MEF Standard

MEF 140

Broadband Access E-Line and Broadband Access E-LAN Service Definitions

June 2025

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Table of Contents

List of Figures

List of Tables

1 List of Contributing Members

The following members of the MEF participated in the development of this document and have requested to be included in this list.

- AT&T
- Bell Canada
- Iometrix
- Proximus
- Rivada Space Networks

2 Abstract

Broadband Access Networks are being used to provide Internet Access and multimedia services to Subscribers. In this document Broadband Access Networks include DOCSIS®[1], e.g., [3] and [4],[2] Passive Optical Networks (PON), e.g., [19], [20], and [21], and satellite networks[3], e.g., [1] and [7]. Service Providers have begun purchasing Carrier Ethernet and Carrier Ethernet-like Services over these networks and are using them to provide OSI Layer 2 [17] access to their Subscribers' locations.

Due to the technologies used and the architectural choices made, some of these Broadband Access Networks do not fully comply with the requirements for Operator Ethernet Services specified in MEF 51.1 [30] and MEF 26.2 [27]. This document defines two new Operator Ethernet Services, Broadband Access E-Line and Broadband Access E-LAN, to address these use cases. These new Services are modeled on the Access E-Line and Access E-LAN Services defined in MEF 51.1 which are based on the Service Attributes defined in MEF 26.2. To accommodate the use of Broadband Networks for delivering Ethernet Services, this document allows additional Service Attribute values beyond those in MEF 51.1 and MEF 26.2. This document also explains the rationale for each deviation from MEF 51.1 and MEF 26.2.

[1] DOCSIS® is a registered trademark of Cable Television Laboratories, Inc.
[2] The documents referenced here for the Broadband Access Network technologies are not intended to be an exhaustive or limiting set, but rather examples of document that underlie the technologies.
[3] The Services defined in this document may be applicable to other networks such as 4G/5G, but requirements for only the listed Broadband Access Networks are considered.

3 Terminology and Abbreviations

This section defines the terms used in this document. In many cases, the normative definitions to terms are found in other documents. In these cases, the third column is used to provide the controlling reference in other MEF or external documents.

In addition, terms defined in MEF 26.2 [27] and MEF 51.1 [30] are included in this document by reference and are not repeated in the table below.

Term	Definition	Reference
Broadband Access Network	A network that transports data using one of the following access technologies: DOCSIS, PON, or satellite.	This document
Broadband Access Network Operator	The administrative entity that provides a Broadband Access Network.	This document
Broadcast Frame	An Ethernet Frame in which the destination MAC address is ff:ff:ff:ff:ff:ff (hexadecimal)	This document
Ethernet Interface	One or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1 [32].	This document
External Network Network Interface	The interfaces across which two Network Operators connect	Adapted from MEF 4 [22]
Multicast Frame	An Ethernet Frame in which the least significant bit of the first byte of the destination MAC address is 1.	This document
Priority Tagged Service Frame	A Service Frame in which the two bytes following the Source Address have the value 0x8100 and the corresponding C-Tag VLAN ID field has the value 0x000.	Adapted from MEF 10.4 [26]
Service	A connectivity service defined in this document (MEF 140), MEF 6.3 [24], or MEF 51.1 [30].	This document
Service Frame	An IEEE Std 802.3™ Ethernet Frame exchanged between a Service Provider and a Subscriber across a UNI.	Adapted from MEF 10.4
Unicast Frame	An Ethernet Frame in which the least significant bit of the first byte of the destination MAC address is 0.	This document
Untagged Service Frame	A Service Frame in which the two bytes following the Source Address do not have the value 0x8100 nor the value 0x88a8.	Adapted from MEF 10.4
VLAN Tagged Service Frame	A Service Frame in which the two bytes following the Source Address have the value 0x8100 and the corresponding C-Tag VLAN ID has a value that is not 0x000.	Adapted from MEF 10.4

Table 1 – Terminology

Abbreviation	Definition	Reference
DOCSIS	Data over Cable Service Interface Specification	CableLabs® documents [3][4]
EI	External Interface	MEF 26.2
ENNI	External Network Network Interface	MEF 26.2
EVC	Ethernet Virtual Connection	MEF 10.4
OVC	Operator Virtual Connection	MEF 26.2
PON	Passive Optical Network	ITU-T documents [19][20][21]
UNI	User Network Interface	MEF 10.4
IEEE Std 802.3™	A generic reference to the IEEE Ethernet standard used when referring to attributes of Ethernet that do not vary across versions from IEEE Std 802.3™-2012 [9] through IEEE Std 802.3™-2018 [11].	This document

Table 2 – Abbreviations

4 Compliance Levels

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**NOT RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 (RFC 2119 [12], RFC 8174 [16]) when, and only when, they appear in all capitals, as shown here. All key words must be in bold text.

Items that are **REQUIRED** (contain the words **MUST** or **MUST NOT**) are labeled as **[Rx]** for required. Items that are **RECOMMENDED** (contain the words **SHOULD** or **SHOULD NOT**) are labeled as **[Dx]** for desirable. Items that are **OPTIONAL** (contain the words **MAY** or **OPTIONAL**) are labeled as **[Ox]** for optional**.**

5 Document Conventions

5.1 Numerical Prefix Conventions

This document uses the prefix notation to indicate multiplier values as shown in Table 3.

Decimal		Binary	
Symbol	Value	Symbol	Value
k	10^3	Ki	2^{10}
M	10^6	Mi	2^{20}
G	10^9	Gi	2^{30}
T	10^{12}	Ti	2^{40}
P	10^{15}	Pi	2^{50}
E	10^{18}	Ei	2^{60}
Z	10^{21}	Zi	2^{70}
Y	10^{24}	Yi	2^{80}

Table 3 – Numerical Prefix Conventions

5.2 Diagram Conventions

The diagrams in this document have several components that appear frequently. These components are represented in a standard way as described in Figure 1:

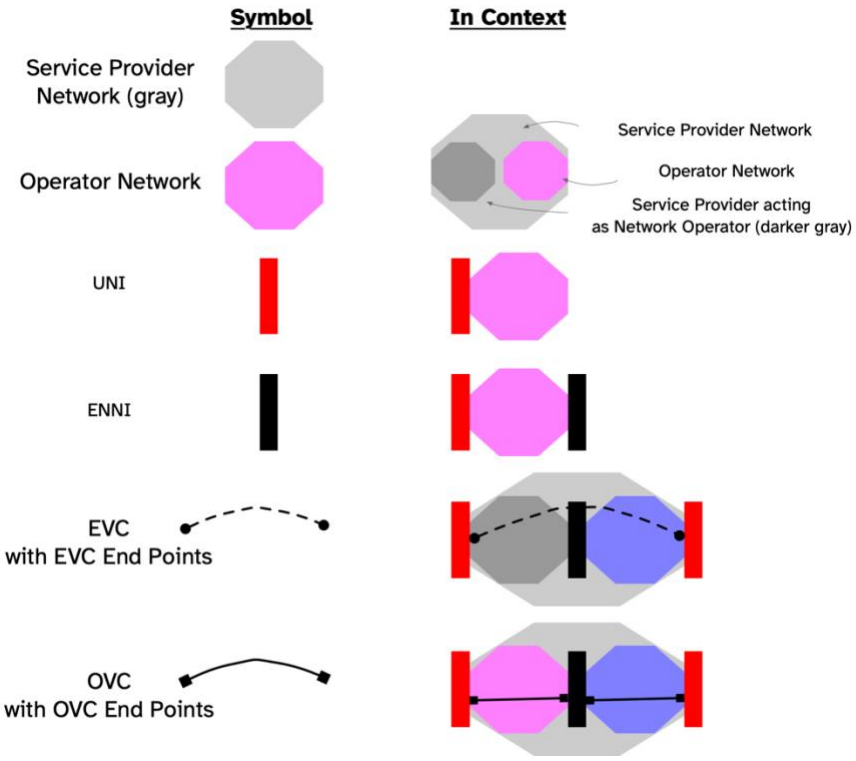

Figure 1 – Diagram Conventions

Gray octagons represent the (Ethernet) Service Provider Network. Non-gray octagons represent Operator Networks. The color of the octagons are relevant only insofar as different color octagons in the same diagram represent different Network Operators. A darker gray octagon within a larger gray octagon represents the case where the Service Provider is acting as a Network Operator.

UNIs are represented by red rectangles and appear along one of the edges of a Service Provider or Operator Network octagon. ENNIs are represented by black rectangles and appear between two Network Operator octagons. EVCs are represented by dashed lines with circles at the ends representing EVC End Points. They appear between two or more UNIs. OVCs are represented by solid lines with squares on the ends representing OVC End Points. The color of the EVCs and OVCs are not relevant and are used to distinguish between multiple instances in the same diagram.

5.3 Identifiers

Several Service Attributes use the term "Identifier" (e.g., Envelope Identifier in section 9.3). These Identifiers are strings that meet the following requirement:

[R1] An Identifier **MUST** be a string consisting of 1 to 45 UTF-8 characters in the range of 32–126 (0x20 to 0x7e), inclusive.

6 Introduction

This document describes how a Broadband Access Network, defined as a network that transports data using one of the following access technologies — DOCSIS, PON, or satellite — can be used to deliver Carrier Ethernet Services. One differentiating characteristic of these Broadband Access Networks is that they can share management and resources of the access connection between a variety of traffic types and multiple Subscribers. This is different than traditional Carrier Ethernet Services which are usually based on dedicated access connections. As a result, these networks may not fully comply with the requirements for MEF Carrier Ethernet Services. This document defines two new Operator Ethernet Services, Broadband Access E-Line and Broadband Access E-LAN which adapt Access E-Line and Access E-LAN Services defined in MEF 51.1 to the characteristics of Broadband Access Networks.

This section introduces important concepts related to Carrier Ethernet Services. It then describes some of the properties of a Broadband Access Network that justify the definition of two new Operator Ethernet Services: Broadband Access E-Line and Broadband Access E-LAN.

6.1 Carrier Ethernet Service Model

The Subscriber Ethernet Services defined in MEF 6.3 [24] are used to provide OSI Layer 2 connectivity between Subscriber locations across a Service Provider network. Subscribers purchase Ethernet Virtual Connections (EVCs) to connect two or more locations.

MEF 10.4 [26] defines Service Attributes whose values are agreed to between the Service Provider and the Subscriber that describe the behavior of EVCs, Subscriber User Network Interfaces (UNIs), and EVC End Points, as observed by the Subscriber.

MEF 6.3 defines six Subscriber Ethernet Services by specifying constraints on the values of various MEF 10.4 [26] Service Attributes. MEF 6.3 defines point-to-point “Line” Services, multipoint-to-multipoint “LAN” Services, and rooted-multipoint “Tree” Services. For each of these there are two variations, “Private” Services and “Virtual Private” Services. See section 7 in MEF 6.3 for a description of how these Services are differentiated.

Although the Service Provider is responsible for providing UNI-to-UNI connectivity for the Subscriber, it is frequently not possible for the Service Provider to provide the connectivity entirely on its own network. For example, the Subscriber can have UNIs at locations that are not located in the service area of the Service Provider. MEF 26.2 [27] addresses this issue by defining Operator Ethernet Services provided by Network Operators to the Ethernet Service Provider based on Operator Virtual Connections (OVCs). In this case, EVCs are composed by concatenating OVCs.

An Ethernet Service Provider can purchase an OVC from a Network Operator that connects one or more UNIs to one or more External Network Network Interfaces (ENNIs), which are the interfaces across which two Network Operators connect. OVCs are not required to include UNIs; they can connect just ENNIs together. If an OVC contains at least one UNI, it is called an Access OVC, and if it contains only ENNIs, it is called a Transit OVC.

OVCs, like EVCs, have a MEF Standard, MEF 26.2, that defines Service Attributes for the OVCs, Operator UNIs, ENNIs, and OVC End Points. And, as with EVCs, there is a MEF Standard, MEF

51.1 [30], that defines Operator Services such as Access E-Line, Access E-LAN, Transit E-Line, and Transit E-LAN.

In this document, the term Service (when capitalized) refers to a connectivity service defined in one of the following MEF Standards:

- MEF 6.3 [24] – Subscriber Ethernet Services Definitions
- MEF 51.1 [30] – Operator Ethernet Services Definitions
- MEF 140 (this document) – Broadband Access E-Line and Broadband Access E-LAN Service Definitions

An EVC that is not implemented entirely within the Service Provider's Network is implemented as the concatenation of two or more OVCs. Figure 2 shows examples of EVCs with and without concatenation of OVCs.

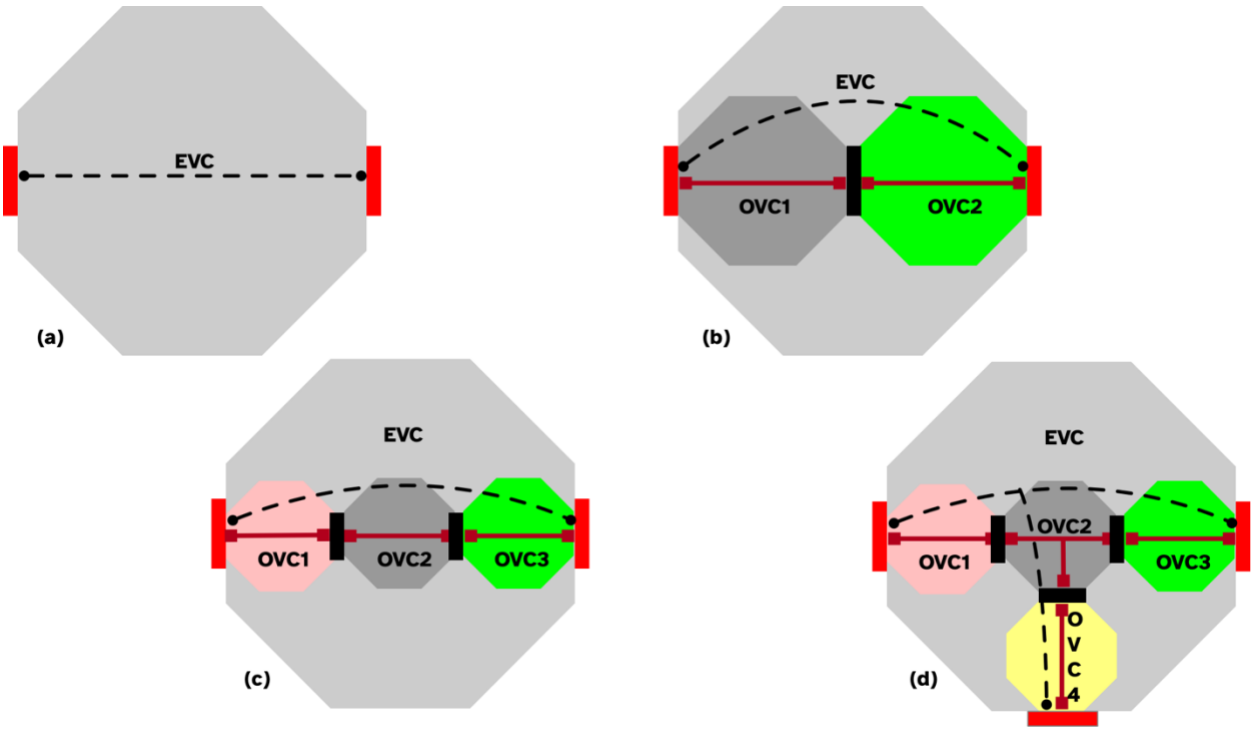

Figure 2 – Examples of OVCs and EVCs

In the diagram, in cases (a), (b), and (c), Ethernet Service Provider Gray is delivering an Ethernet Private Line or Ethernet Virtual Private Line to the Subscriber. In case (d) it is delivering an Ethernet Private LAN or Ethernet Virtual Private LAN with three UNIs.

In case (a), the EVC is delivered entirely by Service Provider Gray on its own network since both UNIs are accessible to it.

In case (b), the right-hand UNI is not accessible on Gray's network, so Gray purchases OVC2 from Network Operator Green in order to reach the right-hand UNI. OVC2 is an access OVC, and it is a point-to-point OVC, so it is an Access E-Line Service. OVC1 is also an Access E-Line.

Case (c) is a bit more complex. Service Provider Gray does not have access to either UNI. It purchases an Access E-Line from Operator Pink (OVC1) and another one from Operator Green (OVC3) and provides a transit OVC (Transit E-Line) between them (OVC2).

In case (d), Service Provider Gray (again) does not have access to any of the UNIs, so it purchases three Access E-Line Services, OVC1 from Pink, OVC3 from Green, and OVC4 from Yellow, and ties them together with OVC2, a Transit E-LAN Service.

6.2 Using Broadband Access Networks to deliver OVCs

The OVCs shown in Figure 2 would normally be delivered over a network infrastructure that can implement an "Ethernet-like" transport, i.e., one that can transport:

- Unicast Frames — Ethernet Frames in which the least significant bit of the first byte of the destination MAC address is 0
- Multicast Frames — Ethernet Frames in which the least significant bit of the first byte of the destination MAC address is 1
- Broadcast Frames — Ethernet Frames in which the destination MAC address is (hexadecimal) ff:ff:ff:ff:ff:ff

The behavior of these Services is consistent with the Provider Bridging model (defined in IEEE 802.1Q™-2018 [8]) that employs MAC-address learning, VLAN tagging, and flooding. The implementation could be on a Provider Bridged infrastructure, but it could, for example, be based on other network architectures that can emulate Provider Bridging such as VPLS [13][14] or VXLAN [15].

Broadband access technologies such as DOCSIS [3] and [4], Passive Optical Networks (PON) [19], [20], and [21]), and satellite [1] and [7] (see footnote 2 in section 2) are used to deliver multimedia services and Internet Access Services to Subscriber premises. But Service Providers have begun delivering Layer 2 services similar to Carrier Ethernet over these access networks[4]. In these situations, the Broadband Access Network Operator, defined as the administrative entity that provides a Broadband Access Network, sells an OVC to the Ethernet Service Provider.

Note: In MEF 26.2 [27], a Network Operator can also sell an OVC to a Super Operator — a Network Operator that uses other Network Operators to provide connectivity to one more OVC End Points of its OVC. MEF 26.2 uses the term SP/SO when referring to a role that can be either a Service Provider or Super Operator. The Services defined in this document can also be sold to a Super Operator; however, for clarity and simplicity, this document uses the term Service Provider throughout.

The Ethernet Service Provider composes the end-to-end Subscriber Service (EVC) using these OVCs concatenated with additional OVCs. Examples of this composition are shown in Figure 3.

[4] The method used for transporting/encapsulating Ethernet Frames within the Broadband Access Network varies based on the technology of the Broadband network and is beyond the scope of this document.

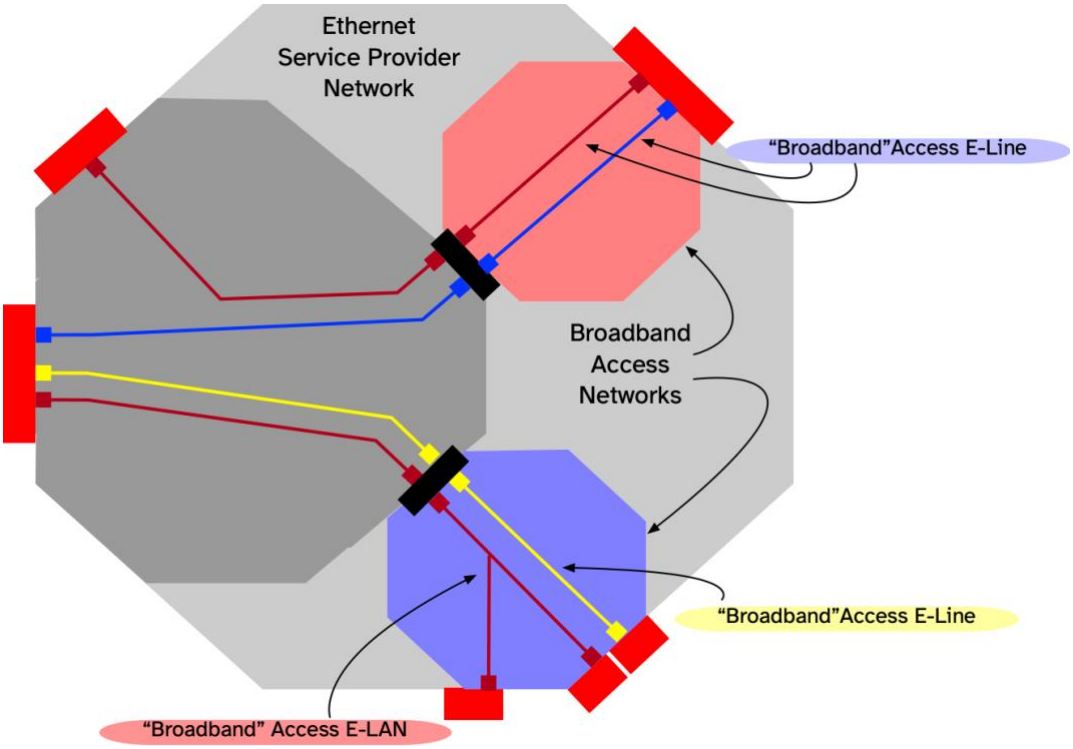

Figure 3 – Examples of Subscriber UNIs on Broadband Access Networks

Due to the unique aspects of Broadband Access Network architectures, the behavior of OVCs that traverse a Broadband Access Network can differ from the Services defined in MEF 51.1 [30]. Consequently, the allowed values for several of the Service Attributes that describe the relevant Services defined in MEF 51.1 need to be changed, and behaviors mandated for some Service Attribute values need to deviate substantially from the definitions in MEF 26.2. In addition, a new Service Attribute is introduced (see section 8.1.6). The differences are sufficient to warrant the definition of two new Operator Ethernet Services: Broadband Access E-Line and Broadband Access E-LAN.

Implications of these differences that can potentially have an impact on the definition of Broadband Access E-Line and Broadband Access E-LAN Services include:

- These networks might use Bandwidth Profiles that do not conform with the requirements specified in MEF 26.2.
- In many cases, these networks interpret Layer 2 Control Protocol (L2CP) frames and Service OAM (SOAM) frames in a way that conflict with normal operation of Services defined in MEF 51.1.
- The MAC Bridging behavior in these networks, specifically related to MAC learning and flooding of unicast frames, might be different than as specified in IEEE Std 802.1Q™-2018 [8]. For example, in some cases the Ethernet Service cannot become operational until an Ethernet Frame is received from the Subscriber at the UNI in the Broadband Access Network.
- These networks might manipulate the C-Tag in ways that are inconsistent with Services defined in MEF 51.1.

- These networks might discard certain types of Ethernet Frames such as Priority Tagged Service Frames, i.e., Service Frames, IEEE 802.3™ Ethernet Frames[5] exchanged between a Service Provider and a Subscriber across a UNI, with the two bytes following the Source Address having the value 0x8100 and the corresponding C-Tag VLAN ID field having the value 0x000.
- These networks might impose additional constraints on Multicast or Broadcast Frame delivery.

In order to optimize for services such as multimedia distribution, these networks might be configured to deliver more bandwidth towards each UNI (often called the "downstream" direction) than they will accept from each UNI (often called the "upstream" direction). This could affect the Bandwidth Profiles that are defined for Services on Broadband Access Networks.

Broadband Access Network Operators have dealt with the differences described above in different ways that are not necessarily compatible with MEF Service definitions. This document attempts to address these differences by specifying appropriate alternative values for several Service Attributes and modified behavior for some given values of a number of Service Attributes.

[5] In this document IEEE Std 802.3™ is used as a generic reference to the IEEE Ethernet standard used when referring to attributes of Ethernet that do not vary across versions from IEEE Std 802.3™-2012 [9] through IEEE Std 802.3™-2018 [11].

7 Service Attribute Comparisons to MEF 51.1 and MEF 26.2

As noted in section 6, the Operator Ethernet Services definitions in this document are based on the definitions for Access E-Line and Access E-LAN in MEF 51.1 [30]. The MEF 51.1 definitions are based on the Service Attributes in MEF 26.2 [27]. MEF 26.2 defines Service Attributes to describe Operator Ethernet Services.

Sections 7.1 through 7.5 of this document enumerate these Service Attributes. If the value or values specified in MEF26.2 and MEF 51.1 are applicable to Broadband Access E-Line or Broadband Access E-LAN Services, the entry contains "per MEF 51.1" (or in some cases "per MEF 26.2"). If that value is also easy to describe (e.g., a single integer or string), the value is also shown. If the value or values specified for Broadband Access E-Line or Broadband Access E-LAN Services deviate from the requirements in MEF 51.1 and MEF 26.2, the entry points to a section in this document that describes the deviation.

Broadband Access Networks, as defined in this document, do not support VUNI functionality including RUNI and Feeder OVC behaviors and are therefore beyond the scope of this document.

Although this document defines deviations from MEF 26.2 and MEF 51.1 for a few OVC End Point at an ENNI Service Attributes and for a few ENNI Service Attributes, the Services defined in this document can coexist at an ENNI with the Operator Services defined in MEF 51.1.

For the convenience of the reader, in the tables in the following subsections, if a Service Attribute does not conform with the values specified in MEF 51.1 and/or MEF 26.2 or if there are additional conditions or explanation associated with its value, the table cell with the Service Attribute name is shaded.

7.1 OVC Service Attributes

An OVC is an association of OVC End Points that are located at the External Interfaces (UNIs and ENNIs) and represents the logical connection between those End Points. The Service Attributes that describe the properties of an OVC are the OVC Service Attributes.

Table 4 lists the OVC Service Attributes and the allowed values for Broadband Access E-Line and Broadband Access E-LAN Services. The definitions of these Services are modeled on the definitions of Access E-Line and Access E-LAN in MEF 51.1 — for Access E-Line (MEF 51.1 tables 6, 9, and 12) and Access E-LAN (MEF 51.1 tables 6, 10, and 15).

[R2] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the OVC Service Attributes **MUST** meet the specifications in Table 4.

OVC Service Attributes	Broadband Access E-Line	Broadband Access E-LAN
OVC ID	per MEF 51.1	per MEF 51.1
OVC Type	*Point-to-Point* per MEF 51.1	*Multipoint-to-Multipoint* per MEF 51.1
OVC End Point List	*2 End Point Identifiers* per MEF 51.1	*2 or more End Point Identifiers* per MEF 51.1
Maximum Number of UNI OVC End Points	*1* per MEF 51.1	*≥1* per MEF 51.1
Maximum Number of ENNI OVC End Points	*1* per MEF 51.1	*≥1* per MEF 51.1
OVC Maximum Frame Size	*≥1526* bytes per MEF 51.1	*≥1526* bytes per MEF 51.1
OVC CE-VLAN ID Preservation	*Preserve*, *Strip* See section 8.1.1	*Preserve*, *Strip* See section 8.1.1
OVC CE-VLAN PCP Preservation	*Enabled* or *Disabled* per MEF 51.1	*Enabled* or *Disabled* per MEF 51.1
OVC CE-VLAN DEI Preservation	*Enabled* or *Disabled* per MEF 51.1	*Enabled* or *Disabled* per MEF 51.1
OVC S-VLAN PCP Preservation	*Not Applicable* per MEF 51.1	*Enabled* or *Disabled* per MEF 51.1
OVC S-VLAN DEI Preservation	*Not Applicable* per MEF 51.1	*Enabled* or *Disabled* per MEF 51.1
OVC List of Class of Service Names	At least one Class of Service Name other than *Discard* per MEF 51.1	At least one Class of Service Name other than *Discard* per MEF 51.1
OVC Service Level Specification	See section 8.1.2	See section 8.1.2
OVC Frame Delivery	See section 8.1.3	See section 8.1.3
OVC Available MEG Level	*None* or ≤ 6 See section 8.1.4	*None* or ≤ 6 See section 8.1.4
OVC L2CP Address Set	See section 8.1.5	See section 8.1.5
OVC Bandwidth Profile Algorithm Type	New Service Attribute See section 8.1.6	New Service Attribute See section 8.1.6

Table 4 – OVC Service Attributes and Allowed Values

7.2 OVC End Point at ENNI Service Attributes

Broadband Access E-Line and Broadband Access E-LAN Services do not support Hairpin Switching (see MEF 26.2 [27], section 12.3.1). Thus, the OVC for a Broadband Access E-Line Service or a Broadband Access E-LAN Service associates exactly one OVC End Point an ENNI. Table 5 compares the OVC End Point at an ENNI Service Attributes and allowed values for Broadband Access E-Line and Broadband Access E-LAN Services with the requirements in MEF 51.1 — for Access E-Line (MEF 51.1 tables 7 and 13) and Access E-LAN (MEF 51.1 tables 7 and 16) Services.

[R3] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the OVC End Point at an ENNI Service Attributes **MUST** meet the specifications in Table 5.

OVC EP at the ENNI Service Attributes	Broadband Access E-Line	Broadband Access E-LAN
OVC End Point Identifier	per MEF 51.1	per MEF 51.1
OVC End Point External Interface Type	*ENNI* per MEF 51.1	*ENNI* per MEF 51.1
OVC End Point External Interface Identifier	per MEF 51.1	per MEF 51.1
OVC End Point Role	*Root* per MEF 51.1	*Root* per MEF 51.1
OVC End Point Map	See section 8.2.3	See section 8.2.3
OVC End Point Class of Service Identifier	*F = S-Tag PCP* Per MEF 51.1	*F = S-Tag PCP* Per MEF 51.1
OVC End Point Color Identifier	⟨*F, M*⟩ per MEF 26.2 See section 8.2.1	⟨*F, M*⟩ per MEF 26.2 See section 8.2.1
OVC End Point Egress Map	per MEF 51.1	Per MEF 51.1
OVC End Point Egress Equivalence Class Identifier	per MEF 51.1	Per MEF 51.1
Ingress Bandwidth Profile per OVC End Point	*Disabled* per MEF 51.1	*Disabled* Per MEF 51.1
Egress Bandwidth Profile per OVC End Point	*Disabled* per MEF 51.1	*Disabled* Per MEF 51.1
Ingress Bandwidth Profile per Class of Service Name	See section 9	See section 9
Egress Bandwidth Profile per Egress Equivalence Class Name	See section 9	See section 9
OVC End Point Aggregation Link Depth	1 to number of ENNI physical interface Links per MEF 51.1	1 to number of ENNI physical interface Links per MEF 51.1
OVC End Point Source MAC Address Limit	*Disabled* or ⟨*N*, τ⟩ per MEF 51.1	*Disabled* or ⟨*N*, τ⟩ per MEF 51.1
OVC End Point MIP	See section 8.2.2	See section 8.2.2
OVC End Point MEP List	See section 8.2.2	See section 8.2.2

Table 5 – OVC End Point at an ENNI Service Attributes and Allowed Values

7.3 OVC End Point at UNI Service Attributes

This section is analogous to section 7.2, but lists the Service Attribute values for the OVC End Point at a UNI. Since Broadband Access E-Line and Broadband Access E-LAN are Access Services, they must have at least one UNI. Table 6 compares the OVC End Point at a UNI Service Attributes and allowed values for Broadband Access E-Line and Broadband Access E-LAN Services with the requirements in MEF 51.1 — for Access E-Line (MEF 51.1 tables 7 and 14) and Access E-LAN (MEF 51.1 tables 7 and 17).

[R4] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the OVC End Point at a UNI Service Attributes **MUST** meet the specifications in Table 6.

OVC EP at the UNI Service Attributes	Broadband Access E-Line	Broadband Access E-LAN
OVC End Point Identifier	per MEF 51.1	per MEF 51.1
OVC End Point External Interface Type	*UNI* per MEF 51.1	*UNI* per MEF 51.1
OVC End Point External Interface Identifier	per MEF 51.1	per MEF 51.1
OVC End Point Role	*Root* per MEF 51.1	*Root* per MEF 51.1
OVC End Point Map	See section 8.2.3	See section 8.2.3
OVC End Point Class of Service Identifier	*OVC EP*, *C-Tag PCP*, or *DSCP* per MEF 51.1	*OVC EP*, *C-Tag PCP*, or *DSCP* Per MEF 51.1
OVC End Point Color Identifier	⟨*F, M*⟩ per MEF 26.2 See section 8.2.1	⟨*F, M*⟩ per MEF 26.2 See section 8.2.1
OVC End Point Egress Map	per MEF 51.1	Per MEF 51.1
OVC End Point Egress Equivalence Class Identifier	per MEF 51.1	Per MEF 51.1
Ingress Bandwidth Profile per OVC End Point	*Disabled* per MEF 51.1	*Disabled* Per MEF 51.1
Egress Bandwidth Profile per OVC End Point	*Disabled* Per MEF 51.1	*Disabled* Per MEF 51.1
Ingress Bandwidth Profile per Class of Service Name	See section 9	See section 9
Egress Bandwidth Profile per Egress Equivalence Class Name	See section 9	See section 9
OVC End Point Aggregation Link Depth	*Not Applicable* per MEF 51.1	*Not Applicable* per MEF 51.1
OVC End Point Source MAC Address Limit	*Disabled* or ⟨*N*, τ⟩ per MEF 51.1	*Disabled* or ⟨*N*, τ⟩ per MEF 51.1
OVC End Point MIP	See section 8.2.2	See section 8.2.2
OVC End Point MEP List	See section 8.2.2	See section 8.2.2

Table 6 – OVC End Point at a UNI Service Attributes and Allowed Values

7.4 Operator UNI Service Attributes

Broadband Access E-Line and Broadband Access E-LAN Services must include at least one UNI. Since MEF 51.1 [30] does not impose any constraints on the values of the Operator UNI Service Attributes specified in MEF 26.2 [27], Table 7 compares the Operator UNI Service Attributes and allowed values for Broadband Access E-Line and Broadband Access E-LAN Services with the requirements in MEF 26.2.

[R5] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the Operator UNI Service Attributes **MUST** meet the specifications in Table 7.

Operator UNI Service Attributes	Broadband Access E-Line	Broadband Access E-LAN
Operator UNI Identifier	per MEF 26.2	per MEF 26.2
Operator UNI Physical Layer	See section 8.3.1	See section 8.3.1
Operator UNI Synchronous Mode	See section 8.3.1	See section 8.3.1
Operator UNI Number of Links	See section 8.3.1	See section 8.3.1
Operator UNI Link Aggregation	See section 8.3.1	See section 8.3.1
Operator UNI Port Conversation ID to Aggregation Link Map	See section 8.3.1	See section 8.3.1
Operator UNI Service Frame Format	See section 8.3.1	See section 8.3.1
Operator UNI Maximum Service Frame Size	≥ *1522* bytes per MEF 26.2	≥ *1522* bytes per MEF 26.2
Operator UNI Default CE-VLAN ID	*Not Applicable* See section 8.3.3	*Not Applicable* See section 8.3.3
Operator UNI Maximum Number of OVC End Points	≥ *1* per MEF 26.2	≥ *1* per MEF 26.2
Operator UNI Maximum Number of CE-VLAN IDs per OVC End Point	≥ *1* per MEF 26.2	≥ *1* per MEF 26.2
Operator UNI Ingress Bandwidth Profile per UNI	*Disabled* See section 8.3.2	*Disabled* See section 8.3.2
Operator UNI Egress Bandwidth Profile per UNI	*Disabled* See section 8.3.2	*Disabled* See section 8.3.2
Operator UNI Link OAM	*Enabled* or *Disabled* per MEF 26.2	*Enabled* or *Disabled* Per MEF 26.2
Operator UNI MEG	*Enabled* or *Disabled* per MEF 26.2	*Enabled* or *Disabled* Per MEF 26.2
Operator UNI LAG Link MEG	*Enabled* or *Disabled* per MEF 26.2	*Enabled* or *Disabled* per MEF 26.2
Operator UNI E-LMI	*Disabled* See section 8.3.4	*Disabled* See section 8.3.4
Operator UNI Token Share	*Enabled* or *Disabled* per MEF 26.2	*Enabled* or *Disabled* per MEF 26.2
Operator UNI Envelopes	See section 9	See section 9
Operator UNI L2CP Address Set	See section 8.1.5	See section 8.1.5
Operator UNI L2CP Peering	per MEF 26.2	per MEF 26.2

Table 7 – Operator UNI Service Attributes and Allowed Values

7.5 ENNI Attributes

There are three sets of Attributes associated with the ENNI:

- ENNI Common Attributes (MEF 26.2 [27], section 9)
- ENNI Service Attributes (MEF 26.2, section 13)
- Operator Multilateral Attributes (MEF 26.2, section 10)

A brief description of these Service Attributes is provided in this section for the convenience of the reader. The definitive descriptions of these Service Attributes are found in the MEF 26.2 sections noted above.

There are three sets of Service Attributes for the ENNI because each requires a different set of parties (Network Operators and Service Providers) to agree to the values. In Figure 4 there are two Network Operators connected by an ENNI. The ENNI is carrying three Services for three different Service Providers. The two Network Operators must agree on the physical attributes of the ENNI—how fast is it, is there a LAG, the frame format, etc. These are the *ENNI Common Attributes*. These Service Attributes are agreed to by the two Network Operators (although the values might be visible to the Service Providers).

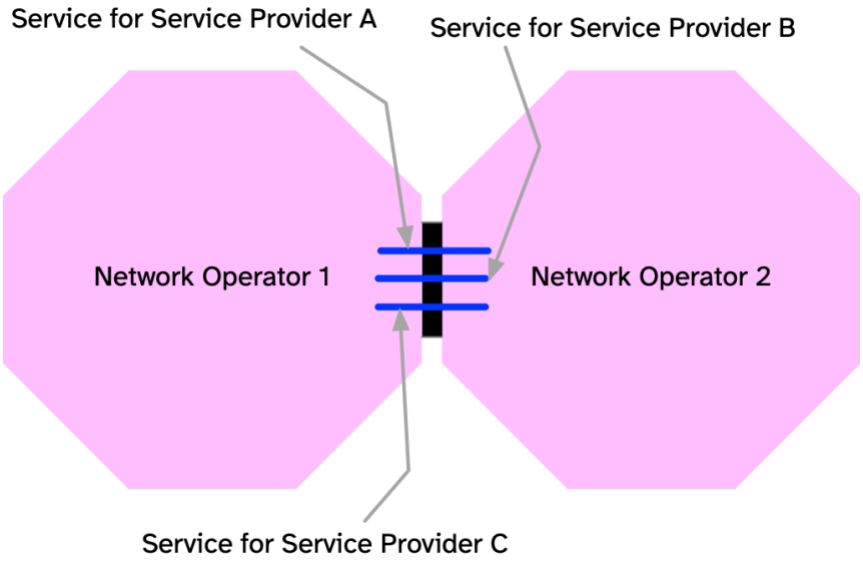

Figure 4 – Parties Associated with ENNI-related Service Attributes

Each Service Provider has a set of Service Attribute values that are agreed to by each of the Network Operators. These are called *ENNI Service Attributes*. An example is bandwidth: Service Provider A might need to agree on ingress bandwidth to the left side of the ENNI (among other things) with Network Operator 1 and on the right side with Operator 2, as might Service Provider C (independently).

Finally, there are some attributes that have to be agreed to by all of the parties (both Network Operators and all of the Service Providers using the ENNI), for example Maximum Frame Size. These are the *Operator Multilateral Attributes*.

MEF 51.1 does not impose any constraints on the values for any of the ENNI-related Service Attributes specified in MEF 26.2. Therefore Table 8, Table 9, and Table 10 compare the values with the requirements in MEF 26.2.

7.5.1 ENNI Common Attributes

Table 8 compares the ENNI Common Attributes and allowed values for Broadband Access E-Line and Broadband Access E-LAN Services with the requirements in MEF 26.2.

[R6] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the ENNI Common Attributes **MUST** meet the specifications in Table 8.

ENNI Common Attributes	Broadband Access E-Eline	Broadband Access E-LAN
ENNI Peering Identifier	Per MEF 26.2	Per MEF 26.2
ENNI Physical Layer	Per MEF 26.2	Per MEF 26.2
ENNI Frame Format	Per MEF 26.2	Per MEF 26.2
ENNI Number of Links	Per MEF 26.2	Per MEF 26.2
ENNI Link Aggregation	Per MEF 26.2	Per MEF 26.2
ENNI Port Conversation ID to Aggregation Link Map	Per MEF 26.2	Per MEF 26.2
ENNI MEG	Per MEF 26.2	Per MEF 26.2
ENNI LAG Link MEG	Per MEF 26.2	Per MEF 26.2
ENNI Link OAM	Per MEF 26.2	Per MEF 26.2

Table 8 – Requirements for ENNI Common Attributes and Allowed Values

7.5.2 ENNI Service Attributes

Table 9 compares the ENNI Service Attributes and allowed values for Broadband Access E-Line and Broadband Access E-LAN Services with the requirements in MEF 26.2.

[R7] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the ENNI Service Attributes **MUST** meet the specifications in Table 9.

ENNI Service Attributes	Broadband Access E-Line	Broadband Access E-LAN
Operator ENNI Identifier	Per MEF 26.2	Per MEF 26.2
S-VLAN ID Control	Per MEF 26.2	Per MEF 26.2
Maximum Number of OVCs	Per MEF 26.2	Per MEF 26.2
Maximum Number of OVC End Points per OVC	*1* See section 8.4.1	*1* See section 8.4.1
ENNI Token Share	Per MEF 26.2	Per MEF 26.2
ENNI Envelopes	See section 9	See section 9

Table 9 – Requirements for ENNI Service Attributes and Allowed Values

7.5.3 Operator Multilateral Attributes

Table 10 compares the Operator Multilateral Attributes and allowed values for Broadband Access E-Line and Broadband Access E-LAN Services with the requirements in MEF 26.2 and MEF 45.1.

[R8] For Broadband Access E-Line and Broadband Access E-LAN Services, the values for the Operator Multilateral Attributes **MUST** meet the specifications in Table 10.

Operator Multilateral Attributes	Broadband Access E-Line	Broadband Access E-LAN
ENNI L2CP Peering	Per MEF 45.1	Per MEF 45.1
ENNI Tagged L2CP Frame Processing	Per MEF 45.1	Per MEF 45.1
ENNI Maximum Frame Size	≥ *1526* Per MEF 26.2	≥ *1526* Per MEF 26.2

Table 10 – Requirements for Operator Multilateral Attributes and Allowed Values

8 Explanation of Deviations from MEF 26.2 and MEF 51.1

If any entry in any of the tables in section 7 is not "per MEF 51.1" or "per MEF 26.2", it will point to a subsection in this section or section 9 containing additional information.

8.1 OVC Service Attributes

This section contains information and requirements on OVC Service Attributes whose allowable values are different from the values specified in MEF 26.2 [27] and MEF 51.1 [30]. Also included are OVC Service Attributes that require further clarification and discussion.

8.1.1 OVC CE-VLAN ID Preservation Service Attribute

This OVC Service Attribute specifies whether and how the C-Tag VLAN ID value is modified from ingress frame to the resulting egress frame. The allowed values for this Service Attribute are *Preserve* and *Strip*.

In MEF 26.2, this Service Attribute can have one of three values: *Preserve*, *Retain*, or *Strip*. The behavior is described in section 12.7 of MEF 26.2 in tables 8, 9, and 10.

Broadband Access E-Line and Broadband Access E-LAN Services use OVC End Map values that differ from those in MEF 26.2. The structure of the OVC End Point Map in this document is modeled on the structure of the EVC End Point Map in MEF 10.4. MEF 26.2 does not specify the mappings *All-NP*, *UT/PT*, and *UT* that are specified in this document. With the inclusion of these additional methods for mapping frames to the OVC End Point, the Default CE-VLAN ID Service Attribute as specified in MEF 26.2 is not relevant. Consequently, the behavior and allowed values for the OVC CE-VLAN Preservation Service Attribute differ substantially from MEF 26.2.

There are four combinations of ingress and egress OVC End Points (and associated EIs):

- ENNI to ENNI – section 8.1.1.1
- UNI to UNI – section 8.1.1.2
- ENNI to UNI – section 8.1.1.3
- UNI to ENNI – section 8.1.1.4

Only the UNI to ENNI case is affected by the value of the OVC CE-VLAN ID Preservation Service Attribute. Nevertheless, there are preservation requirements that are independent of the value of the OVC CE-VLAN ID Preservation Service Attribute, and these are discussed in the indicated sub-sections.

In the following tables and accompanying text, the following symbols and abbreviations are used:

- UT represents an Untagged Service Frame, i.e., a Service Frame where the two bytes following the Source Address do not have the value 0x8100 nor the value 0x88a8.
- PT represents a Priority Tagged Service Frame, i.e., a Service Frame in which the two bytes following the Source Address have the value 0x8100 and the corresponding C-Tag VLAN ID field has the value 0x000

- CT is a VLAN Tagged Service Frame, i.e., a Service Frame where the two bytes following the Source Address have the value 0x8100 and the corresponding C-Tag VLAN ID has a value that is not 0x000
- CTI indicates that the C-Tag VLAN ID value in the egress frame is the same as that of ingress frame
- ST is a Single Tagged ENNI Frame (see MEF 26.2 [27]).
- ST/CT (value of C-Tag VLAN ID > 0), ST/PT (value of C-Tag VLAN ID = 0) indicate a Double Tagged ENNI Frame (see MEF 26.2).

8.1.1.1 Ingress ENNI to Egress ENNI

For frames that egress at an ENNI as a result of an ingress frame at another ENNI in the OVC, the value of this Service Attribute does not apply.

Requirements [R75] and [R76] in MEF 26.2 [27] mandate that regardless of the value of the OVC CE-VLAN ID Preservation Service Attribute, an egress frame at an ENNI that results from an ingress frame at an ENNI is required to have the same format, either ST or ST/CT, and if the format is ST/CT, the C-Tag VLAN ID value is required to be the same in the ingress frame and the resulting egress frame (but the S-Tag VLAN ID value can be different on the two ENNIs).

8.1.1.2 Ingress UNI to Egress UNI

For frames that egress at a UNI as a result of an ingress frame from another UNI in the OVC, the value of this Service Attribute does not apply. Note that an Ingress UNI to Egress UNI can only occur for a Broadband Access E-LAN Service.

In this case, the behavior is completely defined by the values of the OVC End Point Maps at each of the UNIs and the requirements associated with those values. This is consistent with the behavior defined for EVCs in MEF 10.4.

Table 11 shows the allowed mix of OVC End Point Map values for UNIs within an OVC that supports a Broadband Access E-LAN Service. It extends Table 18 in MEF 10.4 to include the new OVC End Point Map values defined in this document, *All-NP* and *UT* (see section 8.2.3).

			OVC End Point at UNI #2 – End Point Map Value					
			All	*All-NP*	*UT/PT*	*UT*	*List* with 1 entry	*List* with >1 entry
OVC End Point at UNI #1 – End Point Map Value	1	All	√					
	2	All-NP		√				
	3	UT/PT			√	√	√	
	4	UT			√	√	√	
	5	List with 1 entry			√	√	√	
	6	List with >1 entry						√

Table 11 – Allowed Mixing of OVC End Point Map Service Attribute Values

The values in rows 1 and 2 are mandated by [R26] and the value in row 6 is mandated by [R21]. Requirements [R27] and [R22], respectively, mandate that the value of the C-Tag VLAN ID be

preserved for the combinations in rows 1, 2, and 3, i.e., the value of the C-Tag VLAN ID in a frame at the egress UNI is the same as the value as the C-Tag VLAN ID in the frame from which it resulted at the ingress UNI. For the combinations in rows 1 and 2, an Untagged Service Frame at an ingress UNI results in an Untagged Service Frame at an egress UNI.

Rows 3, 4, and 5 indicate that modification can – but does not have to – occur between ingress and egress. An Untagged Service Frame at ingress can result in an Untagged Service Frame or a VLAN-tagged Service Frame at egress and vice versa. A Priority Tagged Service Frame at ingress can result in an Untagged Service Frame (see [R31]) or a VLAN-tagged Service Frame at egress (but not vice versa).

8.1.1.3 Ingress ENNI to Egress UNI

For frames that egress at an ENNI as a result of an ingress frame from a UNI in the OVC, the value of this Service Attribute does not apply.

[R9] For Broadband Access E-Line and Broadband Access E-LAN Services, when the ingress OVC End Point is located at an ENNI and egress OVC End Point is located at a UNI, the relationships between the format of the frame at the ingress ENNI and the corresponding frame at the egress UNI **MUST** be as specified in Table 12.

Ingress OVC End Point Location	Ingress Frame Format	Egress OVC End Point Location	Egress Frame Formats for OVC End Point Map Values at Egress @UNI					
			All	*All-NP*	*List >1 entry*	*List 1 entry*	*UT/PT*	*UT*
ENNI	ST	UNI	UT	UT	Disc	CTe	UT	UT
ENNI	ST/CT	UNI	CTI	CTI	CTx	CTe	UT	UT
ENNI	ST/PT	UNI	PT	Disc	Disc	CTe	UT	UT
Notes: Disc = No frame is transmitted at the egress UNI CTe = The frame is transmitted with the C-tag VLAN ID value corresponding to the entry in the OVC End Point Map List at the egress UNI (note that this allows C-VLAN ID translation/renumbering) CTx = If the value of CT in the ingress ENNI frame appears in the OVC End Point Map List at the egress UNI, the frame is transmitted with that C-tag VLAN ID value otherwise it is Disc (note that this provides C-VLAN ID filtering)								

Table 12 – Relationship between C-Tag in Ingress and Egress Frames for Egress at a UNI

8.1.1.4 Ingress UNI to Egress ENNI

For frames that egress at an ENNI as a result of an ingress frames at an UNI in the OVC, [R10] describes the behavior when the value of the OVC CE-VLAN ID Preservation Service Attribute = *Preserve* and [R11] describes the behavior when the value of the Service Attribute = *Strip*.

[R10] For Broadband Access E-Line and Broadband Access E-LAN Services, when the value of the OVC CE-VLAN ID Preservation Service Attribute = *Preserve* and the ingress OVC End Point is located at a UNI and the egress OVC End Point is located at an ENNI, the relationships between the format of the frame at the ingress UNI and the corresponding frame at the egress ENNI **MUST** be as specified in Table 13.

Ingress OVC End Point Location	Ingress Frame Format	Egress OVC End Point Location	Egress Frame Format
UNI	UT	ENNI	ST
UNI	CT	ENNI	ST/CTI
UNI	PT	ENNI	ST/PT

Table 13 – UNI to ENNI Frame Formats for *Preserve*

[R11] For Broadband Access E-Line and Broadband Access E-LAN Services, when the value of the OVC CE-VLAN ID Preservation Service Attribute = *Strip* and the ingress OVC End Point is located at a UNI and the egress OVC End Point is located at an ENNI, then the resulting egress frame at the ENNI **MUST** include an S-Tag and no C-Tag.

8.1.2 OVC Service Level Specification Service Attribute

MEF 26.2 specifies that the value of this Service Attribute is either *None* or a structure that specifies performance objectives for one or more of nine Performance Metrics specified per Class of Service Name and per sets of ordered OVC End Point pairs. MEF 51.1 recommends that Network Operators support an SLS with the four delay metrics defined in MEF 26.2 (One-Way Frame Delay, One-way Mean Frame Delay, One-Way Frame Delay Range, One-Way Inter-Frame Delay Variation) [D3] and One-Way Frame Loss Ratio [D4] (also defined in MEF 26.2).

Some Broadband Access Network Operators do not adhere to [D3] and [D4] because they don't provide performance objectives for services across their networks, and therefore OVCs across the networks of these Network Operators will have a value of *None* for this Service Attribute. Nevertheless, this document does not preclude a Broadband Access Network Operator from providing a Service Level Specification with a value other than *None*, and therefore [D3] and [D4] from MEF 51.1 are modified as follows:

[D1] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Service Level Specification Service Attribute is not *None*, then the Broadband Network Access Operator **SHOULD** support the four delay metrics (Frame Delay, Frame Delay Range, Mean Frame Delay and Inter-Frame Delay Variation) as specified in MEF26.2, in the Service Level Specification.

[D2] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Service Level Specification Service Attribute is not *None*, then the Broadband Network Access Operator **SHOULD** support the Frame Loss Ratio metric as specified in MEF26.2, in the Service Level Specification.

Note that when the term *support* is used in a normative context in this document, it means that the Broadband Access Network Operator is capable of enabling the functionality upon agreement between the Service Provider and the Broadband Access Network Operator.

As noted above, objectives are specified between ordered sets of End Point pairs, so the asymmetric characteristics of some Broadband Access Networks can be accommodated in an SLS specification.

If an SLS is specified for the OVC, the Performance metrics, except for the One-way Availability Performance Metric, apply to Qualified Service Frames and Qualified ENNI Frames, collectively referred to as Qualified Frames.

MEF 26.2 defines Qualified Frames for OVCs in section 12.13.1.3 as a list of conditions that a frame must meet to be considered a Qualified Frame. Since many aspects of the OVC definition have been modified in this document, this document provides an updated definition of Qualified Frames for Broadband Access E-Line and Broadband Access E-LAN Services (heavily based on the MEF 26.2 definition).

Qualified Frames are defined as every EI Frame that satisfies the following criteria for a given ordered OVC End Point pair ⟨*i,j*⟩, a Class of Service Name, *CoS_Name*, and a given time interval, T_l, such that:

- Each EI Frame ingresses at the EI where OVC End Point *i* is located,
- Each EI Frame maps to OVC End Point *i* via an OVC End Point Map (see section 8.2.3),
- Each EI Frame should be delivered to OVC End Point *j* according to the OVC Frame Delivery Service Attribute (see section 8.1.3)
- The first bit of each EI Frame arrives at the ingress EI where the OVC End Point is located within the time interval T_l and within the time interval $\Delta t_k \in AT_{T_l}^{\langle i,j \rangle}$ (see section 12.13.1.2 in MEF 26.2)
- Each EI Frame has the given Class of Service Name, *CoS_Name*,
- If the value of the OVC Bandwidth Profile Algorithm Type Service Attribute (see section 8.1.6) is Token Bucket:
  - Each EI Frame that is subject to an ingress Bandwidth Profile has an Ingress Bandwidth Profile Color Declaration equal to Green, and
  - Each EI Frame that is not subject to an ingress Bandwidth Profile has the Color Green per the value of the OVC End Point Color Identifier Service Attribute (see section 8.2.1).
- Each EI Frame is not discarded per MEF 26.2 requirements:
  - [R8], [R166], [D3], [D4], [D5], [D6], [D14]
- Each EI Frame is not discarded per the following requirements in this document:
  - [R37], [R49]

8.1.3 OVC Frame Delivery Service Attribute

This Service Attribute specifies for each of three types of Data EI Frames — Unicast, Multicast, and Broadcast — one of *Deliver Unconditionally*, *Deliver Conditionally,* or *Discard*. Note that this Service Attribute specifies the delivery behavior only for Data EI Frames, not L2CP EI Frames or SOAM EI Frames. See MEF 26.2 section 8.7 for a discussion of frame types, and sections 8.1.4, 8.1.5, and 8.2.2 of this document for a discussion of the behavior of SOAM and L2CP frames.

Furthermore, MEF 26.2 indicates that in any case in which conditional delivery is specified, the conditions must be explicitly defined and agreed on.

Requirements [R11], [R12], and [R13] in MEF 51.1 [30] indicate that for O-Line Services (Broadband Access E-Line in the context of this document) the Network Operator must support[6] *Deliver Unconditionally* for all three types of Data EI Frames. Similarly, recommendations [D17] and [D18] in MEF 51.1 indicate that for O-LAN Service (Broadband Access E-LAN in the context of this document) that the value should be *Deliver Conditionally*[7] for Unicast Data EI Frames and should be *Deliver Unconditionally* for Broadcast EI Data Frames. There are no specific requirements for Multicast Data EI Frames.

Some Broadband Access Networks do not support these requirements (see section 6.2). This document provides an alternative set of requirements.

8.1.3.1 OVC Frame Delivery for Unicast Data EI Frames

The allowed values for the OVC Frame Delivery Service Attribute for Unicast Data EI Frames are *Deliver Unconditionally* and *Deliver Conditionally*. Broadband Access Networks sometimes behave differently based on the direction of a frame, and therefore the requirements below account for these differences.

[D3] For Broadband Access E-Line Services, the Broadband Access Network Operator **SHOULD** support a value of *Deliver Unconditionally* for the OVC Frame Delivery Service Attribute for Unicast Data EI Frames.

As noted above, MEF 51.1 requires that all Unicast Data EI Frames are delivered without condition for Access E-Line. Some Broadband Access Networks discard frames towards a UNI that have unknown MAC addresses. Therefore, this document allows the Broadband Access Network to support a value of *Deliver Conditionally* for Unicast Data EI Frames for both Broadband Access E-Line and Broadband Access E-LAN Services. Requirement [R12] and [O1] allow this behavior.

[O1] For Broadband Access E-Line Services, the Broadband Access Network Operator **MAY** support a value of *Deliver Conditionally* for the OVC Frame Delivery Service Attribute for Unicast Data EI Frames.

[R12] For Broadband Access E-Line Services, if the value of the OVC Frame Delivery Service Attribute for Unicast Data EI Frames is *Deliver Conditionally*, then the conditions specified for OVC Frame Delivery **MUST** be such that delivery of Unicast Data EI Frames from UNI to ENNI yields the same delivery behavior as if the value were *Deliver Unconditionally*.

[6] MEF 51.1 explains that the term *support*, when used in a normative context, means that the Operator is capable of enabling the functionality upon agreement between the Service Provider or Super Operator and the Operator.
[7] With the condition that delivery of unicast frames is subject to the dynamic learning and filtering process as described in IEEE 802.1Q™-2018 [8] for Independent and Shared VLAN learning bridges.

[D4] For Broadband Access E-LAN Services, the Broadband Access Network Operator **SHOULD** support a value of *Deliver Conditionally* for the OVC Frame Delivery Service Attribute for Unicast Data EI Frames with the condition that Unicast Data EI Frames are subject to the dynamic learning and filtering process as described in IEEE 802.1Q™-2018 [8] for Independent and Shared VLAN learning bridges.

[O2] If the value of the OVC Frame Delivery Service Attribute for Unicast Data EI Frames in a Broadband Access E-Line Service or a Broadband Access E-LAN Service is *Deliver Conditionally*, then Unicast Data EI Frames that ingress at an ENNI **MAY** be discarded if the destination is an unknown (e.g., not yet learned or aged-out, etc.) MAC address.

Note that [D4] is equivalent to [D17] in MEF 51.1.

8.1.3.2 OVC Frame Delivery for Broadcast Data EI Frames

As noted above, MEF 51.1 requires the Network Operator to support the value *Deliver Unconditionally* for Broadcast Data EI Frames for Access E-Line Services and indicates that the value for Broadcast Data EI Frames should be *Deliver Unconditionally* for Access E-LAN Services. Some Broadband Access Networks, however, can only deliver Broadcast Data EI Frames transmitted in one direction, usually Data EI Frames that ingress at a UNI. In most networks it is critical that Broadcast Data EI Frames be supported in at least one direction in order for protocols such as DHCP and a variety of other discovery protocols to operate.

[D5] For Broadband Access E-Line and Broadband Access E-LAN Services, the Broadband Access Network Operator **SHOULD** support a value of *Deliver Unconditionally* for the OVC Frame Delivery Service Attribute for Broadcast Data EI Frames.

[O3] For Broadband Access E-Line and Broadband Access E-LAN Services, the Broadband Access Network Operator **MAY** support a value of *Deliver Conditionally* for the OVC Frame Delivery Service Attribute for Broadcast Data EI Frames.

[R13] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Frame Delivery Service Attribute for Broadcast Data EI Frames is *Deliver Conditionally*, then the conditions specified for OVC Frame Delivery **MUST** be such that delivery of Broadcast Data EI Frames from UNI to ENNI and from UNI to UNI yields the same delivery behavior as if the value were *Deliver Unconditionally*.

[O4] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Frame Delivery Service Attribute for Broadcast Data EI Frames is *Deliver Conditionally*, then Broadcast Data EI Frames that ingress at an ENNI **MAY** be discarded.

8.1.3.3 OVC Frame Delivery for Multicast Data EI Frames

Multicast Data EI Frames can be particularly problematic for Broadband Access Networks, and in many cases, they are not carried at all (i.e., discarded). In MEF 26.2 there are no specific requirements for Multicast Data EI Frames. MEF 51.1 requires *Deliver Unconditionally* for Access E-Line but does not impose any specific requirements for Access E-LAN.

For Broadband Access E-Line and E-LAN Services, the value of OVC Frame Delivery for Multicast Data EI Frames Service Attribute can be any of the MEF 26.2 values, i.e., *Deliver Unconditionally*, *Deliver Conditionally*, or *Discard*. This behavior deviates from MEF 51.1 for Access E-Line services.

8.1.4 OVC Available MEG Level Service Attribute

The OVC Available MEG Level value is the lowest Service OAM (SOAM) MEG Level that can be used by the Service Provider for a Maintenance Entity Group[8] (MEG) that can traverse the OVC transparently. MEF 26.2 [27] indicates that the value of this Service Attribute can be *None* or a value from *0* to *7*. MEF 51.1 [30], however, requires the value to be less than or equal to 6.

As noted in section 8.1.3.3, some Broadband Access Networks cannot transport Multicast Frames. Service OAM as defined in ITU-T Y.1731 [18] uses Multicast Frames for several common functions. Therefore, this document modifies the requirement in MEF 51.1 [R2] by allowing a value of *None*.

[R14] For Broadband Access E-Line and Broadband Access E-LAN Services, the value of the OVC Available MEG Level **MUST** be an integer between *0* and *6* (inclusive) or *None*.

8.1.5 OVC L2CP Address Set and Operator UNI L2CP Address Set Service Attributes

These two Service Attributes, one for the OVC and one for the Operator UNI, are discussed together because if an OVC has an OVC End Point at a UNI, MEF 45.1 [29] (requirement [R8]) mandates that the value of the Operator UNI L2CP Address Set Service Attribute is the same as the OVC L2CP Address Set Service Attribute. All of the Services addressed in this document have at least one OVC End Point at a UNI, so this requirement holds.

The L2CP Address Set Service Attribute specifies the subset of the Bridge Reserved Addresses that are filtered (i.e., L2CP Frames with this Destination Address are peered or discarded but not passed) at an L2CP Decision Point. MEF 45.1 allows three values, *CTA* (C-Tag Aware), *CTB* (C-Tag Blind), *CTB-2* (C-Tag Blind, option 2). This document allows these three values and one additional value, *Other*.

The value *CTA* is used in Services where not all C-VLAN ID values are mapped to the OVC End Point (just some of them or just Untagged and Priority tagged Service Frames), i.e., the OVC End Point Map at the UNI = *List* or *UT/PT* or *UT*. The behavior associated with the value *CTA* does

[8] Maintenance Entity Group (MEG) is the term used in ITU-T Y.1731[18] and MEF 30.1 [28].
IEEE Std 802.1Q™-2018 [8] uses the term Maintenance Association (MA) for this construct.

not pass any L2CP frames, they are all either discarded or peered (the peered L2CPs are identified in the L2CP Peering Service Attribute).

The value *CTB* is used in Services where all VLAN Tagged, Untagged, and possibly Priority Tagged Service Frames are mapped to the OVC End Point, i.e., the OVC End Point Map at the UNI = *All.* The behavior associated with the value *CTB* passes (forwards) the addresses commonly used for the customer spanning tree and provider MVRP messages and discards or peers the rest of the L2CPs (see Table 6 in MEF 45.1). The behavior associated with the value *CTB-2* is not compliant with IEEE Std 802.1Q™-2018 [8] but has been implemented (for point-to-point Services) in some networks. MEF 45.1 does provide guidance in the case where the OVC End Point Map value = *All-NP* and *UT*.

Some Broadband Access Networks do not pass L2CPs, so *CTB* is not an option in those cases. Therefore, for Broadband Access E-Line and Broadband Access E-LAN Services this document recommends the value be *CTA* in all cases unless the precise behavior specified in [R6] and [R7] of MEF 45.1 can be met.

[O5] For Broadband Access E-Line and Broadband Access E-LAN Services, the value of the OVC L2CP Address Set Service Attribute and the Operator UNI L2CP Address Set Service Attribute **MAY** be *CTA*.

If a Broadband Access Network doesn't peer any L2CPs and complies with [O5] then all L2CPs are discarded.

It is possible, of course, that a Broadband Access Network does, in fact, comply with MEF 45.1 and hence the values *CTB* and *CTB-2* can be specified in the cases allowed in MEF 45.1 (see [R6 and R7] in MEF 45.1).

Although (as noted above) some Broadband Access Networks do not pass L2CPs, some Broadband Access Networks might not look for all the legal values and therefore some might pass. Since there is no definitive method for defining this situation, this document allows one additional value for these Service Attributes.

[O6] For Broadband Access E-Line and Broadband Access E-LAN Services, the value of the OVC L2CP Address Set Service Attribute and the Operator UNI L2CP Address Set Service Attribute **MAY** be *Other*.

If the value of these Service Attributes is *Other*, the Service Provider and the Broadband Access Network Operator need to agree on the handling of L2CPs.

8.1.6 OVC Bandwidth Profile Algorithm Type Service Attribute

This Service Attribute is defined for Broadband Access E-Line and Broadband Access E-LAN Services. The Service Attribute has three possible values and indicates whether bandwidth metering for the OVC is implemented, and if so, uses the Token Bucket algorithm as defined in MEF 26.2 section 17 or the Interval Averaging Algorithm defined in this document in section 9. The allowed values of this Service Attribute are *Token Bucket*, *Interval Averaging, Other*, and *None*.

Requirement [R42] in section 9.2 defines the behavior associated with the values for this Service Attribute.

If the value of this Service Attribute is *Interval Averaging*, then the value of the UNI Token Share Service Attribute is not applicable to the Service.

The value *Other* can be used by Broadband Access Network Operators that implement a different algorithm for metering bandwidth. The details of these alternatives are beyond the scope of this document.

8.2 OVC End Point Service Attributes

This section contains information on OVC End Point Service Attributes whose allowable values are different than the values specified in MEF 26.2 [27] and MEF 51.1 [30] and OVC End Point Service Attributes that require discussion.

8.2.1 OVC End Point Color Identifier (UNI and ENNI)

The value of this Service Attribute defines how the Network Operator and the Subscriber determine the "color" of a frame mapped to the OVC End Point, as either *Green* or *Yellow*. The value of the Service Attribute is a 2-tuple ⟨*F, M*⟩ where *F* indicates a field in the frame and *M* specifies a mapping of the value of the indicated field to a color. Although section 16.7 of MEF 26.2 specifies several acceptable values for ⟨*F, M*⟩, [D5] (ENNI) and [D12] (UNI) in MEF 51.1 recommend that the DEI field should be used to identify color.

Some Broadband Access Network Operators do not support color markings on frames and the Interval Averaging Bandwidth Profiles defined in this document for Broadband Access E-Line and Broadband Access E-LAN Services do not include a color-aware mode and do not declare a color for EI Frames (see section 9). Therefore [O7] rescinds the recommendations in MEF 51.1.

[O7] For Broadband Access E-Line and Broadband Access E-LAN Services, recommendations [D5] and [D12] in MEF 51.1 **MAY NOT** apply.

If the Broadband Access Network Operator is required to support color markings at the ENNI, for example, in order to co-exist with other Carrier Ethernet Services, a value for this Service Attribute can be specified such that all frames are declared to be the same color, either *Green* or *Yellow*. The following example maps all frames to *Yellow*:

⟨*OVC End Point, Yellow*⟩

8.2.2 OVC End Point MIP and OVC End Point MEP List Service Attributes

MEF 51.1 [30] recommends that the value of the OVC End Point MIP Service Attribute be *Enabled* at OVC End Points at UNIs [D8] and ENNIs [D13]. MEF 51.1 recommends that an OVC End Point MEP List Service Attribute value contain at least one Up MEP [D9] at an ENNI and at least two Up MEPs at a UNI [D14].

Some Broadband Access Network Operators do not support ITU/T Y.1731 [18] Service OAM (SOAM) and the requirements and recommendations for Carrier Ethernet Services specified in

MEF 30.1 [28]. Specifically, they do not implement Subscriber MEG MIPs, and they do not instantiate MEPs (EVC, OVC, Physical Link, etc.) at the OVC End Points and in these cases the value of these Service Attributes is *Disabled*.

8.2.3 OVC End Point Map Service Attribute

The value of the OVC End Point Map Service Attribute identifies which EI Frames map to the OVC End Point. The value of the OVC End Point Map Service Attribute is used by a receiving Broadband Access Network to determine which OVC is to be used to handle the incoming EI Frame by identifying the OVC End Point. The value of the OVC End Point Map Service Attribute is also used by a sending Network Operator to populate S-VLAN ID and/or C-VLAN ID fields for an egress EI frame that is mapped to the OVC End Point so that the Subscriber can identify the EVC that carried the EI Frame, or the Service Provider can identify the OVC that carried the EI Frame.

In what follows, section 8.2.3.1 specifies requirements for the OVC End Point Map Service Attribute at an ENNI and section 8.2.3.2 specifies requirements for the OVC End Point Map Service Attribute at UNI.

8.2.3.1 OVC End Point Map Service Attribute at an ENNI

[R15] For Broadband Access E-Line and Broadband E-LAN Services, at an OVC End Point whose External Interface Type Service Attribute = *ENNI*, the value of the OVC End Point Map **MUST** be an S-VLAN ID value.

Requirement [R15] is equivalent to mandating that the value of the OVC End Point Map at an ENNI be of Form E as defined in section 16.5.1 in MEF 26.2.

Requirements [R139] in MEF 26.2 dictates that all ingress EI Frames received at an ENNI with an S-Tag VLAN ID value that is equal to the value of the OVC End Point Map for an OVC End Point located at that ENNI are mapped to that OVC End Point.

Requirement [R140] in MEF 26.2 dictates that all egress EI Frames at the ENNI that map to the OVC End Point have an S-Tag VLAN ID value that is equal to the value of the OVC End Point Map for that OVC End Point.

8.2.3.2 OVC End Point Map Service Attribute at a UNI

MEF 26.2 [27] defines this map as a list of C-VLAN ID values in the range 1…4094 (referred to as *Form U*). Untagged (and Priority Tagged) Service Frames are mapped to the OVC End Point by defining an Operator UNI Default CE-VLAN ID Service Attribute (value in the range 1…4094) and including the chosen value in the OVC End Point Map. That model supports including Untagged frames along with VLAN Tagged frames in an OVC. MEF 10.4 [26] eliminated the CE-VLAN ID for Untagged and Priority Tagged Frames Service Attribute[9] and defined the EVC End Point Map to specify three values:

[9] This Service Attribute was analogous to the Default CE-VLAN ID Service Attribute specified in MEF 26.2 for an OVC End Point at an Operator UNI.

- *List* of one or more C-Tag VLAN ID values, each in the range 1…4094 (consistent with MEF 26.2 Form U),
- *All* indicating that all Service Frames: Untagged, Priority Tagged, and VLAN Tagged are mapped to the EVC End Point, and
- *UT/PT* indicating that (only) Untagged and Priority Tagged Service Frames are mapped to the EVC End Point

This document adopts the model defined in MEF 10.4 with a couple of extensions.

[R16] For Broadband Access E-Line and Broadband E-LAN Services, at an OVC End Point whose External Interface Type Service Attribute = *UNI*, the value of the OVC End Point Map Service Attribute **MUST** be one of the following values:

- *List* of one or more C-Tag VLAN ID values in the range 1…4094 (consistent with MEF 26.2 *Form U*),
- *All* indicating that all Service Frames, Untagged, Priority Tagged, and VLAN Tagged are mapped to the OVC End Point,
- *All-NP* indicating that all Untagged and VLAN Tagged Service Frames are mapped to the OVC End Point (i.e., not Priority Tagged Service Frames),
- *UT/PT* indicating that only Untagged and Priority Tagged Service Frames are mapped to the OVC End Point, and
- *UT* indicating that only Untagged Service Frames are mapped to the OVC End Point

The allowed values in MEF 10.4 are extended for Broadband Access E-Line and Broadband Access E-LAN to include *All-NP* and *UT*. These provide an appropriate mapping for Broadband Access Network Operators that cannot support Priority Tagged Frames. Note that an EVC that that is composed from an OVC with an OVC End Point Map containing a value of *All-NP* or *UT* is not conformant with a Subscriber Ethernet Service defined in MEF 6.3 (see Appendix A).

The following sections define the behavior and requirements for each of the possible values.

8.2.3.2.1 Value of the OVC End Point Map Service Attribute = *List*

[R17] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *List* at an OVC End Point whose OVC End Point Interface Type Service Attribute = *UNI*, then an Ingress Service Frame **MUST** be mapped to the OVC End Point if and only if the Ingress Service Frame is a VLAN Tagged Service Frame with a C-Tag VLAN ID value matching an entry in the value of the OVC End Point Map Service Attribute.

A consequence of [R17] is that Priority Tagged Service Frames are not mapped to the OVC End Point when the value of the OVC End Point Map Service Attribute = *List* since Priority Tagged Service Frames are not included in the definition of VLAN Tagged Service Frames.

[R18] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *List* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then all Egress Service Frames delivered to the OVC End Point and transmitted across the UNI **MUST** be VLAN Tagged Service Frames and have a C-Tag VLAN ID value matching an entry in the value of the OVC End Point Map Service Attribute.

[R19] At each UNI in a Broadband Access Network, a given C-Tag VLAN ID value **MUST** be in at most one value of an OVC End Point Map Service Attribute among all OVC End Points located at the UNI.

Requirement [R19] is a restatement of [R153] in MEF 26.2 [27].

[R20] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *List* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then the number of C-Tag VLAN ID values in the value of the OVC End Point Map Service Attribute for an OVC End Point **MUST** be less than or equal to the value of the Operator UNI Maximum Number CE-VLAN IDs per OVC End Point Service Attribute (Section 14.11 in MEF 26.2) for the UNI where the OVC End Point is located.

[R21] For Broadband Access E-Line and Broadband Access E-LAN Services, for a given OVC End Point whose External Interface Type Service Attribute = *UNI*, if the value of the OVC End Point Map Service Attribute = *List* and more than one C-Tag VLAN ID value is in the list, then all of the OVC End Points at UNIs associated by the same OVC as the given OVC End Point **MUST** have the value of the OVC End Point Map Service Attribute = *List* and with the same list entries.

An implication of [R21] is that, when the conditions of [R21] are met, the value of the C-Tag VLAN ID is mandated to be unchanged for all EI Frames traversing the OVC from UNI to UNI. Note, however, that when the Lists have a single entry, the value of the CE-VLAN ID can change for Service Frames traversing the OVC from UNI to UNI.

[R22] For Broadband Access E-Line and Broadband Access E-LAN Services, if any OVC End Point whose External Interface Type Service Attribute = *UNI* has an OVC End Point Map Service Attribute whose value is *List* and more than one C-Tag VLAN ID value is in the list, then the value of the C-tag VLAN ID in an Egress Service Frame at every other UNI in the OVC **MUST** be the same as the value of the C-tag VLAN ID in the Ingress Service Frame from which it resulted.

8.2.3.2.2 Value of the OVC End Point Map Service Attribute = *All* or *All-NP*

[R23] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *All* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then all Service Frames at the UNI where the OVC End Point is located **MUST** be mapped to the OVC End Point.

[R24] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *All-NP* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then all Service Frames except Priority Tagged Service Frames at the UNI where the OVC End Point is located **MUST** be mapped to the OVC End Point.

[O8] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *All* or *All-NP* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then an Ingress Service Frame with 4095 in C-Tag VLAN ID **MAY** be discarded by the Broadband Access Network Operator.[10]

[R25] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *All* or *All-NP* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then the OVC End Point **MUST** be the only OVC End Point at the UNI.

[R26] For Broadband Access E-Line or Broadband Access E-LAN Services, for a given OVC End Point at an OVC End Point whose External Interface Type Service Attribute = *UNI*, if the value of the OVC EP Map Service Attribute = *All* or *All-NP*, then all the OVC End Points whose External Interface Type Service Attribute = *UNI* associated by the same OVC as the given OVC End Point **MUST** have the same value for the OVC End Point Map Service Attribute.

[R27] For Broadband Access E-Line and Broadband Access E-LAN Services, if a given OVC End Point at an OVC End Point whose External Interface Type Service Attribute = UNI has an OVC End Point Map Service Attribute whose value is *All* or *All-NP*, then the relationship between the format of an Egress Service Frame at every other UNI in the OVC and the Ingress Service Frame from which it resulted **MUST** be as follows:

[10] Equipment manufacturers and Broadband Access Network Operators often expect VLAN ID value 4095 to be available for internal management of the device. It is therefore acceptable to not forward EI frames with C-Tag VLAN ID value 4095.

- If the Ingress Service Frame is an Untagged Service Frame, then the Egress Service Frame is an Untagged Service Frame.
- If the Ingress Service Frame includes a C-tag, then the value of the C-tag VLAN ID in the Egress Service Frame is the same as the value of the C-tag VLAN ID in the Ingress Service Frame.[11]

8.2.3.2.3 Value of the OVC End Point Map Service Attribute = *UT/PT* or *UT*

[R28] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *UT/PT* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then all ingress Untagged Service Frames and all ingress Priority Tagged Service Frames at the UNI **MUST** be mapped to the OVC End Point.

[R29] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *UT* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then all ingress Untagged Service Frames at the UNI **MUST** be mapped to the OVC End Point.

[R30] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *UT/PT* or *UT* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then ingress VLAN Tagged Service Frames at the UNI **MUST NOT** be mapped to the OVC End Point.

[R31] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *UT/PT* or *UT* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then all Egress Service Frames delivered to the OVC End Point and transmitted across the UNI **MUST** be Untagged Service Frames.

[R32] For Broadband Access E-Line or Broadband Access E-LAN Services, if the value of the OVC End Point Map Service Attribute = *UT/PT* or *UT* at an OVC End Point whose External Interface Type Service Attribute = *UNI*, then the OVC End Point **MUST** be the only OVC End Point at the UNI.

8.2.4 Ingress Bandwidth Profile per Class of Service Name and Egress Bandwidth Profile per Class of Service Name

The values of these Service Attributes are either *None* or Bandwidth Profile parameters as specified in section 9.

[11] In the case of the value *All-NP*, this bullet does not apply for ingress frames whose C-tag VLAN ID is 0x000 since these frames are not mapped to the OVC End Point at the ingress UNI.

8.3 Operator UNI Service Attributes

This section contains information on Operator UNI Service Attributes whose allowable values are different than the values specified in MEF 26.2 [27] and MEF 51.1 [30] and Operator UNI Service Attributes that require further discussion.

8.3.1 Operator UNI Physical Layer-related Service Attributes

In a Subscriber Ethernet Service, the UNI specifies the demarcation point between the responsibility of the Subscriber and the responsibility of the (Ethernet) Service Provider. The agreement between those parties is defined by the Subscriber UNI Service Attributes defined in MEF 10.4. Since these are Ethernet Services, the Subscriber UNI Service Attributes that describe the physical interface are based on IEEE Std 802.3™-2015. Each EVC End Point is associated with a Subscriber UNI. This is shown in Figure 5.

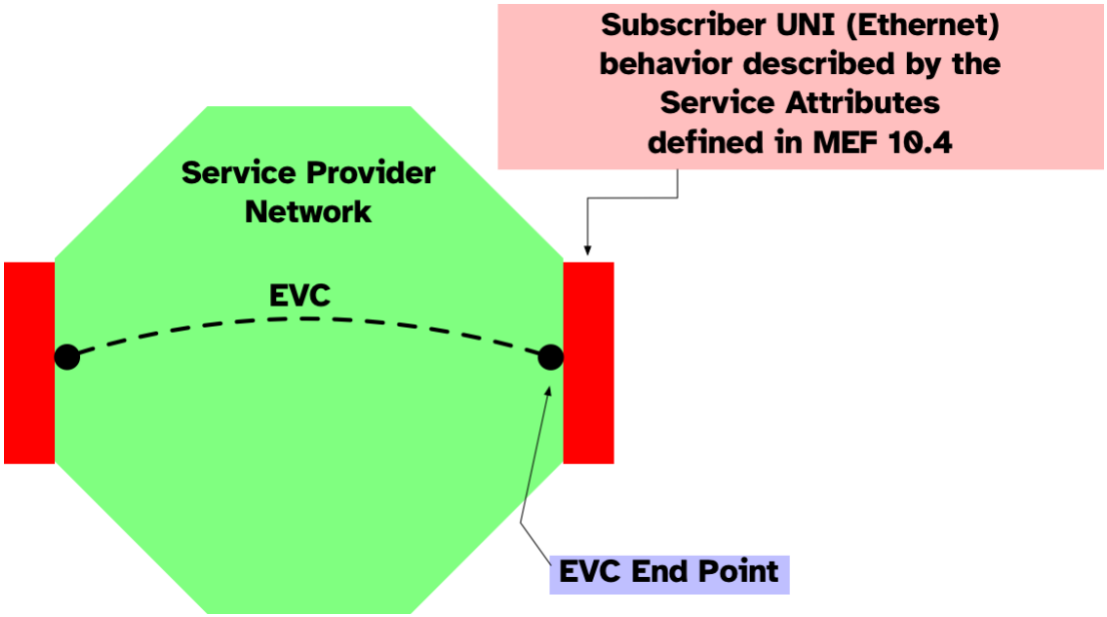

Figure 5 – Subscriber UNI, EVC, and EVC End Points

When the EVC is composed from OVCs (i.e., when, at least, one of the UNIs is accessed by the Service Provider via a Network Operator) such as the Broadband Access E-Line and Broadband Access E-LAN Services defined in this document, the UNIs for the OVCs are described by the Operator UNI Service Attributes defined in MEF 26.2 that are agreed on between the Service Provider and the Network Operator whose network is providing the access Service. Each OVC End Point is associated with an Operator UNI or ENNI. The implicit assumption in MEF 26.2 is that at a UNI, the EVC End Point behavior as observed by the Subscriber and the OVC End Point behavior as observed by the Service Provider that is providing access to that EVC are at the same physical interface. An example is shown in Figure 6. In this case, many of the Subscriber UNI Service Attributes and Operator UNI Service Attributes are required to have the same or consistent values. These relationships are described in Appendix H.3 in MEF 26.2.

Note that in Figure 6 and Figure 7 the blue EVC and OVC End Points are the ones referred to in the accompanying text.

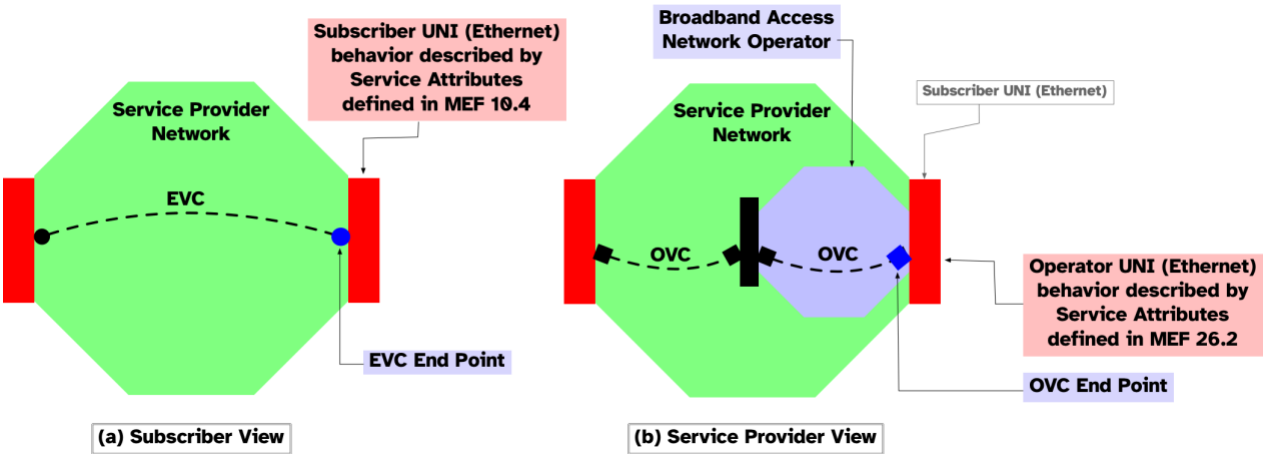

Figure 6 – Example of EVC End Point and OVC End Point at the Same Physical Interface

The model in Figure 6 is supported for Broadband Access E-Line and Broadband Access E-LAN Services.

Figure 7 depicts another model that can be used in Broadband Access Network deployments. In this case, the OVC End Point and the EVC End Point are associated with different physical interfaces. The Subscriber View is the same as in Figure 6. The Subscriber UNI still is required to be implemented by an Ethernet interface, but the Operator UNI could be implemented by an Ethernet interface or a Broadband interface such as a DOCSIS, GPON, or satellite interface.

If the Operator UNI is not associated with the same physical interface as the Subscriber UNI, the Service Provider is responsible for the equipment (shown as the gray box in Figure 7) that translates the Operator UNI physical interface into the Subscriber UNI physical interface. This translation has to be done in a way that results in behavior at the Subscriber UNI that conforms to the EVC, EVC End Point, and Subscriber UNI Service Attributes.

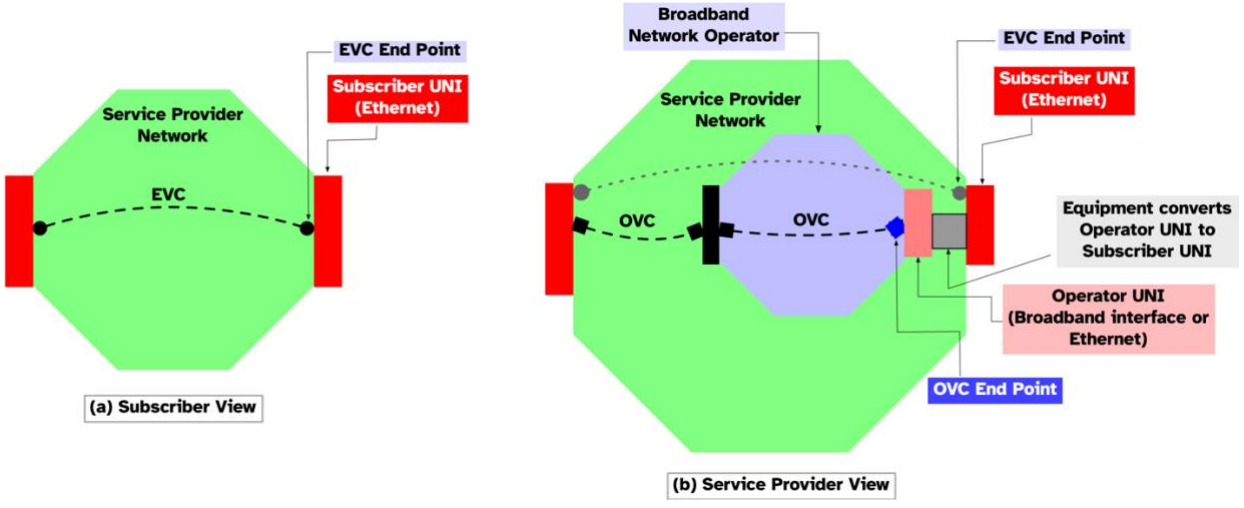

Figure 7 – OVC End Point at a Different Physical Interface from the EVC Endpoint Example

Note that the distinction between the two models is based on which organization is providing the conversion equipment (e.g., Cable Modem, or ONT, or Ethernet Switch, the gray box in Figure 7). If it is provided by the Broadband Access Network Operator, then the Operator UNI and Subscriber UNI are at the same physical interface as shown in Figure 6. But if the Ethernet Service Provider is providing it, then the Operator UNI and Subscriber UNI are at different physical interfaces as shown in Figure 7. Also note that the identity of the provider of the gray box might not be known by the Subscriber.

If the Operator UNI is not at the same physical interface as the Subscriber UNI, it could nonetheless be an Ethernet interface, i.e., one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1 [32], or it could be a non-Ethernet interface such as DOCSIS.

If the Operator UNI is an Ethernet interface, then the details of the Operator UNI physical interface are mandated to conform to the relevant Operator UNI Service Attributes described in MEF 26.2 with modifications specified in this document (see [R5]).

If the Operator UNI is not an Ethernet interface, then the Service Provider and the Broadband Access Network Operator are required to agree on the details of the interface (since the Service Provider is providing the gray box), but these details are beyond the scope of this document. The details must, however, meet the constraints specified in [R33] and [R34].

[R33] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the Operator UNI Physical Layer Service Attribute is not a list of one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1, then there **MUST** exist a map that maps the broadband data that crosses the Operator UNI to a sequence of pairs of the form $\langle s, t \rangle$ where s is a standard Ethernet Frame per Clause 3 of IEEE Std 802.3™ [9]and t is the arrival time at the Operator UNI for all bits in s.

[R34] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the Operator UNI Physical Layer Service Attribute is not a list of one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1, and if the result of applying the map referred to in [R33] is $\{\langle s_k, t_k \rangle, k = 0, 1, 2, \ldots\}$, then the following **MUST** hold:

$$\forall k \geq 0, \qquad t_{k+1} \geq t_k$$

In other words, applying the map required by [R33] yields a sequence of Ethernet Frames, each with an associated arrival time at the Operator UNI, and the arrival times of the Ethernet Frames are monotonically increasing. Note that a sequence of Ethernet Frames with monotonically increasing arrival times is necessary for implementation of both bandwidth management algorithms discussed in section 9.

[R35] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the Operator UNI Physical Layer Service Attribute is list of one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1, then the following Operator UNI Service Attributes **MUST** have values that conform to the requirements specified in MEF 26.2.

- Operator UNI Synchronous Mode
- Operator UNI Number of Links
- Operator UNI Link Aggregation
- Operator UNI Port Conversation to Aggregation Link Map
- Operator UNI Link OAM

MEF 26.2 specifies that the value the Operator UNI Service Frame Format Service Attribute must be Ethernet MAC Frame conforming to Clause 3 of IEEE 802.3™-2012. This is updated by [R36] and [R37] for consistency with MEF 61.1.1:

[R36] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the Operator UNI Physical Layer Service Attribute is a list of one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1, then the Operator UNI Service Frame Format **MUST** have the value *Ethernet MAC Frame conforming to Clause 3 of IEEE Std 802.3™-2018* [10].

[R37] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the Operator UNI Physical Layer Service Attribute is a list of one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1, then the Broadband Access Network **MUST** comply with the Ethernet Media Access Control standards specified in Clauses 3 and 4 of IEEE Std 802.3™-2018.

[R37] is a restatement of [R101] in MEF 26.2. Note that [R37] means that Service Frames will be discarded by the receiving Broadband Access Network if they are not properly constructed. For example, a Service Frame with an incorrect Frame Check Sequence will be discarded. However, this document provides for Service Frames that are longer than the maximum specified in IEEE Std 802.3™.

Note that for Broadband Access E-Line and Broadband Access E-LAN Services, if the Operator UNI is a list of one or more of the physical interfaces specified in Table A1-4 in MEF 61.1.1, the values of the Service Attributes listed in [R35] are likely to be heavily constrained. For example, most Operator UNIs for these Services will have a single physical interface (and no Link Aggregation) without synchronous Ethernet or Link OAM. But this document does not impose these constraints, and a Broadband Access Network Operator is welcome to provide a richer set of capabilities.

[O9] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the Operator UNI Physical Layer Service Attribute is not a list of one or more of the physical interfaces specified in Table A1-4 of MEF 61.1.1, the Operator UNI Service Attributes listed in [R35], and [R36] **MAY** not apply.

If the value of the Operator UNI Physical Layer Service Attribute is not a list of one or more of the physical interfaces specified in Table A1-4 of MEF 61.1.1, the details of the physical interface are beyond the scope of this document.

8.3.2 Operator UNI Ingress Bandwidth Profile per UNI and Operator UNI Egress Bandwidth Profile per UNI

MEF 10.4 [26] eliminated the per-UNI Ingress and Egress Bandwidth Profile Service Attributes that were specified in previous versions of MEF 10. Therefore, no EVCs that are implemented via an Operator UNI will have a per-UNI Bandwidth Profile and therefore there is no need for the OVCs that compose the EVC to have a per-UNI Bandwidth Profile.

[R38] For Broadband Access E-Line and Broadband Access E-LAN Services, the value of the Operator UNI Ingress Bandwidth Profile per UNI and the Operator UNI Egress Bandwidth Profile per UNI Service Attributes **MUST** be *Disabled*.

8.3.3 Operator UNI Default CE-VLAN ID

This Service Attribute provides a mechanism for mapping Untagged and Priority Tagged Service Frames to the OVC End Point. The method for mapping frames to an OVC End Point used for Services described in this document differs from the approach documented in MEF 26.2 in favor of an approach that is a generalization of the approach in MEF 10.4, therefore this Service Attribute is deemed *Not Applicable* for these Services. See section 8.2.3 for more detail.

8.3.4 Operator UNI E-LMI

MEF 26.2 specifies that the value for the Operator UNI E-LMI Service Attribute can be *Enabled* or *Disabled*. However, MEF 10.4 removed the E-LMI Service Attribute. Since it does not make sense for E-LMI to be *Enabled* on the Operator UNI but not on the Subscriber UNI, this document mandates that the value for this Service Attribute be *Disabled*.

8.4 ENNI Service Attributes

This section contains information on ENNI Service Attributes whose allowable values are different than the values specified in MEF 26.2 [27] and MEF 51.1 [30] and ENNI Service Attributes that require further discussion.

8.4.1 Maximum Number of OVC End Points per OVC

Per section 13.4 of MEF 26.2 [27] an OVC can have multiple OVC End Points at an ENNI. This allows hairpin switching but this is not supported for Broadband Access E-Line and Broadband Access E-LAN Services. Therefore, the value of this Service Attribute is always *1*.

[R39] For Broadband Access E-Line and Broadband Access E-LAN Services the value of the Maximum Number of OVC End Points Per OVC Service Attribute **MUST** be 1.

Since [R39] allows only a single OVC End Point (per OVC) at an ENNI, the value of the OVC Maximum Number of ENNI OVC End Points Service Attribute — which is required to be *1* for Broadband Access E-Line and can be greater than *1* for Broadband Access E-LAN — indicates the number of ENNIs the OVC can connect to.

9 Bandwidth Management and Bandwidth Profiles

Some Broadband Access Networks do not implement Bandwidth Profiles based on the Token Bucket algorithm specified in MEF 26.2. Instead, some implement bandwidth metering that is similar to the approach to Bandwidth Profiles introduced in MEF 61.1. Therefore, to facilitate the availability of Broadband Access E-Line and Broadband Access E-LAN Services, this document introduces a Bandwidth Profile approach similar to that of MEF 61.1 and allows the Broadband Access Network Operator to choose this approach as an alternative to the Token Bucket Algorithm.

This section describes the values for the following Service Attributes when the value of the OVC Bandwidth Profile Algorithm Type Service Attribute is *Interval Averaging*:

- Operator UNI Envelopes
- ENNI Envelopes
- OVC End Point Ingress Bandwidth Profile per Class of Service Name
- OVC End Point Egress Bandwidth Profile per Egress Equivalence Class Name

9.1 Overview of Bandwidth Delivered at a UNI on a Broadband Access Network

Multiple services can be delivered at a UNI on a Broadband Access Network including traditional multimedia streams, VoIP streams, Internet Access Services, and, in the context of this document, Broadband Access E-Line and Broadband Access E-LAN Services. This means that the total bandwidth available at the UNI might be split across these multiple services and that each Broadband Access E-Line and Broadband Access E-LAN Service instance may have access to only a fraction of the total UNI bandwidth.

Note that the total available bandwidth is limited by the physical layer bandwidth of the UNI, but the available bandwidth is frequently less than that. For example, the Broadband Access Network might provide a 1 Gbps physical layer at the UNI, but the bandwidth available to the Subscriber may only be 100 Mbps for Broadband Access E-Line and Broadband Access E-LAN Services.

Some of the services delivered at the UNI may have bandwidth assigned that is not sharable. For example, there could be 10 VoIP channels, each channel using 1 Mbps which is carved out of the total bandwidth and not available to any other service. On the other hand, there could be 3 multimedia streams available at 20 Mbps each, but if, for a time interval, all three are not in use, then the unused bandwidth could be used by other data services at the UNI such as Internet Access or Broadband Access E-Line and Broadband Access E-LAN Services. Other standards organizations such as the Broadband Forum and 3GPP have addressed similar bandwidth management paradigms[12] for ADSL and Digital Cellular networks (for example). This document expresses bandwidth management in the terminology and structure of MEF Services.

MEF 26.2 (section 17) specifies a Token Bucket algorithm. The Token Bucket algorithm, however, specifies burst tolerance in a way that is not aligned with the bandwidth management methods utilized in some Broadband Access Networks. Bandwidth management in some Broadband Access

[12] The Broadband Forum TR-176 [2] (section 4.2) discusses Rate-Adaptive Profiles. and TR-144 [5] (section 7.11) describes dynamic bandwidth behaviors. The 3GPP (ETSI) Technical Standard 23.203 [6] defines an architecture where bandwidth profiles and data flows are tied to the ability to charge the Subscriber for the bandwidth utilized.

Networks better aligns with the specification of Bandwidth Profiles in MEF 61.1 [31], the IP Service Attributes Standard. Therefore, in this document Bandwidth Profiles for Broadband Access E-Line and Broadband Access E-LAN Services provide the option to use a method that is similar to the Bandwidth Profiles specified in MEF 61.1. However, a Broadband Access Network Operator can alternatively implement bandwidth management consistent with MEF 26.2 or some other algorithm. This document defines a new Service Attribute called OVC Bandwidth Profile Algorithm Type that specifies the algorithm to be used. See section 8.1.6.

9.2 Bandwidth Profile Flows

A Bandwidth Profile Flow in a Broadband Access E-Line or a Broadband Access E-LAN Service is a set of EI Frames that meet a specific criterion described below in [R40]. Each Bandwidth Profile Flow is associated with a Bandwidth Profile that describes the amount of bandwidth that can be used by the Bandwidth Profile Flow. This definition of a Bandwidth Profile Flow is applicable the OVC Bandwidth Profile Algorithm Type Service Attribute value is *Token Bucket* or *Interval Averaging* (see section 8.1.6).

MEF 26.2 allows multiple methods for specifying Bandwidth Profile Flows, however other MEF standards constrain the allowed methods. Specifically,

- MEF 51.1 [30] does not allow Bandwidth Profile Flows to be defined by OVC End Point
- MEF 10.4 [26] does not include Bandwidth Profile Flows specified per UNI

Therefore, per CoS Name and per Egress Equivalence Class Bandwidth Profile Flows at an OVC End Point are the only Bandwidth Profile Flow specifications used for Broadband Access E-Line and Broadband Access E-LAN Services. This is a subset of the criteria specified in MEF 26.2.

[R40] For Broadband Access E-Line and Broadband Access E-LAN Services, a Bandwidth Profile Flow **MUST** be specified using one of the following criteria[13]:

1. all ingress EI Frames that map to a given Class of Service Name, that map to a given OVC End Point, and that are not discarded by [R101][14] in MEF 26.2
2. all egress EI Frames that map to a given Egress Equivalence Class Name, that map to a given OVC End Point, and that are not discarded by [R101] in MEF 26.2.

In MEF 61.1, as in MEF 26.2, each Bandwidth Profile Flow is assigned to an envelope. An envelope is a construct defined to allow multiple Bandwidth Profile Flows to share bandwidth, although it is common to have an envelope that contains a single Bandwidth Profile Flow. The definition and parameters associated with an envelope are different for the OVC Bandwidth Profile Algorithm Type Service Attribute values *Token Bucket* and *Interval Averaging*. The Bandwidth Profile Envelope for the Token Bucket Algorithm is defined in MEF 26.2 and the envelope for the

[13] [R40] is a subset of [R230] in MEF 26.2 (specifically criteria 2 and 5 in [R230]) because only Bandwidth Profile Flow per Class of Service Name/Egress Equivalence Class Name are supported in this document.
[14] [R101] in MEF 26.2 requires that the Operator Network comply with the Ethernet Media Access Control standards specified in Clauses 3 and 4 of IEEE Std 802.3™-2012.

Interval Averaging Algorithm, hereafter referred to as the Interval Averaging Bandwidth Profile Envelope, is defined below is section 9.3.

[R41] For Broadband Access E-Line and Broadband Access E-LAN Services, the Bandwidth Profile Flows in a Bandwidth Profile Envelope **MUST** meet exactly one of the following conditions:

1. They are all based on criterion 1 in [R40]
2. They are all based on criterion 2 in [R40]

A Bandwidth Profile Flow based on criterion 1 in [R40] is called an Ingress Bandwidth Profile Flow. A Bandwidth Profile Flow based on criterion 2 in [R40] is called an Egress Bandwidth Profile Flow.

[R42] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Bandwidth Profile Algorithm Type Service Attribute is not *Other* or *None*, then the Bandwidth Profile parameters and algorithm **MUST** conform to:

- The Token Bucket parameters and algorithm as defined in MEF 26.2 section 17 if the value of the of the OVC Bandwidth Profile Algorithm Type Service Attribute = *Token Bucket*, or
- The Interval Averaging parameters and algorithm as defined in sections 9.3, 9.4, and 9.5 if the value of the OVC Bandwidth Profile Algorithm Type Service Attribute = *Interval Averaging*.

If the value of the OVC Bandwidth Profile Algorithm Type Service Attribute = *Interval Averaging*, the Interval Averaging Bandwidth Profile Envelope and Interval Averaging Bandwidth Profile parameters and algorithm as defined in sections 9.3 through 9.5 apply.

9.3 Interval Averaging Bandwidth Profile Parameters

Interval Averaging Bandwidth Profile Envelope parameters are summarized in Table 14.

Parameter Name	Symbol	Units/Values
Envelope Identifier	*envelopeId*	Identifier (see [R1])
Envelope Maximum Information Rate	*envelopeMaxIr*	Bits per second (Integer>0)
Envelope IR Time	*envelopeIrTime*	Milliseconds (Real number>0)

Table 14 – Interval Averaging Bandwidth Profile Envelope Parameters

Each Interval Averaging Bandwidth Profile Envelope has a name (*envelopeId*).

An Interval Averaging Bandwidth Profile Envelope has a Maximum Information Rate (*envelopeMaxIr*) which is the limit on the total aggregate information rate of traffic across all the Bandwidth Profile Flows in the Interval Averaging Bandwidth Profile Envelope.

Information rates are averaged over a time interval. Therefore, the Interval Averaging Bandwidth Profile Envelope has a parameter, the Envelope IR Time (*envelopeIrTime*) specified in milliseconds, which is the averaging period.

[R43] If the value of the OVC Bandwidth Profile Algorithm Type Service Attribute = *Interval Averaging*, then the value of the Operator UNI Envelopes Service Attribute and the ENNI Envelopes Service Attribute **MUST** be a list of 3-tuples ⟨*envelopeId, envelopeMaxIr, envelopeIrTime*⟩.

Each Interval Averaging Bandwidth Profile Flow has a set of Interval Averaging Bandwidth Profile Flow parameter values. These are summarized in Table 15.

Parameter Name	Symbol	Units/Values
Envelope Id	*bpfEnvelope*	Identifier (see [R1])
Committed Information Rate	*bpfCir*	Bits per second (Integer>0)
Maximum Information Rate	*bpfMaxIr*	Bits per second (Integer>0)
Burst Behavior	*bpfBurst*	*Optimize-Delay* or *Optimize-Throughput*

Table 15 – Interval Averaging Bandwidth Profile Flow Parameters

When using the Interval Averaging algorithm, each Bandwidth Profile Flow is assigned to an Interval Averaging Bandwidth Profile Envelope (*bpfEnvelope*). As noted above, this provides a mechanism for sharing bandwidth among Interval Averaging Bandwidth Profile Flows.

When using the Interval Averaging algorithm, each Bandwidth Profile Flow has a Committed Information Rate (*bpfCir*) parameter. This represents the portion of the total Interval Averaging Bandwidth Profile Envelope bandwidth (*envelopeMaxIr*) that is allocated for the Bandwidth Profile Flow, if needed, and enforced per [R44] below. A Bandwidth Profile Flow can opportunistically use bandwidth above *bpfCir* up to *bpfMaxIr*.

[R44] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, then the sum of the *bpfCir* values for all Bandwidth Profile Flows in an Interval Averaging Bandwidth Profile Envelope **MUST** be less than or equal to the value of *envelopeMaxIr* for the Interval Averaging Bandwidth Profile Envelope.

The value of *envelopeMaxIr* limits the total amount of bandwidth available to Bandwidth Profile Flows within the Interval Averaging Bandwidth Profile Envelope, so if it were less than the sum of the *bpfCir* values, then it would be impossible for all the Bandwidth Profile Flows to achieve their committed bandwidth during a time interval of duration *envelopIrTime*.

When using the Interval Averaging algorithm, each Bandwidth Profile Flow has a *bpfMaxIr* parameter. The value of *bpfMaxIr* is a limit on the information rate that can be used by the Bandwidth Profile Flow during a time interval of duration *envelopIrTime*. In other words, if additional Interval Averaging Bandwidth Profile Envelope bandwidth is available, each Bandwidth Profile Flow can be allocated some of the additional bandwidth as long as the total amount of bandwidth allocated to the Bandwidth Profile Flow during a time interval of duration *envelopIrTime* does not exceed *bpfMaxIr*.

[R45] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, then for a Bandwidth Profile Flow contained in an Interval Averaging Bandwidth Profile Envelope, the value of the Bandwidth Profile Flow's *bpfMaxIr* **MUST** be greater than or equal the value of its *bpfCir*.

Each Bandwidth Profile Flow has a Burst Behavior parameter, *bpfBurst*. This value of this parameter is either *Optimize-Delay* or *Optimize-Throughput*. See section 9.5 for a description of how the value of this parameter impacts the behavior of a Service as observed by the Service Provider and/or Subscriber.

9.4 Interval Averaging Bandwidth Profile Behavior

If the value of the OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, then the effect of metering a stream of EI Frames against a Bandwidth Profile — that is, comparing the actual sequence of EI Frames to the description in terms of the Bandwidth Profile parameter values — is to declare each frame either conformant or non-conformant. This information can be used to take further action, for example policing or shaping. The combined effect is such that each frame has one of two outcomes:

- The frame is declared non-conformant and discarded
- The frame is declared conformant passed immediately or after a short delay

The desired behavior described by an Interval Averaging Bandwidth Profile is specified in terms of average information rates. The average information rate of a stream of Ethernet Frames over a given time interval is defined to be the sum of the lengths of the Ethernet Frames in the stream (in bytes), multiplied by 8, and divided by the duration of the averaging interval in seconds. Specifically, if N is the number of Ethernet Frames in a stream of Ethernet Frames whose first bit of the destination MAC address passes a reference point (e.g., a UNI) during a time interval of duration Δt, and *Lp* is the length in bytes from the first byte of the destination MAC address to the last byte of the FCS of the p^{th} such Ethernet Frame, the average information rate is:

$$IR = 8 * \frac{\sum_{p=1}^{N} L_p}{\Delta t}$$

For Bandwidth Profile Flows in a given Interval Averaging Bandwidth Profile Envelope, the *envelopeIrTime* Interval Averaging Bandwidth Profile Envelope parameter is the averaging interval (Δt in the above equation). Defining the average information rate in this way means that bursts of Ethernet Frames are possible. A burst of Ethernet Frames might pass the reference point at a rate much higher than the average information rate, but for a time duration much shorter than Δt, provided that Ethernet Frames pass the reference point at rate lower than the average information rate for the remainder of Δt. Therefore, the value of *envelopeIrTime* defines a limit on the size of a burst.

For example, if the UNI physical layer data rate is 1 Gbps and a single Interval Averaging Bandwidth Profile Envelope with a single Bandwidth Profile Flow with a *bpfCir* of 500Mbps and Δt = *envelopeIrTime* = 1 second, a burst of 1Gbps for 500ms followed by 500ms with no traffic, then all frames conform to the Bandwidth Profile parameters. The burst in this example is over 60MB of data. As another example, if Δt = *envelopeIrTime* = 250ms, then the burst would be 1

Gbps for 125ms (15MB) followed by 125ms with no traffic. In both cases the average information rate is 500 Mbps.

Informally, the objective is as follows:

- For each Bandwidth Profile Flow in an Interval Averaging Bandwidth Profile Envelope, allocate up to *bpfCir* to that flow, if necessary (i.e., if at least that much traffic for the Bandwidth Profile Flow is arriving at the reference point).
- Determine how much available bandwidth remains, by subtracting the amounts allocated in the previous bullet from the *envelopeMaxIr* for the Interval Averaging Bandwidth Profile Envelope. See [R47].
- Allocate this remainder across all the Bandwidth Profile Flows, such that:
    - No more is allocated to a given Bandwidth Profile Flow than the amount of traffic arriving for that flow at the reference point.
    - No more is allocated to a given Bandwidth Profile Flow than the *bpfMaxIr* for that Bandwidth Profile Flow. See [R46].

[R46] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Bandwidth Profile Algorithm Type Service Attribute is *Interval Averaging*, then the average information rate of EI Frames during any time interval of duration *envelopeIrTime* declared conformant in an Interval Averaging Bandwidth Profile Flow **MUST** be less than or equal to *bpfMaxIr*.

[R47] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of the OVC Bandwidth Profile Algorithm Type Service Attribute is *Interval Averaging*, then the average information rate of EI Frames during any time interval of duration *envelopeIrTime* declared conformant in an Interval Averaging Bandwidth Profile Envelope **MUST** be less than or equal to *envelopeMaxIr*.

Detailed methods subject to [R46] and [R47] for allocation of additional (opportunistic) bandwidth to each Bandwidth Profile Flow are beyond the scope of this document. However recommendations [D6] [D7] and requirements [R48][R49] apply to methods for allocation of additional bandwidth to each Bandwidth Profile Flow.

[D6] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, then during any time interval of duration *envelopeIrTime*, if the average information rate for a Bandwidth Profile Flow exceeds *bpfCir*, then enough EI Frames in the Bandwidth Profile Flow **SHOULD** be declared non-conformant such that the average information rate during the time interval is at least *bpfCir* and at most *bpfMaxIr*.

Recommendation [D6] indicates that the goal is to keep the bandwidth utilization for a Bandwidth Profile Flow during any interval of duration *envelopeIrTime* between *bpfCir* and *bpfMaxIr*. It is possible that there isn't a set of frames that can be declared non-conformant in order to keep the bandwidth below *bpfMaxIr* that doesn't also result in the bandwidth being below *bpfCir*.

[D7] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, then during any time interval of duration *envelopeIrTime*, enough EI Frames in the Bandwidth Profile Flows contained in a given Interval Averaging Bandwidth Profile Envelope whose average information rate during the time interval exceeds their *bpfCir* values **SHOULD** be declared non-conformant in order to ensure that the average information rate for all frames during the time interval that are declared conformant is at most *envelopeMaxIr*.

The goal of [D6] and [D7] is to keep the bandwidth allocated to each Bandwidth Profile Flow to at least *bpfCir* but not more than *bpfMaxIr*.

[R48] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, an EI Frame in a Bandwidth Profile Flow **MUST** be declared conformant unless it is declared non-conformant per [D6] or [D7].

[R49] For Broadband Access E-Line and Broadband Access E-LAN Services, if the value of OVC Bandwidth Profile Algorithm Service Attribute is *Interval Averaging*, EI Frames that are declared non-conformant **MUST** be discarded.

Note that EI Frames discarded as a result of the above requirements are not considered Qualified Ethernet Frames (see MEF 26.2 [27] section 12.13.1.3), and hence do not contribute to any Frame Loss Ratio objective specified in the Service Level Specification if an SLS is specified for the Service. Conversely, EI Frames that are declared conformant by the Bandwidth Profile meter do constitute Qualified Ethernet Frames (provided they meet the other criteria specified in MEF 26.2) and hence cannot be discarded without risk of failing to meet a Frame Loss Ratio objective in the Service Level Specification.

As an illustration of the above behavior, consider a Bandwidth Profile when the value of the Bandwidth Profile Algorithm Type Service Attribute = *Interval Averaging* with *envelopeMaxIr* = 100Mb/s, and the following Bandwidth Profile Flows:

Bandwidth Profile Flow	bpfCir	bpfMaxIr
1	20 Mbps	20 Mbps
2	0	40 Mbps
3	0	100 Mbps
4	0	100 Mbps

Table 16 – Example of Bandwidth Profile Flow Parameters

Following are various example traffic patterns with the expected behavior of each per the above requirements and recommendations:

- If traffic is offered for only flow 1 then no more than 20 Mbps is forwarded
- If traffic is offered for only flow 2 then no more than 40 Mbps is forwarded
- If traffic offered across all flows and the average information rate over some interval of length *envelopeIrTime* is $\geqslant$ 100 Mbps:
  → no more than 20 Mbps is passed for flow 1

→ the additional bandwidth available to other flows is at least 80 Mbps = *envelopeMaxIr*-20 Mbps for Flow 1

As noted above, details of the allocation of bandwidth above *bpfCir* to the flows is beyond the scope of this document but could, for example, be allocated to the Bandwidth Profile Flows as frames arrive during *envelopeIrTime* (up to *bpfMaxIr* for each Bandwidth Profile Flow or *envelopeMaxIr* for the Interval Averaging Bandwidth Profile Envelope) or be based on the relative values of their *bpfMaxIr* (e.g., 1, 2, 5, 5) assuming that each of the flows needed at least that much additional bandwidth.

9.5 Frame Bursts

When a burst of Ethernet Frames is received — that is, a number of Ethernet Frames in quick succession such that the Information Rate over a short time exceeds the average Information Rate over *envelopeIrTime* — it can be beneficial for the Broadband Access Network Operator to delay some of the Ethernet Frames such that the burst is "smoothed out". This is typically implemented by buffering Ethernet Frames and servicing the buffer at the desired rate — in other words, by shaping.

The disadvantage of smoothing bursty traffic is that Frame Delay and the variation in Frame Delay from Frame to Frame (frequently called inter-frame delay variation or delay variation) are adversely affected. If Ethernet Frames are buffered, then the average end-to-end delay will increase. Additionally, as different Ethernet Frames can be buffered for different lengths of time, the delay variation is also increased.

Each Bandwidth Profile Flow includes the *bpfBurst* parameter to indicate the desired Burst Behavior. If the Bandwidth Profile Flow comprises traffic that is sensitive to delay and delay variation, such as voice or video traffic, then *bpfBurst* can be set to *Optimize-Delay*. Conversely, if the Bandwidth Profile Flow comprises traffic that is more sensitive to loss, such as TCP traffic, then *bpfBurst* can be set to *Optimize-Throughput*.

There are no requirements specifically relating to the Burst Behavior parameter; it is included as a guide for the Service Provider or Broadband Access Network Operator as to how to implement the Interval Averaging Bandwidth Profile behavior so as to meet the Subscriber's or Service Provider's needs and provide them with a good quality of experience; for example, whether to apply shaping, policing, or a combination of these to the Bandwidth Profile Flow.

Note that if the Service includes a Service Level Specification that contains objectives for any of the four delay-related Performance Metrics, then the choice of value for the *bpfBurst* parameter might impact the degree to which the Performance Objectives specified in the SLS are met. Consequently, when the value of *bpfBurst = Optimize-Throughput*, the agreed values of the delay-related Performance Objectives in the SLS will likely be less stringent then when the value of *bpfBurst = Optimize-Delay*. The difference in delay and throughput between the values *Optimize-Delay* and *Optimize-Throughput* is beyond the scope of this document.

Whether Ethernet Frames are delayed or not, they cannot be re-ordered.

[R50] For Broadband Access E-Line and Broadband Access E-LAN Services, regardless of the value of the OVC Bandwidth Profile Algorithm Type Service Attribute, Ethernet Frames **MUST NOT** be reordered by the Broadband Access Network.

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Appendix A Compatibility of Broadband Access E-Line and Broadband Access E-LAN with MEF 6.3 (Informative)

Subscriber Ethernet Services (EVCs) as defined in MEF 6.3 [24] can be composed from Operator Ethernet Services (OVCs) which are defined in MEF 51.1 [30] based on the Service Attributes defined in MEF 26.2 [27].

The Service Attributes in MEF 26.2 [27] are defined so that the composition of OVCs into EVCs could result in Subscriber Ethernet Services that met the requirements of MEF 10.3 [25] and MEF 6.2 [23]. Since the publication of MEF 26.2, MEF 10.3 and MEF 6.2 have been updated to MEF 10.4 [26] and MEF 6.3 [24]. There are several functional changes defined in MEF 10.4 that result in some mismatches between the capabilities of OVCs and the capabilities of EVCs. For example, MEF 26.2 includes the Operator UNI Default CE-VLAN ID Service Attribute as a mechanism for mapping Untagged and Priority Tagged Frames to an OVC End Point and MEF 10.4 uses a different mechanism for mapping these frames to an EVC End Point.

This document defines the OVC End Point Map Service Attribute with values that can be consistent with MEF 10.4, so that mismatch is partially mitigated for Broadband Access E-Line and Broadband Access E-LAN Services (although any EVC might also include other OVCs that are not carried over Broadband Access Networks). But this document does modify, extend, or redefine several other Service Attributes that can result in EVCs that don't faithfully match the Service Attribute values defined in MEF 10.4 and/or the behavior described by those Service Attributes. This doesn't mean that the resulting Subscriber Ethernet Service won't work, but rather that the resulting Service (e.g., EVPL, EPL, EVP-LAN, etc.) won't behave exactly like the Service defined in MEF 6.3 and based on MEF 10.4.

The list below identifies the Service Attributes described in this document that will most affect compatibility with MEF 6.3-defined Services in which a Broadband Access E-Line Service or a Broadband Access E-LAN Service is a component.

Note that in each case it is possible to specify a value for the Service Attribute for Broadband Access E-Line Service and/or Broadband Access E-LAN Service such that it is possible for an EVC resulting from the composition of OVCs that includes these Services to be compatible with MEF 10.4 and MEF 6.3. This will depend on the capabilities of the Broadband Access Network components and the Broadband Access Network Operator configuration of those components.

These include:

- OVC CE-VLAN ID Preservation (see section 8.1.1) – This Service Attribute is defined in MEF 26.2 but does not have an analogous Service Attribute in MEF 10.4. In this document the definition of the behavior associated with this Service Attribute attempts to be as close as possible to the MEF 26.2 definition. If the value for the OVC End Point Map is *All*, *List*, or *UT/PT* and the value of this Service Attribute is *Preserve*, the resulting OVC can be used to implement EVCs compatible with MEF 6.3.
- OVC Frame Delivery (see section 8.1.3) – The definition of this Service Attribute in this document supports the behavior defined in MEF 10.4 and MEF 6.3. Specifically, compatible behavior can be achieved by:

- For Broadband Access E-Line Services specifying *Deliver Unconditionally* for Unicast, Multicast and Broadcast Frames, and
- For Broadband Access E-LAN Services specifying *Deliver Conditionally* (see [D4] for the condition) for unicast frames and *Deliver Unconditionally* for Broadcast Frames. There are no specific requirements for Multicast Frames.

This document, however, includes some extensions that are not compatible in order to deal with situations in Broadband Access Networks such as:

- Some Broadband Access Networks discard Broadcast Frames that ingress at an ENNI, and
- Some Broadband Access Networks will not deliver Unicast Frames to unknown destination addresses to UNIs.

- OVC L2CP Address Set Service Attribute (see section 8.1.5) – Broadband Access Networks do not, in general, process Layer 2 Control Protocols. Therefore, the standard applications of CTA and CTB (especially CTB) cannot always be realized. Therefore, an additional value, *Other*, is introduced. However, if a Broadband Access Network can support the requirements in MEF 45.1 (specifically related to CTB or CTB-2), then the value of the OVC L2CP Address Set Service Attribute would be compatible with an OVC as defined in MEF 26.2 and with an EVC as defined in MEF 10.4.
- OVC End Point Map Service Attribute (section 8.2.3) – As noted above, the definition of this Service Attribute for an OVC End Point located at an Operator UNI is derived from the MEF 10.4 definition rather than the MEF 26.2 definition. The values *All*, *List*, and *UT/PT* are compatible with MEF 10.4 and MEF 6.3, however, the values that avoid mapping Priority Tagged Service Frames to the OVC End Point (i.e., *All-NP* and *UT*) are not compatible with MEF 6.3 Services.
- Bandwidth Profiles (see section 9) defined in this document can differ substantially from the Bandwidth Profiles based on the Token Bucket Algorithm used in MEF 26.2. The Bandwidth Profile algorithm defined in this document, called Interval Averaging is derived from MEF 61.1 (IP Services) and provides a new option that is similar to what some Broadband Access Networks currently use for bandwidth management. The choice of Bandwidth Profile algorithm is agreed to via a new Service Attribute defined in this document, OVC Bandwidth Profile Algorithm Type Service Attribute. This new Service Attribute allows the Service Provider to use either *Token Bucket*, *Interval Averaging*, *Other,* or *None*. If *Token Bucket* or *None* is specified, or if no Bandwidth Profiles are used (i.e., the value of the Ingress and Egress Bandwidth Profile per Class of Service Name Service Attributes = *None*, see section 8.2.4) then compatibility can be achieved.

These Service Attributes along with their compatible values are summarized in Table 17.

Service Attribute	MEF 6.3 Compatible Values	Notes / Comments
OVC CE-VLAN ID Preservation	*Preserve*	OVC End Point Map Service Attribute has to have value *All*, *List*, or *UT/PT*
OVC Frame Delivery	For Broadband Access E-Line: *Deliver Unconditionally* for all frame types and for Broadband Access E-LAN, *Deliver Unconditionally* for broadcast and *Deliver Conditionally* for *unicast*.	See [D4] for the condition required for *Deliver Conditionally*
OVC L2CP Address Set Service	CTB or CTB-2 if the value of the OVC End Point Map at the UNI = *All* and CTA if the value is *List* or *UT/PT*.	
OVC End Point Color Identifier	Any value that results in all ingress frames being declared *Green*.	
OVC End Point Map	*All*, *List*, *UT/PT*	*All-NP* and *UT* (introduced in this document) are not compatible but if Priority Tagged Service Frames are not used, then there is compatibility.
Ingress and Egress Bandwidth Profile per Class of Service Name	*None* or OVC Bandwidth Profile Algorithm Type Service Attribute = *Token Bucket*	

Table 17 – MEF 6.3 Compatible Values for Service Attributes

Appendix B Acknowledgements (Informative)

The following contributors participated in the development of this document and have requested to be included in this list.

- Bertrand **BUCLIN**
- Bob **KLESSIG**
- Isabelle **MORENCY**
- Rayan **OUZERI**
- Larry **SAMBERG**
- Polly **WEMANS**
- Jason **WOLFE**