by periodically sending a Get PDU requesting statistics attributes of various objects of interest. Some alteration in the provisioning of the D-ONU may occur based on events that occur after the D-ONU has registered. For example, DHCP snooping might learn an IP address assigned to a user device; in response, the DPoE System provisions an anti-spoofing ACL rule on the D-ONU to match that particular MAC/IP combination. Systems with remote-controlled multicast forwarding (as opposed to local D-ONU forwarding based on IGMP or MLD snooping) might send commands to add and remove multicast forwarding entries to the D-ONU as required. The D-ONU might autonomously report events to the DPoE System, particularly indications of faults.

### III.7 Link Deregistration

The logical link will typically disappear when it is deregistered by management command, for example when a user unsubscribed from a service and that logical link is no longer needed, or if the D-ONU is powered off.

## Appendix IV Example Rules (Informative)

This section shows some example rule sets to accomplish particular actions on a frame.

### IV.1 Field Masking Example

Some field codes have sub-fields that are of interest. For example, an S-Tag has TPID, PCP, DEI, and VID fields. Rather than assign every sub-field a unique code for identification, the OAM message allows a number of bits on both the most significant ("left") side of the field and the least significant ("right") side to be ignored for purposes of comparison. The requirements for sub-field identification in an OAM message are described in Section 9.5.1.3. For the sake of notation in the following example and figures, a sub-field identifier will be written with the format {Field Code, Instance, MSB, LSB}.

As an example, to specify the TPID sub-field of an S-Tag in a PB frame, the sub-field identifier is {0x07,0,0,16}:

0x07 (identifies an S-VLAN field, per Table 91)

0 refers to the instance of the S-Tag in the frame

0 refers to the MSB mask (ignore no bits on the left side)

16 refers to and the LSB mask (ignore all bits of the VID, DEI, and PCP fields).

Similarly, to select just the PCP field of an S-Tag in a PB frame, the sub-field identifier is {0x07,0,16,13}:

0x07 (identifies an S-VLAN field, per Table 91)

0 refers to the instance of the S-Tag in the frame

16 refers to the MSB mask (ignore the 16 MSB -- the TPID)

13 refers to the LSB mask (ignore the VID and DEI).

The following figures depict the sub-field identifiers for OAM messages using the format described above.

Figure 26 depicts the sub-field identifiers used for an untagged Ethernet frame.

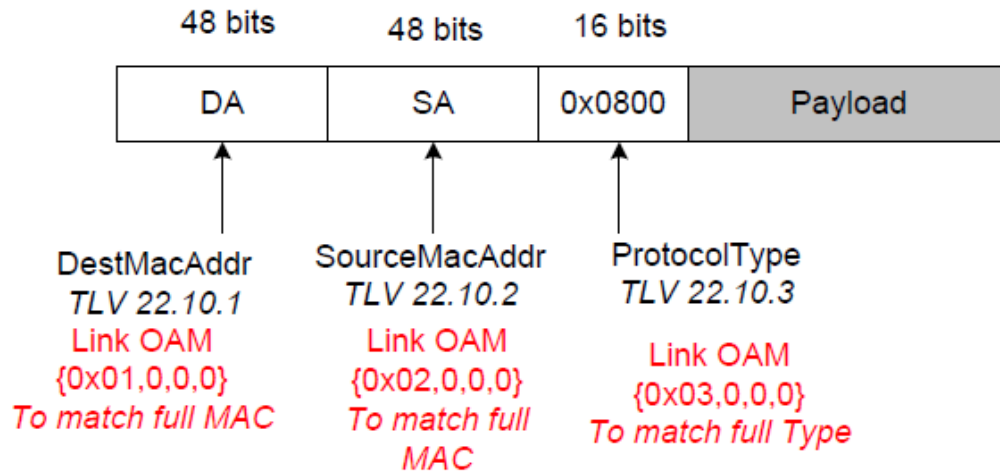
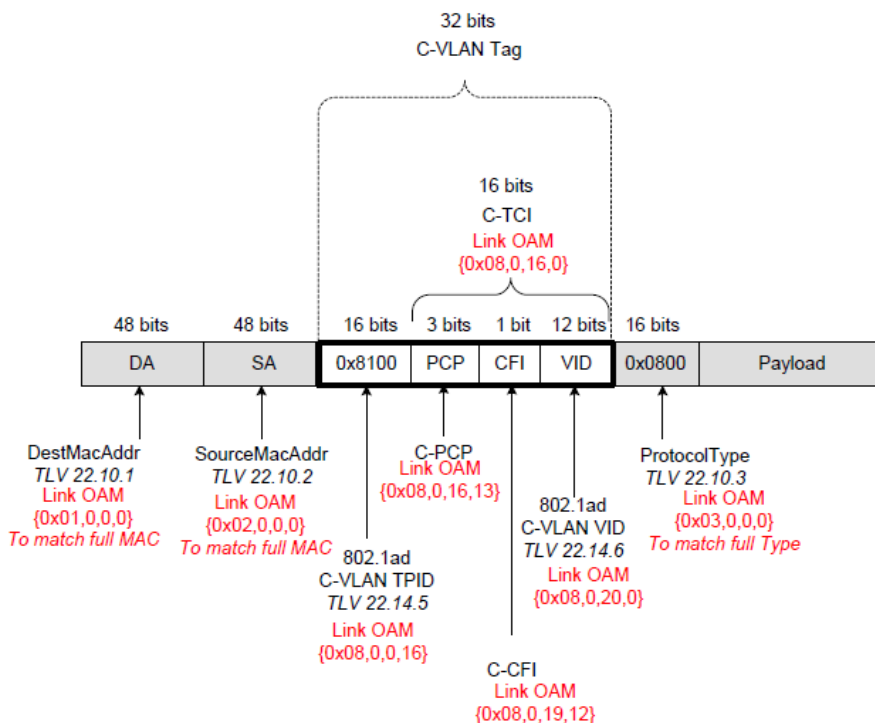


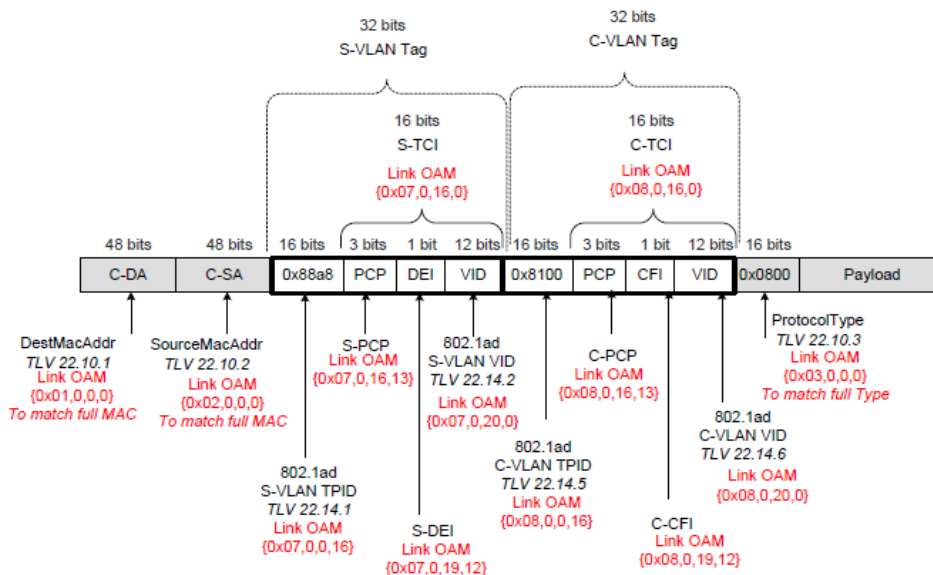
Figure 26 - Field Masking Example for Untagged Frame

Figure 27 depicts the sub-field identifiers used for an 802.1Q C-tagged frame. Note that the DA, SA and Protocol Type fields are able to be identified within the 802.1Q C-tagged frame, in addition to the fields in the tag.



**Figure 27 - Field Masking Example for 802.1Q C-tagged Frame**

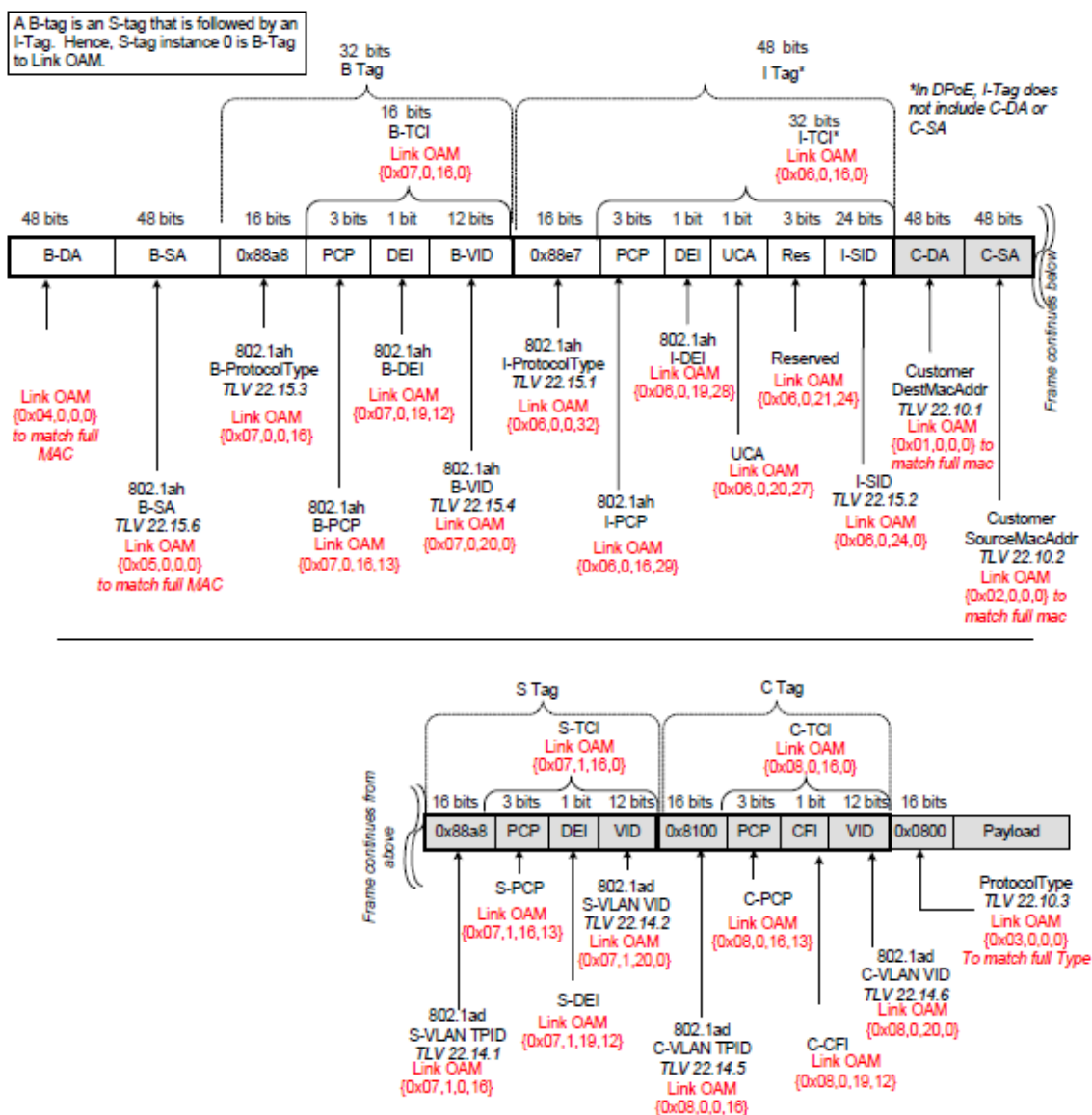
Figure 28 depicts the sub-field identifiers used for an 802.1ad tagged frame. Note that the original customer DA, SA and Protocol Type fields are able to be identified within the 802.1ad tagged frame, in addition to the S-Tag and C-Tag fields.



**Figure 28 - Field Masking Example for 802.1ad Tagged Frame**

Figure 29 depicts an 802.1ah encapsulated 802.1ad tagged frame. Note that the Customer DA, Customer SA and Protocol Type fields are able to be identified, in addition to the B-Tag, I-Tag, S-Tag and C-Tag fields. This example illustrates that to the D-ONU, a B-Tag is effectively an S-Tag, which is followed by an I-Tag, since both the B-Tag and S-Tag fields use 0x88a8 as the TPID. Therefore, to identify the B-Tag, the OAM message uses the sub-field identifier for the first instance of the S-Tag (i.e., 0). Likewise, to identify the S-Tag of the encapsulated 802.1ad frame the OAM message uses a sub-field identifier for the second instance of the S-Tag (i.e., 1).

As shown in Figure 29, the I-Tag field is considered to be 48 bits in length and does not include the Customer Destination MAC address or Customer Source MAC address. This deviates from IEEE 802.1ah, and applies to all DPoE requirements.



**Figure 29 - Field Masking Example for 802.1ah Encapsulated 802.1ad Tagged Frame**

## IV.2 TPID Translation

Some legacy equipment uses pre-standard TPID values to indicate S-VLAN tags. For example, two tags in a frame might have TPIDs 0x9100 and 0x8100, rather than 0x88A8 and 0x8100. It can be desirable to normalize the TPID values so that core equipment only need be concerned with standard VLAN tag values.

Translating a value is a matter of matching frames to which we want to apply this translation, and then rewriting the appropriate value in the frame. Let's assume that the D-ONU has been instructed to treat TPID 0x9100 as a C-VLAN tag. The TPID of a VLAN tag can be found in the most significant 16 bits of the tag.

For these frames, we want to overwrite the VLAN tag with another VLAN tag with identical VID, but with a different TPID. One way to do this is to copy the input field to the output, and then overwrite the TPID.

Condition: ( $\{C\text{-}VLAN\ 0, 0, 16\} == 0x9100$ )

Result: Copy C-VLAN 0; Set (C-VLAN 0, 0, 16) 0x88A8; Replace C-VLAN 0;

## Appendix V Acknowledgements

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

**Contributor**

John Dickinson, Edwin Mallette

Drew Davis, Paul Gray, Victor Hou

Lane Johnson, Curtis Knittle, Glenn Russell, Vikas Sarawat, Karthik Sundaresan

Jimmy Hu

Tim Brophy

Shamim Akhtar, Mehmet Toy

Mike Holmes, Wen Li

Hesham ElBakourey

Victor Blake

Janet Bean

Dylan Ko

Christopher Griffith, Michael Peters

Robert Harris, Armin Sepehri

Marek Hajduczenia

**Company Affiliation**

Bright House Networks

Broadcom

CableLabs

Ciena

Cisco

Comcast

Finisar Corporation

Hitachi

Independent Consultant

Motorola

Qualcomm-Atheros

Sumitomo

Time Warner Cable

ZTE

## Appendix VI Revision History

### VI.1 Engineering Changes for DPoE-SP-OAMv2.0-I02-130328

| ECN                 | Date       | Summary                                                                  | Author            |
|---------------------|------------|--------------------------------------------------------------------------|-------------------|
| OAMv2.0-N-12.0048-1 | 10/08/2012 | eOAMv2.0 for HW_REV, VENDOR, and MODEL                                   | Curtis Knittle    |
| OAMv2.0-N-12.0050-1 | 10/18/2012 | Fixes to incorrect definition of attributes and TLV formats in OAMv2 I01 | Marek Hajduczenia |
| OAMv2.0-N-12.0052-1 | 10/31/2012 | Removal of optional requirement for 10G-EPON FEC                         | Marek Hajduczenia |
| OAMv2.0-N-12.0056-1 | 12/6/2012  | Changes to OAM resulting from comments submitted by IEEE P1904.1         | Marek Hajduczenia |
| OAMv2.0-N-12.0059-2 | 12/07/2012 | Suspend/Resume Alarm changes (align with SIEPON)                         | Marek Hajduczenia |
| OAMv2.0-N-13.0062-1 | 12/15/2012 | Changes to MPLS definition in DPoE OAM specs                             | Marek Hajduczenia |
| OAMv2.0-N-13.0066-2 | 1/24/2013  | Delay and Drop Counters Simplification for OAMv2.0                       | Curtis Knittle    |

### VI.2 Engineering Changes for DPoE-SP-OAMv2.0-I03-130808

| ECN                 | Date      | Summary                                                              | Author            |
|---------------------|-----------|----------------------------------------------------------------------|-------------------|
| OAMv2.0-N-13.0074-1 | 4/11/2013 | Fixes to object context designation for some of clock transport TLVs | Marek Hajduczenia |
| OAMv2.0-N-13.0077-1 | 5/09/2013 | Restore dropped eOAM Requirements                                    | Steve Burroughs   |

### VI.3 Engineering Change for DPoE-SP-OAMv2.0-I04-131114

| ECN                 | Date      | Summary                                  | Author        |
|---------------------|-----------|------------------------------------------|---------------|
| OAMv2.0-N-13.0102-1 | 9/05/2013 | Encryption Key Expiry Time Value for 2.0 | Brionna Lopez |

### VI.4 Engineering Change for DPoE-SP-OAMv2.0-I05-140327

| ECN                 | Date      | Summary                                            | Author            |
|---------------------|-----------|----------------------------------------------------|-------------------|
| OAMv2.0-O-14.0122-1 | 2/27/2014 | UNI management parameters in CM configuration file | Marek Hajduczenia |

### VI.5 Engineering Changes for DPoE-SP-OAMv2.0-I06-140807

| ECN                 | Date      | Summary                                           | Author            |
|---------------------|-----------|---------------------------------------------------|-------------------|
| OAMv2.0-N-14.0143-1 | 4/11/2014 | IP(HSD) changes for DPoE2.0 OAM                   | Steve Burroughs   |
| OAMv2.0-N-14.0154-1 | 5/22/2014 | Updated Multicast Registration flags DPoE OAM v20 | Curtis Knittle    |
| OAMv2.0-N-14.0173-1 | 7/3/2014  | Alignment and cleanup of 802.3 references         | Marek Hajduczenia |
| OAMv2.0-N-14.0188-1 | 7/10/2014 | DPoEv2 OAM edits to Support 2G-EPON               | Lane Johnson      |
| OAMv2.0-N-14.0192-1 | 7/10/2014 | Multicast Logical Link Object Plus Others         | Glen Kramer       |

### VI.6 Engineering Changes for DPoE-SP-OAMv2.0-I07-150319

| ECN                  | Date       | Summary                                                   | Author            |
|----------------------|------------|-----------------------------------------------------------|-------------------|
| OAMv2.0-N-14.0199-1  | 10/30/2014 | Support for Power Saving mechanism                        | Marek Hajduczenia |
| OAMv2.0-N-14.0200-1  | 11/20/2014 | DPoG TLV Reservations, terminology alignment              | Curtis Knittle    |
| *OAMv2.0-N-14.0192-1 | 7/10/2014  | Corrected missing changes from previous ECN incorporation | Glen Kramer       |

**VI.7 Engineering Changes for DPoE-SP-OAMv2.0-I08-151210**

| ECN                 | Date      | Summary                          | Author          |
|---------------------|-----------|----------------------------------|-----------------|
| OAMv2.0-N-15.0218-1 | 11/5/2015 | Laser Power Off units corrected  | Curtis Knittle  |
| OAMv2.0-N-15.0221-2 | 11/5/2015 | Multicast OAM Alignment P1904.1A | Steve Burroughs |

**VI.8 Engineering Changes for DPoE-SP-OAMv2.0-I09-160602**

| ECN                 | Date       | Summary                                                    | Author            |
|---------------------|------------|------------------------------------------------------------|-------------------|
| OAMv2.0-N-15.0224-1 | 12/10/2015 | Support for Tree / Trunk optical line protection mechanism | Marek Hajduczenia |
| OAMv2.0-N-15.0229-1 | 12/31/2015 | Remove DEMARC Specification References and Attributes      | Steve Burroughs   |
| OAMv2.0-N-15.0239-1 | 3/31/2016  | DPoE 2.0-OAM - Retire SOAM Specification                   | Steve Burroughs   |

**VI.9 Engineering Change for DPoE-SP-OAMv2.0-I10-170111**

| ECN                 | Date       | Summary                                                          | Author          |
|---------------------|------------|------------------------------------------------------------------|-----------------|
| OAMv2.0-N-16.0247-3 | 10/20/2016 | Add Software Bundle Object and clarify Manufacturer Info Version | Steve Burroughs |

**VI.10 Engineering Change for DPoE-SP-OAMv2.0-I11-170510**

| ECN                 | Date      | Summary                         | Author          |
|---------------------|-----------|---------------------------------|-----------------|
| OAMv2.0-N-17.0248-3 | 4/13/2017 | Add eSAFE Configuration Objects | Steve Burroughs |

**VI.11 Engineering Changes for DPoE-SP-OAMv2.0-I12-171004**

| ECN                 | Date      | Summary                                                                             | Author          |
|---------------------|-----------|-------------------------------------------------------------------------------------|-----------------|
| OAMv2.0-N-17.0254-1 | 7/13/2017 | Change default Maximum OAM Rate (0xD7/0x000D) to 'unlimited' to match DPoE-IPNEv2.0 | Janet Bean      |
| OAMv2.0-N-17.0255-2 | 8/10/2017 | Partial Alignment with SIEPON 1904.1                                                | Steve Burroughs |
| OAMv2.0-N-17.0256-2 | 8/10/2017 | Modify 0xD7/0006 (SN and Manufacturer Info) Format                                  | Steve Burroughs |

**VI.12 Engineering Changes for DPoE-SP-OAMv2.0-I13-180228**

| ECN                 | Date       | Summary                                                                               | Author            |
|---------------------|------------|---------------------------------------------------------------------------------------|-------------------|
| OAMv2.0-N-17.0257-2 | 2/15/2018  | Update OAM Version and Misc Updates                                                   | Steve Burroughs   |
| OAMv2.0-N-17.0258-1 | 12/21/2017 | Support for new ONU UNI / internal interface types                                    | Marek Hajduczenia |
| OAMv2.0-N-18.0263-1 | 2/8/2018   | Support for new ONU UNI / internal interface types (duplicate of OAMv2.0-N-17.0258-1) | Howard Abramson   |
| OAMv2.0-N-18.0264-1 | 2/8/2018   | S/S1/S2 interface alignment and simplification                                        | Marek Hajduczenia |

**VI.13 Engineering Change for DPoE-SP-OAMv2.0-I14-190213**

| ECN                 | Date       | Summary                                  | Author          |
|---------------------|------------|------------------------------------------|-----------------|
| OAMv2.0-N-18.0269-1 | 11/21/2018 | Add DPoE OAM Embedded Test Agent Support | Steve Burroughs |

**VI.14 Engineering Changes for DPoE-SP-OAMv2.0-I15-230322**

| ECN                 | Date    | Summary                                                      | Author          |
|---------------------|---------|--------------------------------------------------------------|-----------------|
| OAMv2.0-N-19.0271-1 | 9/26/19 | ONU UNI MAC SEC Control                                      | Jason Combs     |
| OAMv2.0-N-29.0272-1 | 9/26/19 | Add 2.5 & 5 Gbps User Port Data Rates                        | Steve Burroughs |
| OAMv2.0-N-23.0282-1 | 3/2/23  | Remove reference to 802.1d and replace with 802.1Q as needed | Steve Burroughs |

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