MEF Standard

MEF 51.1

Operator Ethernet Service Definitions

December 2018

Disclaimer

The information in this publication is freely available for reproduction and use by any recipient and is believed to be accurate as of its publication date. Such information is subject to change without notice and MEF Forum (MEF) is not responsible for any errors. MEF does not assume responsibility to update or correct any information in this publication. No representation or warranty, expressed or implied, is made by MEF concerning the completeness, accuracy, or applicability of any information contained herein and no liability of any kind shall be assumed by MEF as a result of reliance upon such information.

The information contained herein is intended to be used without modification by the recipient or user of this document. MEF is not responsible or liable for any modifications to this document made by any other party.

The receipt or any use of this document or its contents does not in any way create, by implication or otherwise:

a) any express or implied license or right to or under any patent, copyright, trademark or trade secret rights held or claimed by any MEF member which are or may be associated with the ideas, techniques, concepts or expressions contained herein; nor

b) any warranty or representation that any MEF members will announce any product(s) and/or service(s) related thereto, or if such announcements are made, that such announced product(s) and/or service(s) embody any or all of the ideas, technologies, or concepts contained herein; nor

c) any form of relationship between any MEF member and the recipient or user of this document.

Implementation or use of specific MEF standards, specifications, or will be voluntary, and no member shall be obliged to implement them by virtue of participation in MEF Forum. MEF is a non-profit international organization to enable the development and worldwide adoption of agile, assured and orchestrated network services. MEF does not, expressly or otherwise, endorse or promote any specific products or services.

Table of Contents

List of Figures

List of Tables

1 List of Contributing Members

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

- AT&T
- Bell Canada
- Cisco Systems
- Verizon Communications

2 Abstract

This document specifies Operator Ethernet Services based on the Service Attributes defined in MEF 26.2 [7]. The key service constructs are the Operator Virtual Connection (OVC) and the OVC End Points at the External Interfaces (EIs) – the External Network Network Interface (ENNI) and the User Network Interface (UNI). Per MEF 26.2 [7], at least one OVC End Point is at an ENNI. Three General Operator Ethernet Services are defined, based on OVC Type. In addition, two E-Access and two E-Transit services are defined, based on OVC Type and the EIs involved. This document supersedes and replaces MEF 51 [11], which is based on MEF 26.1 [6] Service Attributes, and MEF 33 [9].

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 of the following table is used to provide the reference that is controlling, in other MEF or external documents.

In addition, terms defined in MEF 10.4 [5], MEF 26.2 [7] and MEF 30.1 [8] are included in this document by reference and are not repeated in the table below.

Term	Definition	Reference
Access E-LAN Service	An E-Access Service based on the O-LAN Service definition.	This document
Access E-Line Service	An E-Access Service based on the O-Line Service definition.	This document
E-Access Service	An Operator Ethernet Service that associates at least one OVC End Point that is at a UNI and at least one OVC End Point that is at an ENNI.	This document
E-Transit Service	An Operator Ethernet Service that associates only OVC End Points that are at ENNIs.	This document
Ethernet Service	A connectivity service that carries Ethernet Frames irrespective of the underlying technology and that is specified using Service Attributes as defined in an MEF Specification.	MEF 10.4
General Operator Ethernet Service	An Operator Ethernet Service which is an O-Line, an O-LAN, or an O-Tree Service.	This document
Operator Ethernet Service	An Ethernet Service that is provided by an Operator to another Operator or to an Ethernet Service Provider.	This document
O-LAN Service	An Operator Ethernet Service that uses a Multipoint-to-Multipoint OVC.	This document
O-Line Service	An Operator Ethernet Service that uses a Point-to-Point OVC.	This document
O-Tree Service	An Operator Ethernet Service that uses a Rooted-Multipoint OVC.	This document
SO	Super Operator	This document
SP	Service Provider	This document

Term	Definition	Reference
Transit E-LAN Service	An E-Transit Service based on the O-LAN Service definition.	This document
Transit E-Line Service	An E-Transit Service based on the O-Line Service definition.	This document

Table 1 **– Terminology and Acronyms**

4 Compliance Levels

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 (RFC 2119 [2], RFC 8174 [3]) 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**.**

A paragraph preceded by **[CR*a*]<** specifies a conditional mandatory requirement that **MUST** be followed if the condition(s) following the "<" have been met. For example, "**[CR1]<**[D38]" indicates that Conditional Mandatory Requirement 1 must be followed if Desirable Requirement 38 has been met. A paragraph preceded by **[CD*b*]<** specifies a Conditional Desirable Requirement that **SHOULD** be followed if the condition(s) following the "<" have been met. A paragraph preceded by **[CO*c*]<** specifies a Conditional Optional Requirement that **MAY** be followed if the condition(s) following the "<" have been met.

5 Numerical Prefix Conventions

This document uses the prefix notation to indicate multiplier values as shown in Table 2.

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 2 – Numerical Prefix Conventions

6 Introduction

This document defines Operator Ethernet Services in terms of the Service Attributes specified in MEF 26.2, *External Network Network Interfaces (ENNI) and Operator Service Attributes* [7]. These Service Attributes include: Operator Virtual Connection (OVC) Service Attributes, OVC End Point Service Attributes, External Network Network Interface (ENNI) Service Attributes and Operator User Network Interface (UNI) Service Attributes. This document does not specify any constraints on the ENNI Service Attribute values and the Operator UNI Service Attribute values. Note that for a given Operator Ethernet Service, at least one OVC End Point is required to be at an ENNI, per [R36] of MEF 26.2 [7].

An Operator of a Carrier Ethernet Network (CEN) is responsible for providing the Operator Ethernet Service, with all of its related Service Attributes. The Operator could be a Super Operator, contracting with one or more other Operators (that also could be Super Operators in turn) to provide the OVC Service. The Operator cannot in general discern whether the organization ordering the OVC Service is the Service Provider or a Super Operator.

The term SO is used in this document as shorthand for Super Operator and the term SP/SO is used in this document to mean the Service Provider or Super Operator to whom the OVC Service is provided.

There can be two or more Operator CENs that concatenate OVCs to form any of the EVC Services defined in MEF 6.2, *EVC Ethernet Services Definitions Phase 3* [4]. The Service Provider in this context need not be an Operator of any of the CENs that make up the EVC Service. There can also be two or more Operator CENs that concatenate OVCs to form any of the OVC Services defined in this document. The SO in this context need not be an Operator of any of the CENs that make up the OVC Service.

Note that in the context of an OVC, the Operator UNI Service Attributes, as defined in MEF 26.2 [7], need to be agreed between the SP/SO and the Operator. In the context of an EVC, the UNI Service Attributes, as defined in MEF 10.4 [5], need to be agreed between the Subscriber and the Service Provider.

OVC End Point Service Attributes can be applied at one of two External Interface types.

- UNI, which is the demarcation point between the responsibility of the Service Provider and the responsibility of the Subscriber, as defined in MEF 10.4 [5].
- ENNI, which is a reference point representing the boundary between two Operator CENs that are operated as separate administrative domains, as defined in MEF 26.2 [7].

An OVC End Point is said to be at a UNI when the OVC End Point External Interface Type is UNI, per Section 16.3 of MEF 26.2 [7]. An OVC End Point is said to be at an ENNI when the OVC End Point External Interface Type is ENNI, per Section 16.3 of MEF 26.2 [7]. Note that for all Operator Ethernet Services defined in the document, OVC End Points at an ENNI are not in a VUNI.

In the example shown in Figure 1 below, *Omega 3* (the Subscriber) requires a multipoint Ethernet Service to interconnect its four sites, which are located in four different cities. *Omega 3* buys an EP-LAN service, based on a Multipoint-to-Multipoint EVC, from Service Provider, *SP Alpha*. *SP Alpha* is responsible for connecting the sites and for the UNI-to-UNI performance of the service.

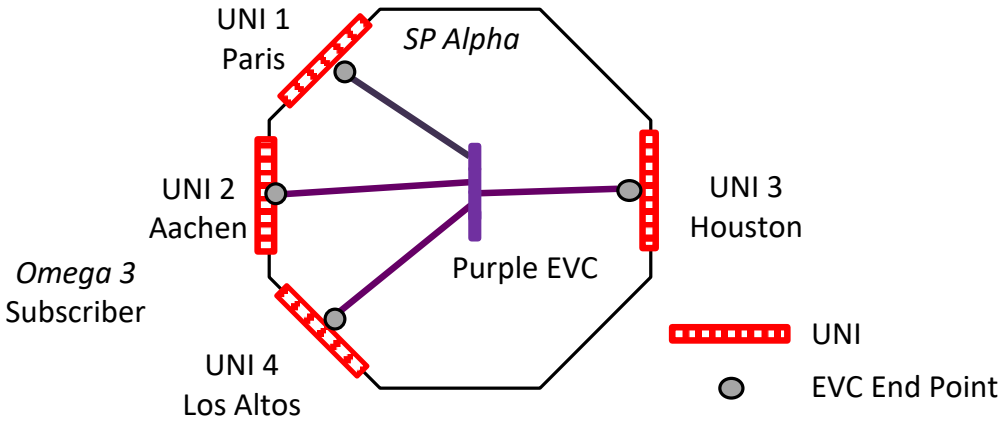

Figure 1 – Example of an EP-LAN Service (from a Service Provider-Subscriber View)

The key service components in the example above are the UNIs at the four sites, the EVC that provides the connectivity and the EVC End Points.

For this example, *SP Alpha* sub-contracts the components of the service to four Operators as shown in Figure 2, with the Operator CENs interconnected at ENNIs.

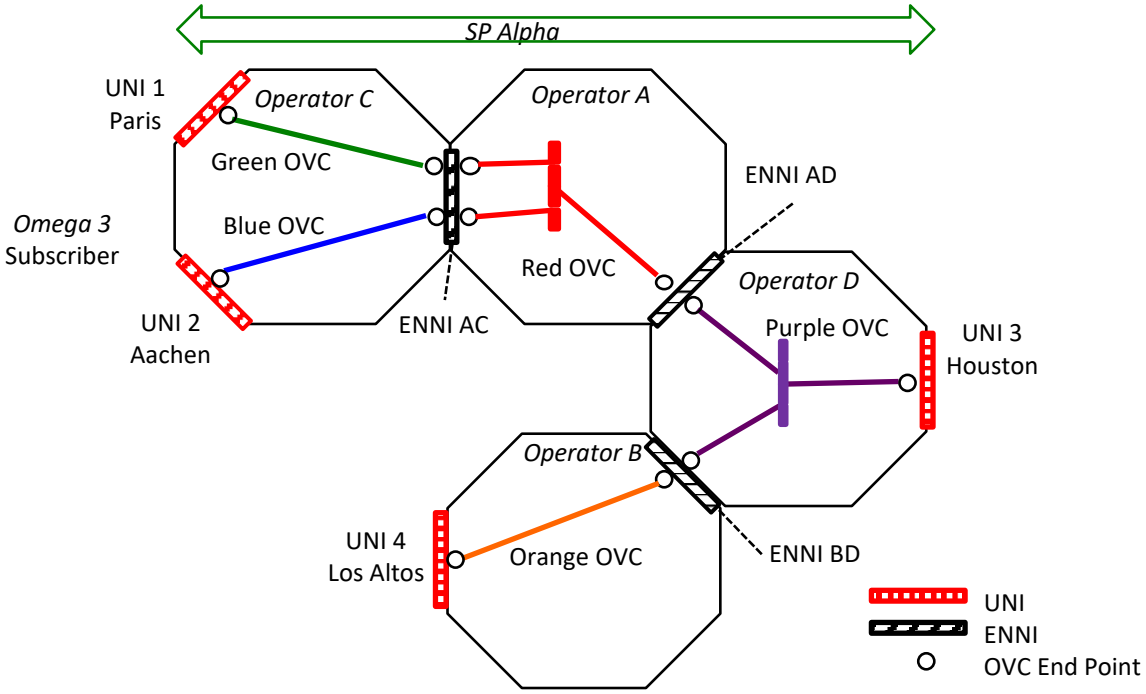

Figure 2 – Example of an EP-LAN Service (from Service Provider-Operator View)

As can be seen above, it is possible to create an EVC with multiple CENs, using a different OVC Type in two or more of the Operators' CENs. In this case, *SP Alpha* designs and builds the EP-LAN service from components provided by the four Operators.

Operator C is responsible for providing access service to Sites 1 and 2 with a Point-to-Point OVC from UNI 1 to ENNI AC, and another point-to-point OVC from UNI 2 to ENNI AC. *Operator B* is responsible for providing access service to Site 4 with a Point-to-Point OVC from UNI 4 to ENNI BD. *Operator D* is responsible for providing access service to Site 3 with a Multipoint-to-Multipoint OVC to interconnect UNI 3 with ENNI AD and ENNI BD. *Operator A* is responsible for the transit service, a Multipoint-to-Multipoint OVC interconnecting ENNI AC with ENNI AD. Note that *Operator A* is doing hairpin switching as defined in MEF 26.2 [7] at ENNI AC.

The Subscriber, *Omega 3*, knows about *SP Alpha* and the EVC, but does not need to know about the Operator CENs and the OVCs.

In the example described above, the Service Provider could also be the Operator of one of the CENs.

In this document, two types of Operator Ethernet Services are defined. An *E-Access Service* is an Operator Ethernet Service that associates at least one OVC End Point at a UNI and at least one OVC End Point at an ENNI. An *E-Transit Service* is an Operator Ethernet Service with all OVC End Points at ENNIs, and no OVC End Points at UNIs. E-Access Services and E-Transit Services form a partition of all possible Operator Ethernet Services, that is, every possible Operator Ethernet Service is either an E-Access Service or an E-Transit Service, and no possible Operator Ethernet Service can be both.

Three General Operator Ethernet Services are defined in this specification that are differentiated by the OVC Type and are shown in Table 3, below.

OVC Type	General Operator Ethernet Service
Point-to-Point	O-Line
Multipoint-to-Multipoint	O-LAN
Rooted-Multipoint	O-Tree

Table 3 – General Operator Ethernet Services Taxonomy

The General Operator Ethernet Services are defined in this document by specifying appropriate constraints on the values of the OVC Service Attributes defined in MEF 26.2 [7] in addition to the constraints in the Common Requirements (Section 7).

In addition, four specific Operator Ethernet Services are defined.

(1) *Access E-Line Service* is an E-Access Service that is derived from the O-Line Service.

(2) *Access E-LAN Service* is an E-Access Service that is derived from the O-LAN Service.

(3) *Transit E-Line Service* is an E-Transit Service that is derived from the O-Line Service.

(4) *Transit E-LAN Service* is an E-Transit Service that is derived from the O-LAN Service.

For all four of these specific Operator Ethernet Services, several Service Attributes have constraints on their values that are more restrictive than the General Operator Ethernet Services from which they're derived. This is summarized in Table 4, below.

Type of Operator Ethernet Service	**General Operator Ethernet Service**		
	O-Line	**O-LAN**	**O-Tree**
E-Access Service	Access E-Line	Access E-LAN	Not Specified in this document
E-Transit Service	Transit E-Line	Transit E-LAN	Not Specified in this document

Table 4 – Specific Operator Ethernet Services Taxonomy

This document supersedes and replaces MEF 51, *OVC Services Definitions* [11] and MEF 33, *Ethernet Access Services Definition* [9].

The remainder of this document is organized as follows:

Section 7 provides the set of common requirements for the General Operator Ethernet Services.

Section 8 provides the set of service-specific requirements for each of the General Operator Ethernet Services, i.e., O-Line Service, O-LAN Service and O-Tree Service. Sections 7 and 8 need to be taken together to completely define one of these General Operator Ethernet Services.

Section 9 specifies the E-Access Service definitions for Access E-Line and Access E-LAN Services.

Section 10 specifies the E-Transit Service definitions for Transit E-Line and Transit E-LAN Services.

Section 11 provides the references used in this document.

Informative appendices are provided at the end:

Appendix A contains use cases relating to how a combination of Operator Ethernet Services could be used to put together an end-to-end EVC Service.

Appendix B contains a SOAM use case involving two nested Super Operators.

Appendix C contains key changes in this document from MEF 51 [11].

Appendix D contains a comparison of Access E-Line Service with the Access E-Line Service specified in MEF 51 [11] and the Access EPL and Access EVPL Services specified in MEF 33 [9].

7 Common Requirements

The Operator Ethernet Services definitions in this document use the service attribute framework from MEF 26.2 [7] as a template. Based on MEF 26.2 [7], four sets of Service Attributes are used to define a given Operator Ethernet Service – OVC, OVC End Point (which can be at either an ENNI or a UNI), ENNI and Operator UNI.

[R1] For a Service Attribute referenced in this document that is specified in MEF 26.2 [7], the mandatory requirements in MEF 26.2 [7] that apply to the Service Attribute **MUST** be met.

The following subsections provide a general description of these service attributes and the common requirements specified for the General Operator Ethernet Services[1]. These common requirements, together with the further constraining requirements for a given Operator Ethernet Service, can be used as the complete set of requirements for the Operator Ethernet Service.

Note that when the term *support* is used in a normative context in this document, it means that the Operator is capable of enabling the functionality upon agreement between the SP/SO and the Operator.

7.1 Recommended values for CIR, EIR, CIRmax and EIRmax

The following recommendation applies to the Ingress Bandwidth Profile per Class of Service Name Service Attribute for an OVC End Point at an ENNI or at a UNI, when the value of the Service Attribute for a given Class of Service Name is *Parameters.*

[D1] For each CoS Name referenced in the OVC End Point Class of Service Identifier for a given OVC End Point, except for the Class of Service Name *Discard*, and for each of the parameters CIR, EIR, CIR_{max} or EIR_{max}, if the Operator supports any value for a given parameter in a range as shown in Table 5, the Operator **SHOULD** support all of the recommended values for that range that are less than or equal to the maximum value supported for that CoS Name and that parameter.

The following recommendation applies to the Egress Bandwidth Profile per Egress Equivalence Class Name Service Attribute for an OVC End Point at an ENNI or at a UNI, when the value of the Service Attribute for a given Egress Equivalence Class Name is *Parameters.*

[D2] For each EEC Name referenced in the OVC End Point EEC Identifier for a given OVC End Point and for each of the parameters CIR, EIR, CIR_{max} or EIR_{max}, if the Operator supports any value for a given parameter in a range as shown in Table 5, the Operator **SHOULD** support all of the recommended values for that range that are less than or equal to the maximum value supported for that EEC Name and that parameter.

The recommendations [D1] and [D2] are intended to encourage Operators to support a standard set of rates, making it easier for the SP/SO to put together a service that crosses multiple Operator CENs. Table 5 below specifies the detailed values to which these recommendations refer.

[1] E-Access and E-Transit service definitions might have additional requirements that constrain the common requirements and are defined separately in Sections 9 and 10, respectively.

Range	Recommended Values for CIR, EIR, CIR_{max} and EIR_{max}
[1,10) Mbps	1,2,3,4,5,6,7,8,9 Mbps
[10-100) Mbps	10,20,30,40,50,60,70,80,90 Mbps
[100-1000) Mbps	100,200,300,400,500,600,700,800,900 Mbps
[1,10) Gbps	1,2,3,4,5,6,7,8,9 Gbps
[10-100) Gbps	10,20,30,40,50,60,70,80,90 Gbps

Table 5 – Recommended values for CIR, EIR, CIR_{max} or EIR_{max}

A value is in the range [X, Y) if X ≤ value < Y. In other words, the range includes all values from X up to but not including Y.

These recommended values can be subject to limitations on the upper end of the range offered by the Operator. Such limitations can include the speed of the EI and any upper limit that an Operator might have for a given CoS Name. For example, one Operator might set a CIR_{max} ceiling of 70 Mbps when the service is associated with a 100 Mbps UNI to control for effects of frame overhead. As another example, another Operator might set a CIR_{max} ceiling of 100 Mbps for the CoS Name of 'Voice'; and yet another CIR_{max} ceiling of 2 Mbps for the CoS Name of 'Synchronization'. See Appendix C of MEF 10.4 [5] for a description of the effects of frame overhead.

Note that the wording of the recommendations specifically allows for the Operator and SP/SO to agree on other values of CIR, EIR, CIR_{max} and/or EIR_{max}. For example, the Operator and SP/SO may agree on parameter values for a given service that can make the service behave as if there is no Ingress or Egress Bandwidth Profile applied, i.e., CIR and CIR_{max} values could be used that are close to the line rate of the PHY. Operators and SP/SOs need to be careful with the selection of these parameter values so that adverse performance impacts on services are limited. A maximum limit of zero is also permitted, e.g., the Operator and SP/SO could agree on a best effort style service with CIR_{max} and CBS = 0 and EIR_{max} and EBS > 0.

The following are examples of how the Bandwidth Profile recommendations in [D1] and [D2] apply.

Example 1: *Operator A* supports CIR values of 3, 15 and 35 Mbps for an Ingress Bandwidth Profile for a given CoS Name for the OVC End Point at a given UNI. As *Operator A* supports a value of 3 Mbps and a maximum value of 35 Mbps, it is recommended that *Operator A* also support all values in Table 5 for the ranges [1,10) and [10,100) up to the maximum value of 35 Mbps. As a result, the following additional values of CIR are recommended to be supported: 1, 2, 4, 5, 6, 7, 8, 9, 10, 20 and 30 Mbps.

Example 2: *Operator B* supports an EIR value of 250 Mbps for an Egress Bandwidth Profile for a given EEC Name for the OVC End Point at a given ENNI. As *Operator B* supports only one value, i.e., 250 Mbps, it is recommended that *Operator B* also support all values in Table 5 for the range [100,1000) up to the maximum value of 250 Mbps. As a result, the following additional values of EIR are recommended to be supported: 100 and 200 Mbps.

Example 3: *Operator C* supports CIR values of 40 and 70 Mbps, and CIR_{max} values of 70, 200 and 400 Mbps for an Ingress Bandwidth Profile for a given CoS Name for the OVC End Point at

a given ENNI. As *Operator C* supports CIR values of 40 and 70 Mbps, it is recommended that *Operator A* also support all CIR values in Table 5 for the range [10,100) up to the maximum value of 70 Mbps. As a result, the following additional CIR value are recommended to be supported: 10, 20, 30, 50 and 60Mbps.

In addition, as *Operator C also* supports CIR_{max} values of 70 Mbps and a maximum of 400 Mbps, it is recommended that *Operator C* also support all CIR_{max} values in Table 5 for the ranges [10,100) and [100,1000) up to the maximum value of 400 Mbps. As a result, the following additional values of CIR_{max} are recommended to be supported: 10, 20, 30, 40, 50, 60, 80, 90, 100, 200 and 300 Mbps.

7.2 OVC Common Requirements

This subsection describes the OVC Service Attributes.

Common requirements on OVC Service Attributes for the General Operator Ethernet Services (those defined in Section 8) are provided in Table 6. This table is organized as follows: the first column lists the OVC Service Attribute and the second column provides a description of the attribute. The third column provides the common requirements for the General Operator Ethernet Services. These requirements and recommendations apply to each of the General Operator Ethernet Services, except that such service can further constrain common table entries, as needed. When the term 'No additional constraints' is used, it means that the requirements from the indicated MEF specification apply, with any of the options allowed for a given attribute.

OVC Service Attribute	Description	Common Requirements for an OVC for the General Operator Ethernet Services
OVC Identifier	A unique identifier within the Operator's network for the OVC.	No additional constraints from MEF 26.2 [7]
OVC Type	One of three possible types can be specified: *Point-to-Point*, *Multipoint-to-Multipoint*, or *Rooted-Multipoint*.	Service-specific requirements are specified in Table 9, Table 10 and Table 11.
OVC End Point List	List of OVC End Point Identifiers.	Service-specific requirements are specified in Table 9, Table 10 and Table 11.
Maximum Number of UNI OVC End Points	The upper bound on the number of OVC End Points that are at different UNIs that can be associated by an OVC.	No additional constraints from MEF 26.2 [7]
Maximum Number of ENNI OVC End Points	The upper bound on the number of OVC End Points that are at ENNIs that can be associated by an OVC. Note: This includes the number of OVC End Points that are associated with the same ENNI (hairpin switching).	No additional constraints from MEF 26.2 [7]

OVC Service Attribute	Description	Common Requirements for an OVC for the General Operator Ethernet Services
OVC Maximum Frame Size	The maximum frame length allowed on the OVC (in Bytes).	No additional constraints from MEF 26.2 [7]
OVC CE-VLAN ID Preservation	*Preserve*, *Strip* or *Retain*. This attribute determines the preservation of the CE-VLAN ID.	No additional constraints from MEF 26.2 [7]
OVC CE-VLAN PCP Preservation	*Enabled* or *Disabled*. This attribute determines the preservation of the Priority Code Point (PCP) field of the C-Tag.	No additional constraints from MEF 26.2 [7]
OVC CE-VLAN DEI Preservation	*Enabled* or *Disabled*. This attribute determines the preservation of the Drop Eligible Indicator (DEI) field of the C-Tag.	No additional constraints from MEF 26.2 [7]
OVC S-VLAN PCP Preservation	*Enabled* or *Disabled*. This attribute determines the preservation of the PCP field of the S-Tag.	No additional constraints from MEF 26.2 [7]
OVC S-VLAN DEI Preservation	*Enabled* or *Disabled*. This attribute determines the preservation of the DEI field of the S-Tag.	No additional constraints from MEF 26.2 [7]
OVC List of Class of Service Names	The Class of Service Names supported by the OVC	No additional constraints from MEF 26.2 [7]
OVC Service Level Specification	*None* or a *4-tuple* <t_s, T, CN, PM>. - t_s is the start time for the SLS - T is the time period of the SLS (e.g., 1 month) - CN is a list of Class of Service Names, and - PM identifies the combination of some or all of the nine Performance Metrics defined in MEF 26.2 [7] for each CoS Name in the list. The performance metrics can be different for each CoS Name.	**[D3]** The Operator **SHOULD** support the four delay metrics (Frame Delay, Frame Delay Range, Mean Frame Delay and Inter-Frame Delay Variation), as specified in MEF 26.2 [7], in an SLS. Note: Operators need to offer all delay metrics to satisfy multiple SP/SOs who have different requirements. This also allows for a SP/SO to choose the Performance Metrics needed for each OVC in the chain so that the EVC performance can be better estimated. **[D4]** The Operator **SHOULD** support the Frame Loss Ratio metric, as specified in MEF 26.2 [7], in an SLS. Note: see also Table 9, Table 10 and Table 11.

OVC Service Attribute	Description	Common Requirements for an OVC for the General Operator Ethernet Services
OVC Frame Delivery	For ingress Unicast, Multicast and Broadcast EI frames, one of *Conditional*, *Unconditional* or *Discard* is specified. If *Conditional*, the conditions need to be specified.	Service-specific requirements are specified in Table 9, Table 10 and Table 11.
OVC Available MEG Level	Specifies the lowest MEG Level available for the SP/SO. Note: A lower level allows for more nesting of Super Operator OVCs with SOAM enabled. See Appendix B, which describes a use case involving nested SO OVCs.	**[R2]** The OVC Available MEG Level **MUST** be ≤ 6.
OVC L2CP Address Set	The subset of the Bridge Reserved Addresses that are Peered or Discarded	No additional constraints from MEF 45.1 [12]

Table 6 – Common Requirements for an OVC

7.3 Common Requirements for an OVC End Point at an ENNI

This subsection describes the OVC End Point Service Attributes for an OVC End Point at an ENNI. The reference for all of the OVC End Point Service Attributes is Section 16 of MEF 26.2 [7]. These attributes apply to a single OVC End Point at an ENNI.

Common requirements for OVC End Point Service Attributes for an OVC End Point at an ENNI for the General Operator Ethernet Services (those defined in Section 8) are provided in Table 7. This table is organized as follows: the first column lists the OVC End Point Service Attributes for an OVC End Point at an ENNI and the second column provides a brief description of the attribute. The third column provides the common requirements for the General Operator Ethernet Services. These requirements and recommendations apply to each of the General Operator Ethernet Services, except that such service can further constrain common table entries, as needed. When the term 'No additional constraints' is used, it means that the requirements from the indicated MEF specification apply, with any of the options allowed for a given Service Attribute. Note that Table 7 applies when the OVC End Point External Interface Type is *ENNI.*

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at an ENNI for the General Operator Ethernet Services
OVC End Point Identifier	A unique identifier within the Operator's network for the OVC End Point	No additional constraints from MEF 26.2 [7]

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at an ENNI for the General Operator Ethernet Services
OVC End Point External Interface Type	Identifies the type of External Interface at which the OVC End Point is located *<UNI, ENNI>*	By definition, the value is *ENNI*
OVC End Point External Interface Identifier	The identifier value for the External Interface at which the OVC End Point is located	No additional constraints from MEF 26.2 [7]
OVC End Point Role	Indicates how ENNI Frames mapped to the OVC End Point can be forwarded *<Root, Leaf, Trunk>*	No additional constraints from MEF 26.2 [7] Note that MEF 26.2 specifies that the OVC End Point Role for a Point-to-Point OVC or for a Multipoint-to-Multipoint OVC is *Root*. This means that the OVC End Point Role = *Root* for the O-Line and O-LAN Services defined in Section 8.1 and 8.2, respectively. For an OVC End Point at an ENNI, the OVC End Point Role for a Rooted-Multipoint OVC can take on the value of *Root*, *Trunk* or *Leaf*, and therefore, any of these values are possible for the O-Tree Service defined in Section 8.3.
OVC End Point Map	The information that determines which ENNI Frames are mapped to the OVC End Point *<Form E, Form T, Form V, Form U>*	**[R3]** For an OVC End Point at an ENNI, the OVC End Point Map Form **MUST** be either *Form E* or *Form T*. Note that the Operator Ethernet Services defined in this document do not use VUNIs, therefore, Form V cannot be used.
OVC End Point Class of Service Identifier	The mechanism that allows a Class of Service Name to be determined for an ingress ENNI Frame *<F, M, P>*	No additional constraints from MEF 26.2 [7] Note that [R167] of MEF 26.2 mandates *F* be based on S-Tag PCP when there is no VUNI.
OVC End Point Color Identifier	The mechanism by which the Color of an ENNI Frame is determined for an ingress ENNI Frame *<F, M>*	**[D5]** The value of *F* in the OVC End Point Color Identifier Service Attribute for an OVC End Point at an ENNI **SHOULD** be S-Tag DEI.

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at an ENNI for the General Operator Ethernet Services
OVC End Point Egress Map	The specification of the content of the S-Tag PCP and DEI values for egress ENNI Frames	No additional constraints from MEF 26.2 [7] See [R201] in MEF 26.2 [7]. Note that for an OVC End Point at an ENNI, with no VUNI, MEF 26.2 [7] constrains the map forms to zero or more of: *CN →S-Tag PCP*, CC *→S-Tag DEI, CC →S-Tag PCP*.
OVC End Point Egress Equivalence Class Identifier	The mechanism that allows an Egress Equivalence Class Name to be determined for an egress ENNI Frame <*F,M,P*>	No additional constraints from MEF 26.2 [7]
Ingress Bandwidth Profile per OVC End Point	Ingress policing on all ingress ENNI frames mapped to the OVC End Point <*Parameters, Disabled*>	**[R4]** Ingress Bandwidth Profile per OVC End Point at the ENNI **MUST** be *Disabled*.
Egress Bandwidth Profile per OVC End Point	Egress policing and shaping on all egress ENNI frames mapped to the OVC End Point <*Parameters, Disabled*>	**[R5]** Egress Bandwidth Profile per OVC End Point at the ENNI **MUST** be *Disabled*.
Ingress Bandwidth Profile per Class of Service Name	Ingress policing on all ingress ENNI frames with a given Class of Service Name for the receiving Operator CEN List of CoS Names with value <*Parameters, Disabled*> for each CoS Name	**[R6]** The Ingress Bandwidth Profile per CoS Name for an OVC End Point at the ENNI **MUST** be a list that includes each CoS Name that is contained in *M* in the value of the OVC End Point Class of Service Identifier for the OVC End Point, except for the Class of Service Name *Discard*, where each such entry in the list specifies *Parameters*, per Section 16.12 of MEF 26.2 [7]. **[D6]** For each Bandwidth Profile Flow specified in the Ingress Bandwidth Profile per Class of Service Name at an OVC End Point at an ENNI, the Operator **SHOULD** support values of 0 and 4 for the token request offset parameter, *F*. Commonly, ENNI Frames have either the same number of tags or one more tag than Service Frames; hence the choice of 0 or 4, respectively, are commonly desired values for *F*.

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at an ENNI for the General Operator Ethernet Services
Egress Bandwidth Profile per Egress Equivalence Class Name	Egress policing and shaping on all egress ENNI Frames with a given Egress Equivalence Class Name List of Egress Equivalence Class Names with value *<Parameters, Disabled>* for each	**[D7]** The Operator **SHOULD** support a list that includes each EEC Name that is contained in *M* in the value of the OVC End Point EEC Identifier for the OVC End Point, where each such entry in the list specifies *Parameters*, per Section 16.13 of MEF 26.2 [7].
OVC End Point Aggregation Link Depth	The number of ENNI links that can carry ENNI Frames mapped to the OVC End Point *<S-VID value, positive integer>*	No additional constraints from MEF 26.2 [7]
OVC End Point Source MAC Address Limit	A limit on the number of different source MAC addresses that can be used *Disabled* or $<N, \tau>$	No additional constraints from MEF 26.2 [7]
OVC End Point MIP	The indication of the instantiation of a MIP *Enabled* or *Disabled* When *Enabled*, several parameter values need to be determined as described in MEF 30.1 [8].	**[D8]** For an OVC End Point at an ENNI, the Operator **SHOULD** support a value of *Enabled* for the OVC End Point MIP. **[CR1]**< [D8] The Operator **MUST** support all MEG levels, from the OVC Available MEG Level for the OVC associating this OVC End Point, up to and including MEG Level 6.

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at an ENNI for the General Operator Ethernet Services
OVC End Point MEP List	A list of MEPs, with each MEP in the list identifying the MEG Level and the MEP direction (Up or Down) to be enabled at the OVC End Point When the list is not empty, several parameter values need to be determined as described in MEF 30.1 [8]. Note that per MEF 26.2 [7], this service attribute is intended for use by a SP/SO.	**[D9]** For an OVC that has OVC End Points at one or more other ENNIs, the Operator **SHOULD** support at least one Up MEP in the OVC End Point MEP List for the OVC End Point at the ENNI[2]. **[CR2]<** [D9] The Operator **MUST** support all MEG Levels, from the OVC Available MEG Level for the OVC associating this OVC End Point, up to and including MEG Level 6. **[CD1]<** [D9] The MEG Level(s) specified **SHOULD NOT** be 0, 1 or 7. **[D10]** The Operator **SHOULD** support at least one Down MEP in the OVC End Point MEP List for the OVC End Point at the ENNI[3]. **[CR3]<** [D10] The Operator **MUST** support all MEG Levels in the range from 3 to 6. **[CD2]<** [D10] The Operator **SHOULD** support MEG Level 2. **[CD3]<** [D10] The MEG Level(s) specified **SHOULD NOT** be 0, 1 or 7. **[D11]** For an OVC End Point at an ENNI, for each MEP in the OVC End Point MEP List, the Operator **SHOULD** support PM-1 as specified in MEF 35.1 [10].

Table 7 – Common Requirements for an OVC End Point at an ENNI

Note: MEF 30.1 [8] requires that SOAM equipment is able to support any valid MEG level for each MEG. However, the MEP and MIP requirements above apply specifically to the services offered by the Operator, rather than to the equipment.

[2] An example of using an Up MEP for an OVC End Point at an ENNI is described in Appendix B. Note, that there could be more than one SP MEG, for example, where Super Operators are part of the service.

[3] See ENNI CD in Figure 22 for an example of using a Down MEP, which is briefly described in Appendix B.

7.4 Common Requirements for an OVC End Point at a UNI

This subsection describes the OVC End Point Service Attributes for an OVC End Point at a UNI. The reference for all of the OVC End Point Service Attributes is Section 16 of MEF 26.2 [7]. These attributes apply to a single OVC End Point at a UNI.

Common requirements for OVC End Point Service Attributes for an OVC End Point at a UNI for the General Operator Ethernet Services (those defined in Section 8) are provided in Table 8. This table is organized as follows: the first column lists the OVC End Point Service Attributes for an OVC End Point at a UNI and the second column provides a brief description of the attribute. The third column provides the common requirements for the General Operator Ethernet Services. When the term 'No additional constraints' is used, it means that the requirements from the indicated MEF specification apply, with any of the options allowed for a given attribute. Note that Table 8 applies when the OVC End Point External Interface Type is *UNI.*

OVC End Point Service Attribute	**Description**	**Common Requirements for an OVC End Point at a UNI for the General Operator Ethernet Services**
OVC End Point Identifier	A unique identifier within the Operator's network for the OVC End Point	No additional constraints from MEF 26.2 [7]
OVC End Point External Interface Type	Identifies the type of External Interface at which the OVC End Point is located <*UNI, ENNI*>	By definition, the value is *UNI*
OVC End Point External Interface Identifier	The identifier value for the External Interface at which the OVC End Point is located	No additional constraints from MEF 26.2 [7]
OVC End Point Role	Indicates how Service Frames mapped to the OVC End Point can be forwarded <*Root, Leaf*>	No additional constraints from MEF 26.2 [7] Note that MEF 26.2 specifies that the OVC End Point Role for a Point-to-Point OVC or for a Multipoint-to-Multipoint OVC is *Root*. This means that the OVC End Point Role = *Root* for the O-Line and O-LAN Services defined in Section 8.1 and 8.2, respectively. For an OVC End Point at a UNI, the OVC End Point Role for a Rooted-Multipoint OVC can take on the value of *Root* or *Leaf*, and therefore, either of these values are possible for the O-Tree Service defined in Section 8.3.

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at a UNI for the General Operator Ethernet Services
OVC End Point Map	The information that determines which Service Frames are mapped to the OVC End Point *<Form E, Form T, Form V, Form U>*	No additional constraints from MEF 26.2 [7] Note that [R151] of MEF 26.2 requires *Form U* to be used for an OVC End Point at a UNI.
OVC End Point Class of Service Identifier	The mechanism that allows a Class of Service Name to be determined for an ingress Service Frame *<F, M, P>*	No additional constraints from MEF 26.2 [7] Note that [R171] of MEF 26.2 mandates *F* be based on one of the following for an OVC End Point at a UNI: OVC End Point, C-Tag PCP or DSCP.
OVC End Point Color Identifier	The mechanism by which the Color of a Service Frame is determined for an ingress Service Frame *<F, M>*	**[D12]** The value of *F* in the OVC End Point Color Identifier Service Attribute for an OVC End Point at a UNI **SHOULD** be *C-Tag DEI*.
OVC End Point Egress Map	The specification of the content of the C-Tag PCP and DEI values for egress Service Frames	No additional constraints from MEF 26.2 [7] See [R201] in MEF 26.2. Note that for an OVC End Point at a UNI, MEF 26.2 [7] constrains the map forms to zero or more of: *CN→C-Tag PCP, CC→C-Tag DEI, CC→C-Tag PCP*.
OVC End Point Egress Equivalence Class Identifier	The mechanism that allows an Egress Equivalence Class Name to be determined for an egress Service Frame *<F, M, P>*	No additional constraints from MEF 26.2 [7]
Ingress Bandwidth Profile per OVC End Point	Ingress policing on all ingress Service Frames mapped to the OVC End Point *<Parameters, Disabled>*	**[R7]** Ingress Bandwidth Profile per OVC End Point at the UNI **MUST** be *Disabled*.
Egress Bandwidth Profile per OVC End Point	Egress policing and shaping on all egress Service Frames mapped to the OVC End Point *<Parameters, Disabled>*	No additional constraints from MEF 26.2 [7]

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at a UNI for the General Operator Ethernet Services
Ingress Bandwidth Profile per Class of Service Name	Ingress policing on all ingress Service Frames with a given Class of Service Name for the receiving Operator CEN List of CoS Names with value <*Parameters, Disabled*> for each CoS Name	**[R8]** Ingress Bandwidth Profile per CoS Name for an OVC End Point at the UNI **MUST** be a list containing each CoS Name that is referenced in the OVC End Point Class of Service Identifier for the OVC End Point, except for the Class of Service Name *Discard*, where each entry in the list specifies *Parameters*, per Section 16.12 of MEF 26.2 [7].
Egress Bandwidth Profile per Egress Equivalence Class Name	Egress policing and shaping on all egress Service Frames with a given Egress Equivalence Class Name List of Egress Equivalence Class Names with value <*Parameters, Disabled*> for each	No additional constraints from MEF 26.2 [7]
OVC End Point Aggregation Link Depth	The number of ENNI links that can carry ENNI Frames mapped to the OVC End Point <*S-VID value, positive integer*>	Not Applicable per Section 16.14 of MEF 26.2 [7]
OVC End Point Source MAC Address Limit	A limit on the number of different source MAC addresses that can be used <*Disabled*, <*N*, τ>>	No additional constraints from MEF 26.2 [7]
Subscriber MEG MIP	The indication of the instantiation of a MIP at the Subscriber MEG Level for the OVC End Point at the UNI <*Enabled* or *Disabled*> When *Enabled*, several parameter values need to be determined as described in MEF 30.1 [8] Note that this attribute only applies when the OVC supports a single EVC.	**[D13]** For an OVC End Point at a UNI, the Operator **SHOULD** support a value of *Enabled* for the Subscriber MEG MIP. **[CD4]**< [D13] The Operator **SHOULD** support configuration of the MEG Level to any value from 5 to 7.

OVC End Point Service Attribute	Description	Common Requirements for an OVC End Point at a UNI for the General Operator Ethernet Services
OVC End Point MEP List	A list of MEPs, with each MEP in the list identifying the MEG Level and the MEP direction (Up or Down) to be enabled at the OVC End Point When the list is not empty, several parameter values need to be determined as described in MEF 30.1 [8]. Note that per MEF 26.2 [7], this service attribute is intended for use by a SP/SO.	**[D14]** The Operator **SHOULD** support at least two Up MEPs in the OVC End Point MEP List for the OVC End Point at the UNI. **[CR4]**< [D14] The Operator **MUST** support all MEG Levels, from the OVC Available MEG Level for the OVC associating this OVC End Point, up to and including MEG Level 6. **[CD5]**< [D9] The MEG Level(s) specified **SHOULD NOT** be 0, 1 or 7. **[D15]** For an OVC End Point at a UNI, for each MEP in the OVC End Point MEP List, the Operator **SHOULD** support PM-1 as specified in MEF 35.1 [10].

Table 8 – Common Requirements for an OVC End Point at a UNI

Note: MEF 30.1 [8] requires that SOAM equipment is able to support any valid MEG level for each MEG. However, the MEP and MIP requirements above apply specifically to the services offered by the Operator, rather than to the equipment.

7.5 External Network Network Interface (ENNI) Common Requirements

This document does not impose any constraints on the values of the ENNI Service Attributes, the ENNI Common Attributes and the Operator Multilateral Attributes, as specified in MEF 26.2 [7].

7.6 User Network Interface (UNI) Common Requirements

This document does not impose any constraints on the values of the Operator UNI Service Attributes, as specified in MEF 26.2 [7].

8 General Operator Ethernet Service Definitions

This section defines the General Operator Ethernet Services, by specifying the constraints from MEF 26.2 [7] for certain service attributes related to the differences among the three General Operator Ethernet Services. The following General Operator Ethernet Service definitions only specify the service attributes where there are differences. To understand the full extent of a General Operator Ethernet Service definition, the attributes and common requirements in Section 7 need to be included.

8.1 O-Line Service Definition

This subsection defines O-Line Service, which is based on the Point-to-Point OVC. An O-Line Service can be used either to connect two ENNIs, to connect two OVC End Points at the same ENNI (hairpin switching), or to connect an ENNI and a UNI.

Figure 3 below shows an example of eight instances of O-Line Service in four Operator CENs that are used in supporting three instances of E-Line Services (see MEF 6.2 [4] for definition of E-Line services).

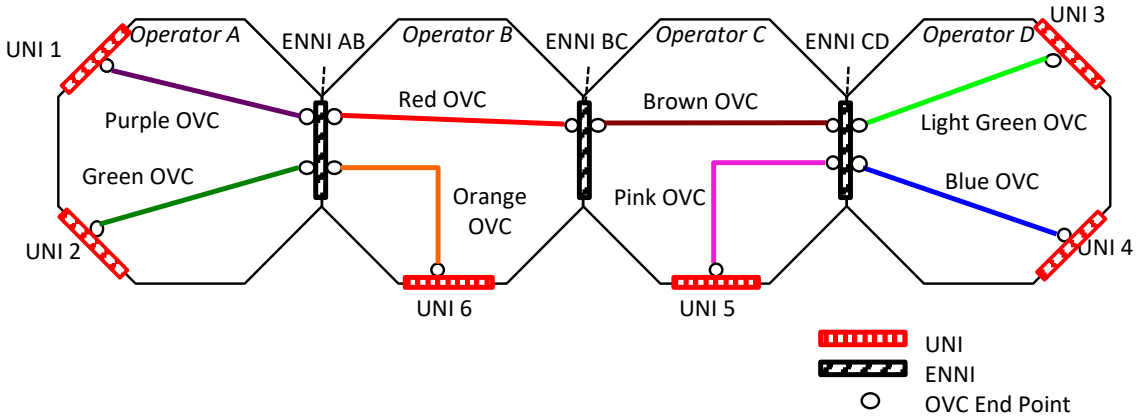

Figure 3 – Example of O-Line Services in Operator CENs (Point-to-Point OVC)

In Figure 3 above, the example depicts the various combinations of External Interfaces that could be used as part of an O-Line Service. In Figure 3, an E-Line EVC Service (not shown) connects UNI 1 and UNI 3 and uses a chain of four O-Line services, namely the Purple, Red, Brown and Light Green OVCs. Note that O-Line Services can also be used as part of an E-LAN or E-Tree service - for example, see Figure 2 for E-LAN service and Figure 6 for E-Tree service.

The full set of requirements for O-Line Service consists of the common requirements specified in Section 7, and the constraints on the value of certain OVC Service Attributes specified in Table 9, below. The first column lists the service attribute, and the second column specifies the constraining requirements for an O-Line Service.

OVC Service Attribute	Constraining Requirements for O-Line Service
OVC Type	**[R9]** For an O-Line Service, the OVC Type **MUST** be *Point-to-Point*.
OVC End Point List	**[R10]** For an O-Line Service, there **MUST** be exactly two end points in the OVC End Point List. Note: At least one of the OVC End Points associated by an OVC is required to be at an ENNI, per [R36] of MEF 26.2 [7].
OVC Service Level Specification	**[D16]** For an O-Line Service, if the SLS includes an objective for a performance metric that has a parameter S, then both ordered OVC End Point pairs **SHOULD** be in the same set S. [4] The constraints in Table 6 also apply.
OVC Frame Delivery	**[R11]** For an O-Line Service, the Operator **MUST** support *unconditional* unicast frame delivery.[5] **[R12]** For an O-Line *Service*, the Operator **MUST** support *unconditional* multicast frame delivery[6]. **[R13]** For an O-Line *Service*, the Operator **MUST** support *unconditional* broadcast frame delivery[6].

Table 9 – Constraining OVC Service Attribute Requirements for O-Line Service

8.2 O-LAN Service Definition

This subsection defines O-LAN Service, which is based on the Multipoint-to-Multipoint OVC. O-LAN Service can be used to connect any type of EI, with the condition that at least one of the EIs is an ENNI. Figure 4 below shows an example of two instances of O-LAN Service, the Green OVC in CEN A to connect the OVC End Points at UNIs 1 and 2 with the OVC End Point at ENNI AB, and the Brown OVC in CEN B to connect the OVC End Point at ENNI AB, the OVC End Point at UNI 5 and two OVC End Points at ENNI BC to allow hairpin switching. Two instances of O-Line Service in CEN C are used to connect UNIs 3 and 4 with the two OVC End Points shown at ENNI BC. The resulting connectivity supports an end-to-end E-LAN Service Type, per MEF 6.2 [4].

[4] The parameter *S* is the subset of ordered OVC End Point pairs and is defined in MEF 26.2 [7], Section 12.13.1.1.
[5] This requirement allows for the SP and Operator to agree on conditional delivery for a given service. For example, in the special case where an Operator might need to learn and filter MAC addresses at an OVC End Point at an ENNI of a P2P OVC on behalf of the peer Operator, then conditional delivery rules could be applied for that service.
[6] This requirement allows for the SP and Operator to agree on conditional delivery for a given service. Examples of conditional delivery include rate enforcement of broadcast and multicast frames or pruning of multicast frames at certain selected OVC End Points.

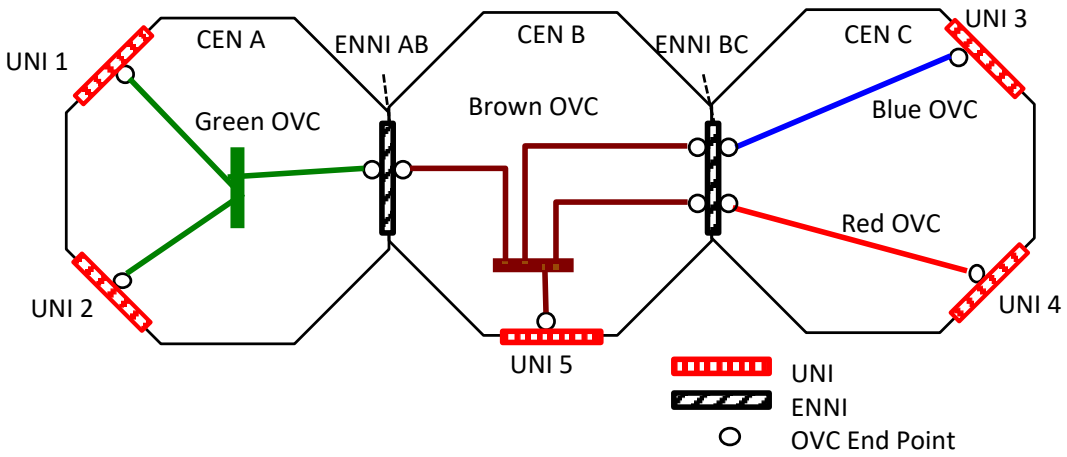

Figure 4 – Example of Two O-LAN Services in CEN A and CEN B

The full set of requirements for O-LAN Service consists of the common requirements specified in Section 7, and the constraints on the value of certain OVC Service Attributes specified in Table 10, below. The first column lists the service attribute, and the second column specifies the constraining requirements for an O-LAN Service.

OVC Service Attribute	Constraining Requirements for O-LAN Service
OVC Type	**[R14]** For an O-LAN Service, the OVC Type **MUST** be *Multipoint-to-Multipoint*. Note: By definition, a Multipoint-to-Multipoint OVC is capable of associating more than two *Root* OVC End Points. See Section 12.2 of MEF 26.2 [7].
OVC End Point List	No additional constraints from MEF 26.2 [7] Note: At least one of the OVC End Points associated by an OVC is required to be at an ENNI, per [R36] of MEF 26.2 [7].
OVC Service Level Specification	No additional constraints from Table 6
OVC Frame Delivery	**[D17]** For an O-LAN Service, Unicast Frame Delivery **SHOULD** be *conditional*[7] with the condition that the delivery of unicast frames is subject to the dynamic learning and filtering process as described in IEEE 802.1Q™-2018 [1] for Independent and Shared VLAN learning bridges. **[D18]** For an O-LAN Service, broadcast frame delivery **SHOULD** be *unconditional*.[6] There are no additional constraints from MEF 26.2 [7] for multicast frame delivery.

Table 10 – Constraining OVC Service Attribute Requirements for O-LAN Service

[7] For a Multipoint-to-Multipoint OVC, an ingress frame at a given EI with a known unicast MAC DA would be forwarded only to the known egress EI. Other conditions may also apply.

8.3 O-Tree Service Definition

This subsection defines O-Tree Service, which is based on the Rooted-Multipoint OVC. O-Tree Service can be used to connect any of the EIs, with the condition that at least one of the EIs is an ENNI.

In the example depicted in Figure 5 below, *SP Alpha* provides an E-Tree Service to the Subscriber. The Subscriber wants four UNIs in the Rooted-Multipoint EVC to start, with two Root EVC EPs and two Leaf EVC EPs, as shown. The Subscriber can add other UNIs in the future.

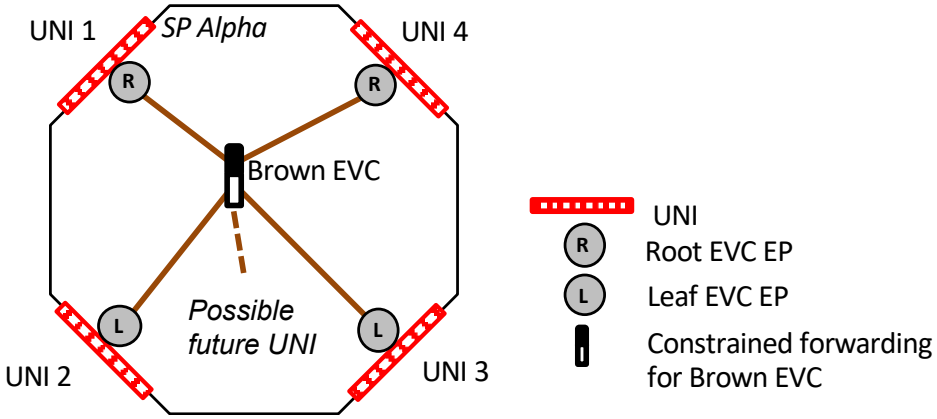

Figure 5 – Subscriber View of the E-Tree Service Example

Now, let's assume that *SP Alpha* needs to buy Operator Ethernet Services from three different Operators to build the end-to-end E-Tree Service. There are many possible options that can be used. In the example depicted in Figure 6 below, *SP Alpha* chooses to have one Operator perform the constrained forwarding, using one Rooted-Multipoint OVC, while the other Operators provide simple access to that Operator's CEN, with Point-to-Point OVCs.

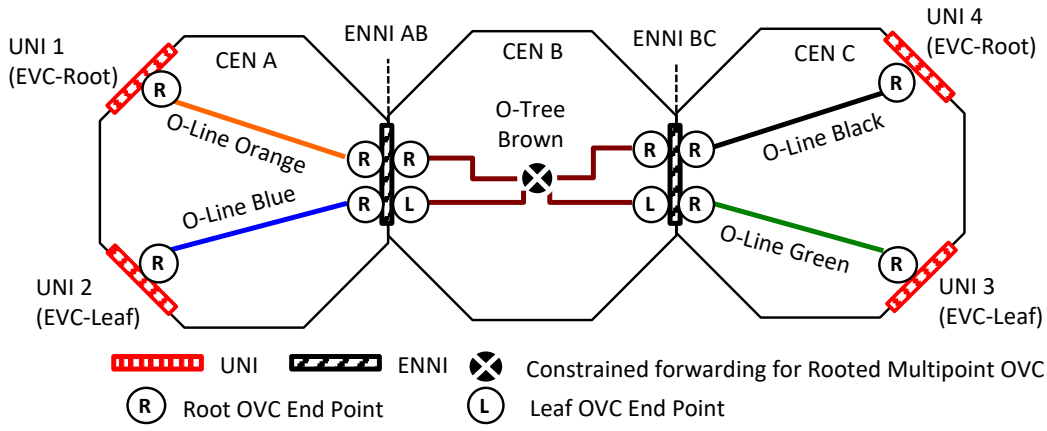

Figure 6 – SP-Operator view of an example O-Tree Service in *Operator B* CEN

Figure 6 depicts the SP-Operator view of the Operator Ethernet Services in support of the E-Tree service. Note that *EVC-Leaf* and *EVC-Root* at the UNIs in Figure 6 refer to the EVC EP Role

Service Attribute (Section 10.3 of MEF 10.4 [5]) value for the EVC implementing the E-Tree Service. These values are per agreement between the Subscriber and the Service Provider.

SP Alpha uses the following Operator Ethernet Services to build the end-to-end E-Tree Service:

- O-Line Orange in CEN A connects UNI 1 with ENNI AB. Both OVC End Points for the OVC have the role of Root.
- O-Line Blue in CEN A connects UNI 2 with ENNI AB. Both OVC End Points for the OVC have the role of Root.
- O-Line Black in CEN C connects UNI 3 with ENNI BC. Both OVC End Points for the OVC have the role of Root.
- O-Line Green in CEN C connects UNI 4 with ENNI BC. Both OVC End Points for the OVC have the role of Root.
- O-Tree Brown in CEN B provides the connectivity and constrained forwarding required for the E-Tree Service. Of the two OVC End Points at ENNI AB, one OVC End Point has the role of Root and connects to O-Line Orange in CEN A to get access to UNI 1 (a root UNI in the end-to-end E-Tree Service); and the other OVC End Point at ENNI AB has the role of Leaf and connects to O-Line Blue in CEN A to get access to UNI 2 (a leaf UNI in the end-to-end E-Tree Service). The OVC End Points at ENNI BC are configured similarly to the two OVC End Points at ENNI AB.

Note that in the above example, only one CEN is involved in controlling the constrained forwarding rules for the end-to-end E-Tree Service.

Figure 7 below depicts a different arrangement of OVCs to support the same end-to-end E-Tree Service. In this example, the *SP Alpha* uses three Rooted-Multipoint OVCs, one in each CEN.

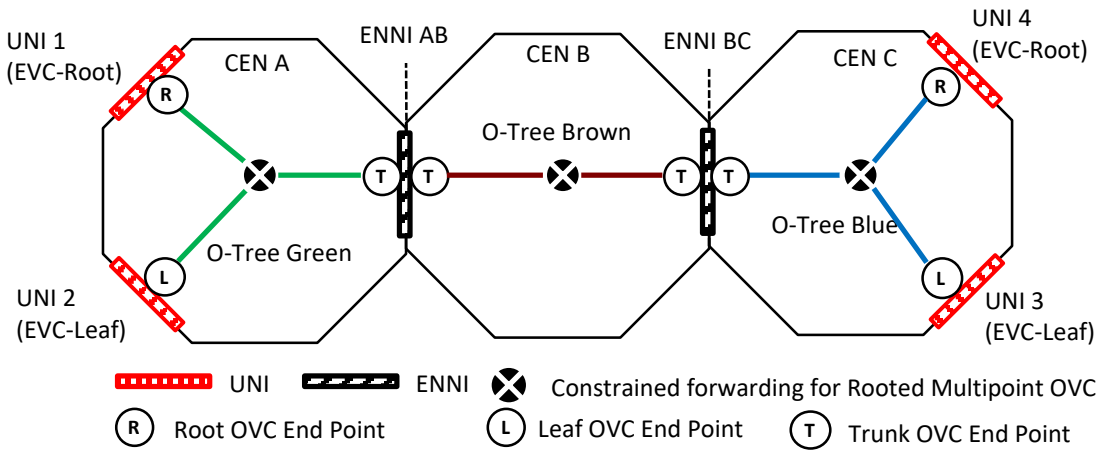

Figure 7 – SP-Operator view of an example of O-Tree Services in all three CENs

Note that *EVC-Leaf* and *EVC-Root* at the UNIs in Figure 7 refer to the EVC EP Role Service Attribute (Section 10.3 of MEF 10.4 [5]) value for the EVC implementing the E-Tree Service. These values are per agreement between the Subscriber and the Service Provider. In the SP-Operator view, the role of each OVC End Point at a UNI is as shown. The UNI roles are the same in both the SP-Subscriber and SP-Operator views.

In this example, *SP Alpha* uses three Operator Ethernet Services to build the E-Tree Service:

- O-Tree Green in CEN A connects UNI 1, UNI 2 and ENNI AB. The OVC End Point at UNI 1 has the role of Root; the OVC End Point at UNI 2 has the role of Leaf; and the OVC End Point at ENNI AB has the role of Trunk. A Trunk OVC End Point is required for this OVC since there are Root and Leaf UNIs in the OVC.

- O-Tree Blue in CEN C connects UNI 3, UNI 4 and ENNI BC. The OVC End Point at UNI 4 has the role of Root; the OVC End Point at UNI 3 has the role of Leaf and the OVC End Point at ENNI BC has the role of Trunk. A Trunk End Point is required for this OVC since there are Root and Leaf UNIs in the OVC.

- O-Tree Brown in CEN B connects ENNI AB with ENNI BC. This is a case of a Rooted-Multipoint OVC with just two OVC End Points. In this example, the OVC End Points are configured with the Trunk role, to ensure connectivity for both the Root and Leaf paths (separate S-VLAN IDs at each ENNI).

In the above example, an alternative arrangement in Operator B CEN is to use a Point-to-Point OVC between ENNI AB and ENNI BC, with the OVC End Point Map at each ENNI containing both S-VLAN IDs (Root/Leaf). In this arrangement, the Point-to-Point OVC would have *Root* End Points, and would preserve the S-VLAN IDs[8].

The full set of requirements for O-Tree Service consists of the common requirements specified in Section 7, and the constraints on the value of certain OVC Service Attributes specified in Table 11, below. The first column in Table 11 lists the Service Attributes and the second column specifies the constraining requirements for an O-Tree Service.

[8] See Figure 36 in MEF 26.2 [7] for a more detailed description of this possible arrangement. Appendix B of MEF 26.2 [7] contains additional examples of the use of Rooted-Multipoint OVCs.

OVC Service Attribute	Constraining Requirements for O-Tree Service
OVC Type	**[R15]** For an O-Tree Service, the OVC Type **MUST** be *Rooted-Multipoint*.
OVC End Point List	No additional constraints from MEF 26.2 [7] Note: At least one of the OVC End Points associated by the OVC is required to be at an ENNI, per [R36] of MEF 26.2 [7].
OVC Service Level Specification	No additional constraints from Table 6
OVC Frame Delivery	**[D19]** For an O-Tree Service, Unicast Frame Delivery **SHOULD** be *conditional* with the condition that the delivery of unicast frames is subject to the dynamic learning and filtering process as described in IEEE 802.1Q™-2018 [1] for Independent and Shared VLAN learning bridges.[9,10] **[D20]** For an O-Tree Service, Broadcast Frame Delivery **SHOULD** be 'unconditional'.[9] There are no additional constraints from MEF 26.2 [7] for multicast frame delivery.

Table 11 – Constraining OVC Service Attribute Requirements for O-Tree Service

[9] For a Rooted-Multipoint OVC, forwarding constraints involving roots and leaves, as specified in R37-R39 of MEF 26.2 [7], apply to all frame types – unicast, multicast and broadcast - and apply at all times regardless of the setting of *conditional* or *unconditional frame delivery*.

[10] For a Rooted-Multipoint OVC, an ingress frame at a given EI with a known unicast MAC DA would be forwarded only to the known egress EI. Other conditions might also apply.

9 E-Access Services

An *E-Access Service* is an Operator Ethernet Service that associates at least one OVC End Point at a UNI and at least one OVC End Point at an ENNI; that is, where the OVC End Point List Service Attribute contains at least one OVC End Point with an OVC End Point External Interface Type of *UNI* and at least one with an OVC End Point External Interface Type of *ENNI*. Note that an *E-Access Service* may associate more than one ENNI, and when it does it also provides transit between the ENNIs. The Purple OVC in Figure 2 shows an example of such an E-Access Service.

MEF 33 [9] defined two *E-Access services*, Access EPL and Access EVPL. This document supersedes MEF 51 [11] and MEF 33 [9] and defines two E-Access services: *Access E-Line* and *Access E-LAN*. Note that *Access E-Line Service* is more flexible than the MEF 33 [9] services and can be configured to give similar behavior as the MEF 33 [9] services, if so desired. Appendix D compares Access E-Line Service as defined in this document with similar services defined in MEF 51 [11] and MEF 33 [9]. Appendix C describes the main differences comparing this document with MEF 51 [11] and MEF 33 [9].

9.1 Access E-Line Service Definition

The Access E-Line Service provides a Point-to-Point OVC connecting one UNI with one ENNI. At the UNI, one or more CE-VLAN IDs can map to a given OVC End Point. At the ENNI, an S-VLAN ID maps to the OVC End Point. Note that an Access E-Line Service is an O-Line Service with additional constraints specified in this section.

Access E-Line Service allows for one or more Class of Service Names, and support for SOAM.

Figure 8 below depicts three examples of Access E-Line Service.

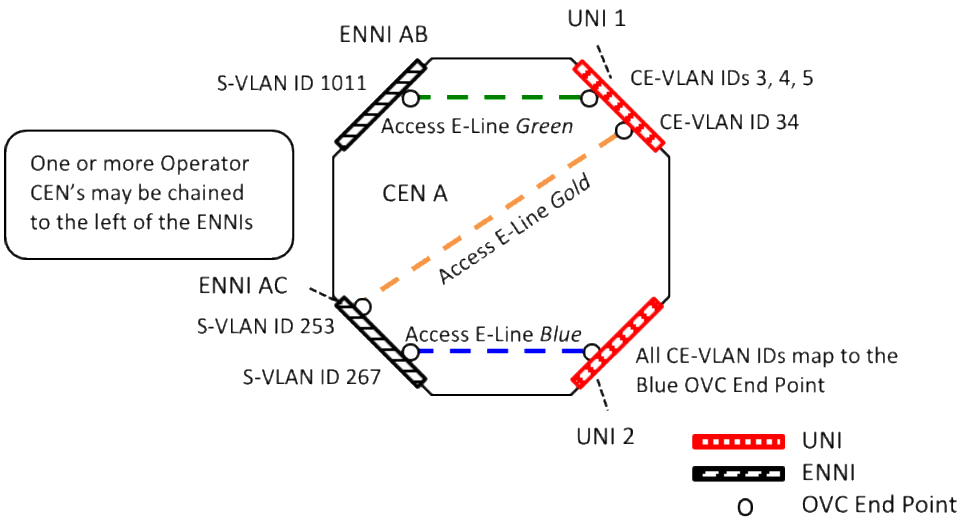

Figure 8 – Example of CEN with Three Access E-Line Services

Access E-Line Service provides access to a UNI that might be capable of more than one virtual connection. It has the capability to map:

- one CE-VLAN ID to an OVC End Point at the UNI (see *Gold* OVC at UNI 1); or,
- more than one (but not all) CE-VLAN IDs to an OVC End Point at the UNI (see *Green* OVC at UNI 1); or
- all CE-VLAN IDs to an OVC End Point at the UNI (see *Blue* OVC at UNI 2).

Access E-Line Service can also support one or more Class of Service Names on the OVC, which is important for flexibility and efficiency in handling different traffic types.

Note that interconnected Operator CENs to the left of the ENNIs shown in Figure 8 can have any type of Operator Ethernet Service. Some examples are listed below:

- Access to a Point-to-Point Operator Ethernet Service that, together with the Access E-Line Service, supports an end-to-end EPL or EVPL Service.
- Access to a Multipoint-to-Multipoint Operator Ethernet Service that, together with the Access E-Line Service, supports an end-to-end EP-LAN or EVP-LAN Service.
- Access to a Rooted-Multipoint Operator Ethernet Service that, together with the Access E-Line Service, supports an end-to-end EP-Tree or EVP-Tree Service.

The following subsections specify the Access E-Line Service definition in terms of the service attribute values.

See Appendix D for a comparison of Access E-Line Service as defined in this document with the Access E-Line Service defined in MEF 51 and with the Access EPL Service and Access EVPL Service as defined in MEF 33 [9].

9.1.1 Access E-Line Service: OVC Requirements

Table 12 below provides the full set of OVC Service Attributes and associated requirements for Access E-Line Service. The first column lists the OVC Service Attribute, and the second column specifies the requirements. In the case where reference is made to Table 6 in this document, it is found in Section 7.2 and where reference is made to Table 9 in this document, it is found in Section 8.1.

OVC Service Attribute	Requirements for Access E-Line Service
OVC ID	Requirements per Table 6, this document
OVC Type	Requirements per Table 9, this document
OVC End Point List	Requirements per Table 9, this document Note that one of the OVC End Points in the OVC End Point List is at an ENNI and the other is at a UNI, by definition.
Maximum Number of UNI OVC End Points	**[R16]** For Access E-Line Service, the maximum number of UNI OVC End Points **MUST** be one.
Maximum Number of ENNI OVC End Points	**[R17]** For Access E-Line Service, the maximum number of ENNI OVC End Points **MUST** be one.

OVC Service Attribute	Requirements for Access E-Line Service
OVC Maximum Frame Size	Requirements per Table 6, this document
OVC CE-VLAN ID Preservation	**[R18]** For Access E-Line Service, the Operator **MUST** support OVC CE-VLAN ID Preservation = *Preserve*. **[D21]** For Access E-Line Service, the Operator **SHOULD** support OVC CE-VLAN ID Preservation = *Strip*. For the case where EVC CE-VLAN ID Preservation is *Disabled* for an EVC and *Preserve* for all of the Access E-Line services supporting the EVC, then a VUNI (see Section 15 of MEF 26.2 [7]) would be required to do the necessary CE-VLAN ID translation for the EVC. The following is an example of OVC CE-VLAN ID Preservation = *Strip*: A Service Provider uses EVPL services in a hub & spoke arrangement, where, for configuration simplicity, each remote UNI uses a single (and the same) CE-VLAN ID (e.g., 10) to map to its EVC. At the hub end, different CE-VLAN IDs are used to map to the EVCs. An Access E-Line service does not need to forward the C-Tag across the ENNI in such an arrangement, the Operator CEN can replace the C-Tag with an S-Tag in going from the UNI to the ENNI and reverse the process in going from the ENNI to the UNI.
OVC CE-VLAN PCP Preservation	**[R19]** For Access E-Line Service, the Operator **MUST** support OVC CE-VLAN PCP Preservation = *Enabled* **[D22]** For Access E-Line Service, the Operator **SHOULD** support OVC CE-VLAN PCP Preservation = *Disabled*. The following is an example of OVC CE-VLAN PCP Preservation = *Disabled*: Customer uses IP-based devices to connect to the service and doesn't care about received PCP values (the subscriber's equipment uses DSCP for classification). In such cases, the C-Tag can be stripped across the ENNI, and the OVC can use a different policy (e.g., forwarding class within the network) to mark the PCP value at the egress UNI.
OVC CE-VLAN DEI Preservation	**[R20]** For Access E-Line Service, the Operator **MUST** support OVC CE-VLAN DEI Preservation = *Enabled* **[D23]** For Access E-Line Service, the Operator **SHOULD** support OVC CE-VLAN DEI Preservation = *Disabled*. The above example for the case of OVC CE-VLAN PCP Preservation = *Disabled* also applies for OVC CE-VLAN DEI Preservation.

OVC Service Attribute	Requirements for Access E-Line Service
OVC S-VLAN PCP Preservation	Not applicable
OVC S-VLAN DEI Preservation	Not applicable
OVC List of Class of Service Names	Requirements per Table 6, this document
OVC Service Level Specification	Requirements per Table 9, this document
OVC Frame Delivery	Requirements per Table 9, this document
OVC Available MEG Level	Requirements per Table 6, this document
OVC L2CP Address Set	Requirements per Table 6, this document

Table 12 – Constrained OVC Requirements for Access E-Line Service

9.1.2 Access E-Line Service: OVC End Point at ENNI Requirements

Table 13 below provides the requirements for Access E-Line Service for the OVC End Point at an ENNI. The first column lists the OVC End Point Service Attributes, and the second column specifies the requirements for the OVC End Point at an ENNI. In the case where reference is made to Table 7 in this document, it is found in Section 7.3.

OVC End Point Service Attribute	Requirements for Access E-Line Service for an OVC End Point at an ENNI
OVC End Point Identifier	Requirements per Table 7, this document
OVC End Point External Interface Type	Requirements per Table 7, this document
OVC End Point External Interface Identifier	Requirements per Table 7, this document
OVC End Point Role	Requirements per Table 7, this document
OVC End Point Map	Requirements per Table 7, this document The value of the OVC End Point Map Service Attribute for an OVC End Point at an ENNI is *Form E*, due to [R138] of MEF 26.2 [7] and the following conditions imposed by this service definition: 1) services defined by this document do not include a VUNI, 2) the OVC End Point Role is *Root* and 3) the OVC End Point External Interface Type is *ENNI*.
OVC End Point Class of Service Identifier	Requirements per Table 7, this document
OVC End Point Color Identifier	Requirements per Table 7, this document
OVC End Point Egress Map	Requirements per Table 7, this document
OVC End Point Egress Equivalence Class Identifier	Requirements per Table 7, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Ingress Bandwidth Profile per Class of Service Name	Requirements per Table 7, this document.
Egress Bandwidth Profile per Egress Equivalence Class Name	Requirements per Table 7, this document
OVC End Point Aggregation Link Depth	Requirements per Table 7, this document
OVC End Point Source MAC Address Limit	Requirements per Table 7, this document
OVC End Point MIP	Requirements per Table 7, this document
OVC End Point MEP List	Requirements per Table 7, this document Note that [D9] and subtending requirements in Table 7 do not apply to an Access E-Line Service.

Table 13 – Constrained OVC End Point at ENNI Requirements for Access E-Line Service

9.1.3 Access E-Line Service: OVC End Point per UNI Requirements

Table 14 below provides the requirements for Access E-Line Service for the OVC End Point at a UNI. The first column lists the OVC End Point Service Attributes, and the second column specifies the requirements for an OVC End Point at a UNI. In the case where reference is made to Table 8 in this document, it is found in Section 7.4.

OVC End Point Service Attribute	Requirements for Access E-Line Service for an OVC End Point at a UNI
OVC End Point Identifier	Requirements per Table 8, this document
OVC End Point External Interface Type	Requirements per Table 8, this document
OVC End Point External Interface Identifier	Requirements per Table 8, this document
OVC End Point Role	Requirements per Table 8, this document
OVC End Point Map	**[R21]** The Operator **MUST** support a mapping of one CE-VLAN ID to the OVC End Point at the UNI. **[D24]** The Operator **SHOULD** support a mapping of more than one (but not all) CE-VLAN IDs to the OVC End Point at the UNI. **[R22]** The Operator **MUST** support a mapping of all CE-VLAN ID to the OVC End Point at the UNI.
OVC End Point Class of Service Identifier	Requirements per Table 8, this document
OVC End Point Color Identifier	Requirements per Table 8, this document
OVC End Point Egress Map	Requirements per Table 8, this document
OVC End Point Egress Equivalence Class Identifier	Requirements per Table 8, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 8, this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 8, this document
Ingress Bandwidth Profile per Class of Service Name	Requirements per Table 8, this document
Egress Bandwidth Profile per Egress Equivalence Class Name	Requirements per Table 8, this document
OVC End Point Aggregation Link Depth	Requirements per Table 8, this document
OVC End Point Source MAC Address Limit	Requirements per Table 8, this document
OVC End Point MIP	Requirements per Table 8, this document
OVC End Point MEP List	Requirements per Table 8, this document

Table 14 – Constrained OVC End Point at UNI Requirements for Access E-Line Service

9.1.4 Access E-Line Service: ENNI Service Attributes & Requirements

No additional constraints from Section 7.5 of this document

9.1.5 Access E-Line Service: UNI Service Attributes & Requirements

No additional constraints from Section 7.6 of this document

9.2 Access E-LAN Service Definition

The Access E-LAN Service provides a Multipoint-to-Multipoint OVC connecting one or more UNIs with one or more ENNIs. Note that an Access E-LAN Service is an O-LAN Service with additional constraints specified in this section.

Access E-LAN Service provides a bridging service intended to support three or more OVC End Points, at least one of which is at a UNI and at least one of which is at an ENNI. Figure 9 below depicts an example of Access E-LAN Service.

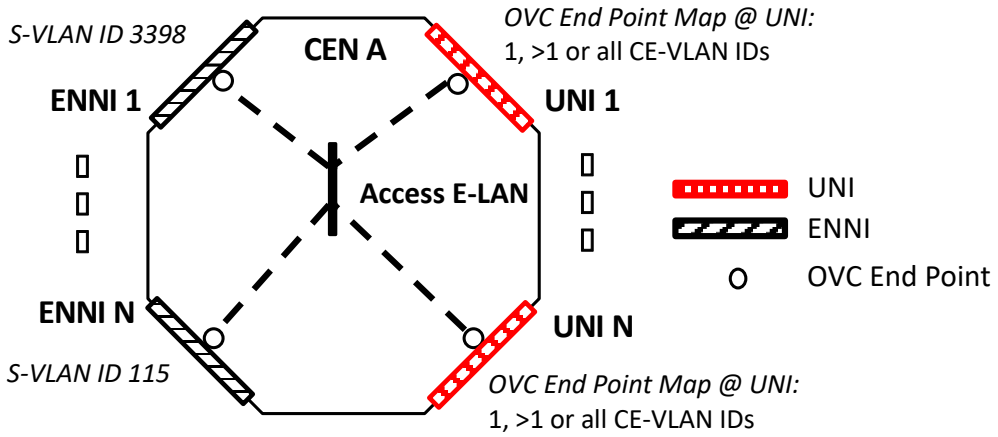

Figure 9 – Example of Access E-LAN Service

Two possible applications for Access E-LAN Service are depicted in Figure 10 below, and then briefly described.

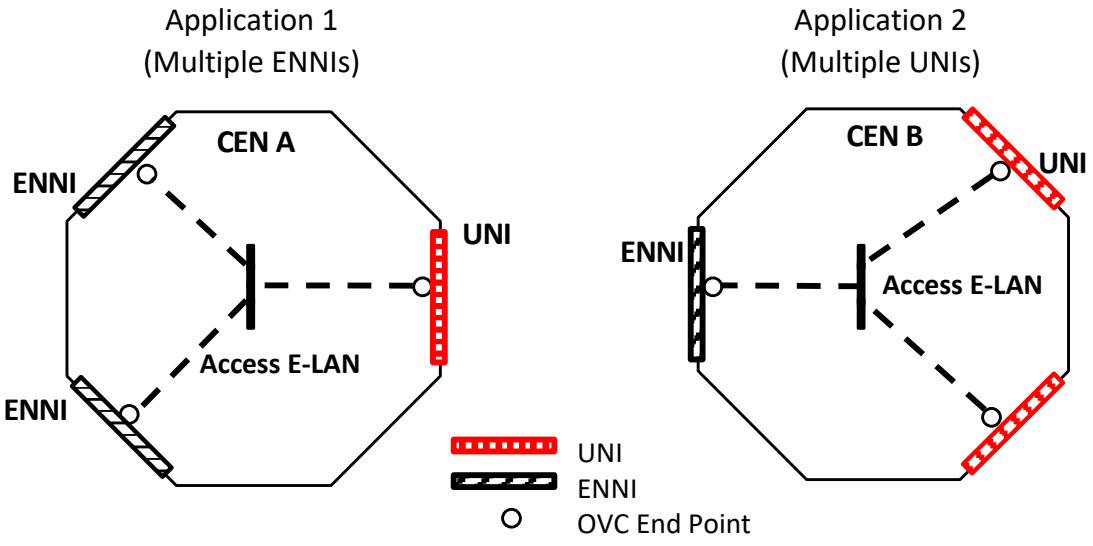

Figure 10 – Two Example Applications for Access E-LAN Services

Application 1: Single UNI, Multiple ENNIs

In this application, depicted in CEN A in Figure 10 above, the Access E-LAN Service associates an OVC End Point at one UNI with OVC End Points at two (or more) ENNIs. The intent is to allow frames to be forwarded between the ENNIs; e.g., this Operator Ethernet Service could be supporting an EVP-LAN service that might be distributed among several CENs. The use of multiple ENNIs provides extended connectivity to multiple CENs, and also can be used for SP/SOs requiring enhanced reliability for services at the UNI.

Application 2: Multiple UNIs, single ENNI

In this application, depicted in CEN B in Figure 10 above, the Access E-LAN Service associates an OVC End Point at one ENNI with OVC End Points at two (or could be more) UNIs. Subscribers might require multiple sites (UNIs) to access other CENs, e.g., connecting OVCs to form an EVC Service, or to access a higher layer service, such as Layer 3, Cloud, etc.

Access E-LAN Service could be used to support an EVC-based EVP-LAN Service. One method of doing so, using the example service in Figure 11, is described below.

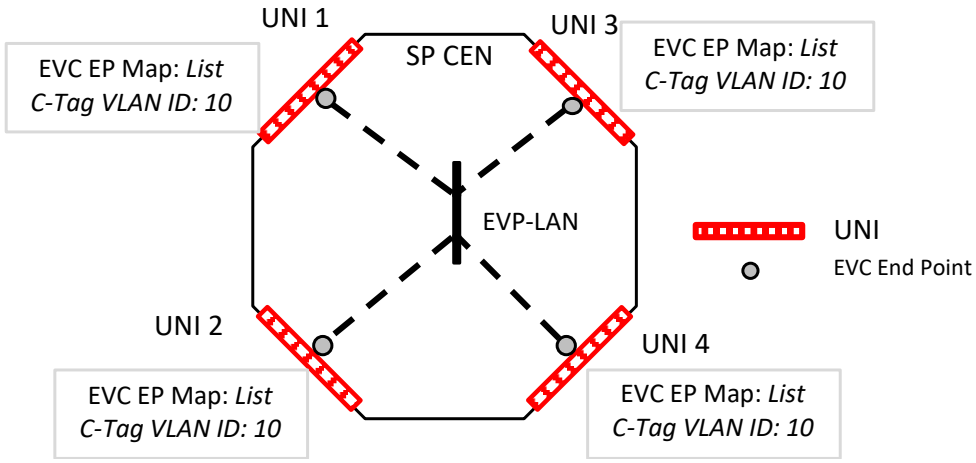

Figure 11 – Example of EVP-LAN Service, with preservation of the CE-VLAN ID

In this example, the Subscriber wants preservation of the CE-VLAN ID (CE-VLAN ID 10 at each of the four UNIs identifies the service). Figure 11 depicts the EVP-LAN Service from a Service Provider-Subscriber perspective. The Subscriber sees one CEN (the SP CEN). The Service Provider selects two Operator CENs (CEN A & CEN B) and orders Access E-LAN Services, including OVC CE-VLAN ID Preservation = *Preserve* in both, to support the EVP-LAN Service. This is shown in Figure 12, below.

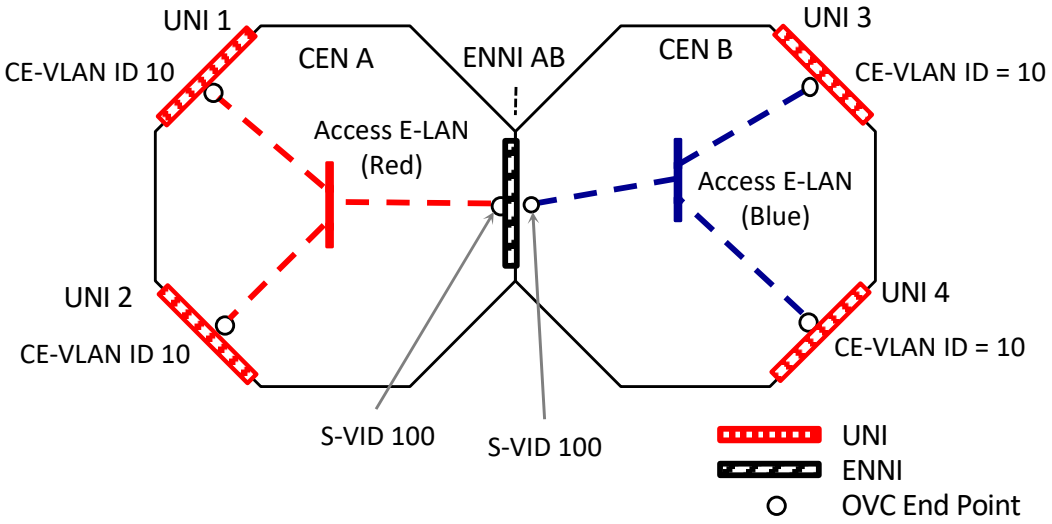

Figure 12 – Example of two Access E-LAN Services supporting the EVP-LAN Service

Figure 12 depicts the Operator Ethernet Services, from the Service Provider-Operator perspective, needed to support the EVP-LAN Service. The SP sees two CENs (CEN A and CEN B).

The Red Access E-LAN Service is built in CEN A, and the Blue Access E-LAN Service is built in CEN B. At the ENNI, the two Access E-LAN Services are stitched together using S-VID 100. This completes the connectivity required for the EVC-based EVP-LAN Service.

An alternative arrangement supporting the EVP-LAN Service described above is shown in Figure 13 below.

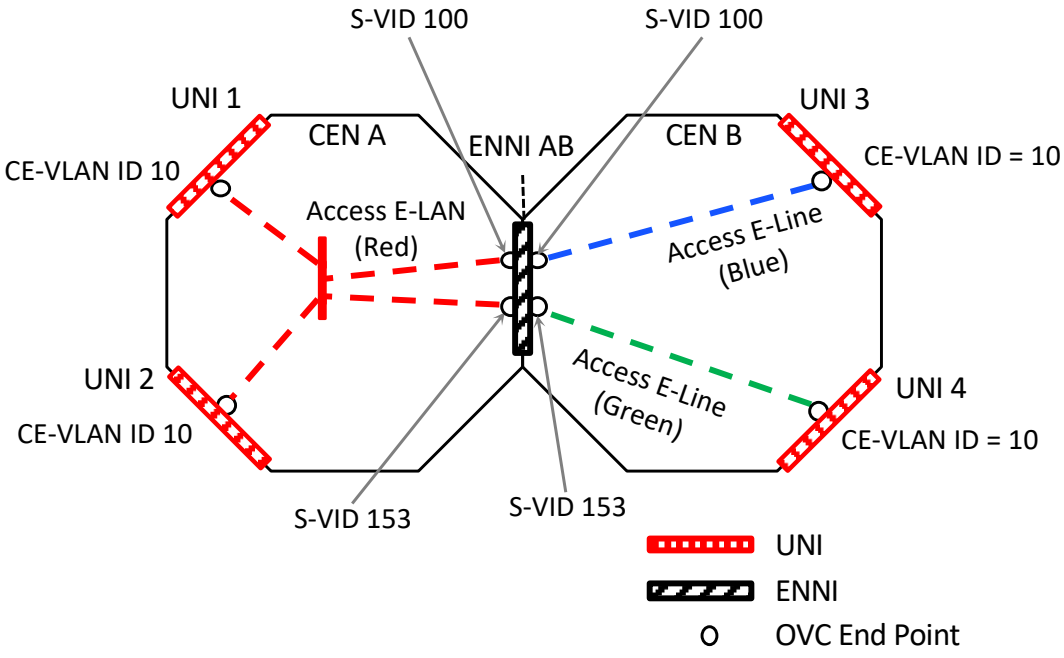

Figure 13 – Example of one Access E-LAN Service supporting the EVP-LAN Service

In this example, one Access E-LAN Service is used in CEN A, with two Access E-Line Services in CEN B. Access E-Line (Blue) provides connectivity to UNI 3 and Access E-Line (Green) provides connectivity to UNI 4. The EVP-LAN service is operationally simplified – there's only one OVC providing the multipoint switching, at the expense of local traffic (UNI 3 to UNI 4) having to get switched in CEN A, which is doing the hairpin switching across the ENNI to provide the required connectivity.

The following subsections specify the Access E-LAN Service definition in terms of the service attribute values.

9.2.1 Access E-LAN Service: OVC Requirements

Table 15 below provides the full set of OVC Service Attributes and associated requirements for Access E-LAN Service. The first column lists the OVC Service Attribute, and the second column specifies the requirements. In the case where reference is made to Table 6 in this document, it is found in Section 7.2 and where reference is made to Table 10 in this document, it is found in Section 8.2.

OVC Service Attribute	Requirements for Access E-LAN Service
OVC ID	Requirements per Table 6, this document
OVC Type	Requirements per Table 10, this document
OVC End Point List	Requirements per Table 10, this document Note that at least one of the OVC End Points in the OVC End Point List is at an ENNI and at least one of the OVC End Points in the OVC End Point List is at a UNI, by definition.
Maximum Number of UNI OVC End Points	**[R23]** For Access E-LAN Service, the maximum number of UNI OVC End Points **MUST** be ≥1.
Maximum Number of ENNI OVC End Points	Requirements per Table 6, this document
OVC Maximum Frame Size	Requirements per Table 6, this document
OVC CE-VLAN ID Preservation	Requirements per Table 6, this document
OVC CE-VLAN PCP Preservation	Requirements per Table 6, this document
OVC CE-VLAN DEI Preservation	Requirements per Table 6, this document
OVC S-VLAN PCP Preservation	Requirements per Table 6, this document
OVC S-VLAN DEI Preservation	Requirements per Table 6, this document
OVC List of Class of Service Names	Requirements per Table 6, this document
OVC Service Level Specification	Requirements per Table 10, this document
OVC Frame Delivery	Requirements per Table 10, this document
OVC Available MEG Level	Requirements per Table 6, this document
OVC L2CP Address Set	Requirements per Table 6, this document

Table 15 – Constrained OVC Requirements for Access E-LAN Service

9.2.2 Access E-LAN Service: OVC End Point at ENNI Requirements

Table 16 below provides the requirements for Access E-LAN Service for the OVC End Point at an ENNI. The first column lists the OVC End Point Service Attributes, and the second column specifies the requirements for an OVC End Point at an ENNI. In the case where reference is made to Table 7 in this document, it is found in Section 7.3.

OVC End Point Service Attribute	Requirements for Access E-LAN Service for an OVC End Point at an ENNI
OVC End Point Identifier	Requirements per Table 7 this document
OVC End Point External Interface Type	Requirements per Table 7, this document
OVC End Point External Interface Identifier	Requirements per Table 7, this document
OVC End Point Role	Requirements per Table 7, this document
OVC End Point Map	Requirements per Table 7 this document The value of the OVC End Point Map Service Attribute for an OVC End Point at an ENNI is *Form E*, due to [R138] of MEF 26.2 [7] and the following conditions imposed by this service definition: 1) services defined by this document do not include a VUNI, 2) the OVC End Point Role is Root and 3) the OVC End Point External Interface Type is ENNI.
OVC End Point Class of Service Identifier	Requirements per Table 7 this document
OVC End Point Color Identifier	Requirements per Table 7 this document
OVC End Point Egress Map	Requirements per Table 7 this document
OVC End Point Egress Equivalence Class Identifier	Requirements per Table 7 this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 7 this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 7 this document
Ingress Bandwidth Profile per Class of Service Name	Requirements per Table 7 this document
Egress Bandwidth Profile per Egress Equivalence Class Name	Requirements per Table 7 this document
OVC End Point Aggregation Link Depth	Requirements per Table 7 this document
OVC End Point Source MAC Address Limit	Requirements per Table 7 this document
OVC End Point MIP	Requirements per Table 7 this document
OVC End Point MEP List	Requirements per Table 7 this document

Table 16 – Constrained OVC End Point at ENNI Requirements for Access E-LAN Service

9.2.3 Access E-LAN Service: OVC End Point at UNI Requirements

Table 17 below provides the requirements for Access E-LAN Service for the OVC End Point at a UNI. The first column lists the OVC End Point Service Attributes, and the second column specifies the requirements for an OVC End Point at a UNI. In the case where reference is made to Table 8 in this document, it is found in Section 7.4.

OVC End Point Service Attribute	Requirements for Access E-LAN Service for an OVC End Point at a UNI
UNI OVC Identifier	Requirements per Table 8, this document
OVC End Point External Interface Type	Requirements per Table 8, this document
OVC End Point External Interface Identifier	Requirements per Table 8, this document
OVC End Point Role	Requirements per Table 8, this document
OVC End Point Map	The following requirements apply: **[R24]** The Operator **MUST** support a mapping of one CE-VLAN ID to the OVC End Point. **[D25]** The Operator **SHOULD** support a mapping of more than one (but not all) CE-VLAN IDs to the OVC End Point. **[R25]** The Operator **MUST** support a mapping of all CE-VLAN IDs to the OVC End Point.
OVC End Point Class of Service Identifier	Requirements per Table 8, this document
OVC End Point Color Identifier	Requirements per Table 8, this document
OVC End Point Egress Map	Requirements per Table 8, this document
OVC End Point Egress Equivalence Class Identifier	Requirements per Table 8, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 8, this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 8, this document
Ingress Bandwidth Profile per Class of Service Name	Requirements per Table 8, this document
Egress Bandwidth Profile per Egress Equivalence Class Name	Requirements per Table 8, this document
OVC End Point Aggregation Link Depth	Requirements per Table 8, this document
OVC End Point Source MAC Address Limit	Requirements per Table 8, this document
Subscriber MEG MIP	Requirements per Table 8, this document
OVC End Point MEP List	Requirements per Table 8, this document

Table 17 – Constrained OVC End Point at UNI Requirements for Access E-LAN Service

9.2.4 Access E-LAN Service: ENNI Requirements

No additional constraints from Section 7.5 of this document

9.2.5 Access E-LAN Service: UNI Requirements

No additional constraints from Section 7.6 of this document.

10 E-Transit Services

An E-Transit Service is an Operator Ethernet Service that associates OVC End Points that are all at ENNIs; that is, a service where every OVC End Point in the OVC End Point List Service Attribute has an OVC End Point External Interface Type of *ENNI*. This section defines two E-Transit services: Transit E-Line Service and Transit E-LAN Service.

10.1 Transit E-Line Service Definition

The Transit E-Line Service provides a single Point-to-Point OVC associating two OVC End Points, each of which is at an ENNI (could be two different ENNIs or the same ENNI, e.g., where hairpin switching is used). Transit E-Line Service includes preservation of CE-VLAN ID, CE-VLAN PCP and CE-VLAN DEI and allows for one or more Class of Service Names. It also includes support for SOAM. Note that a Transit E-Line Service is an O-Line Service with additional constraints specified in this section.

Figure 14 below depicts two examples of Transit E-Line Service.

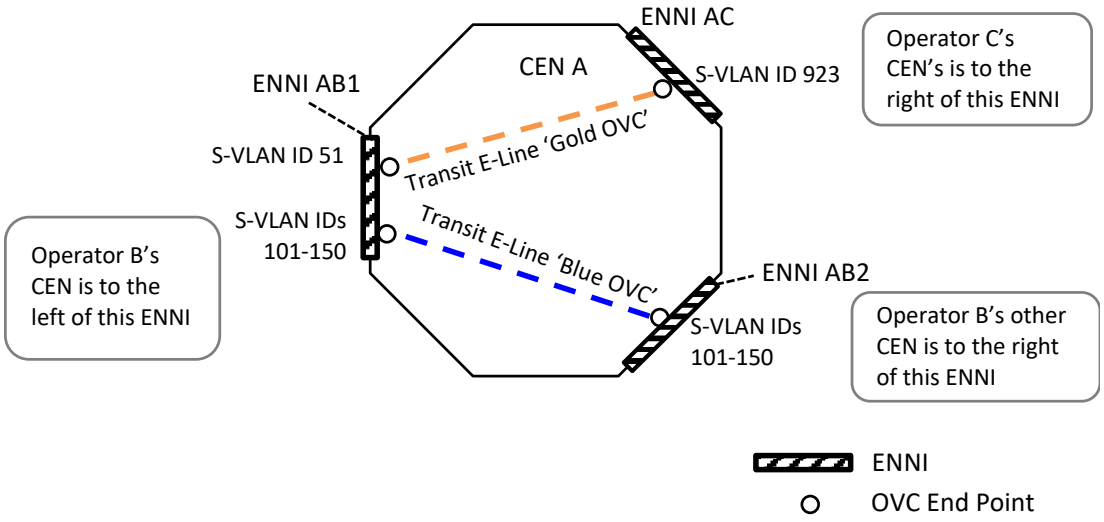

Figure 14 – Examples of Transit E-Line Service

Typically, Transit E-Line Service provides point-to-point connectivity between a pair of ENNIs. It has the capability to map a single S-VLAN ID per OVC End Point at each ENNI (see Gold OVC in Figure 14), or multiple S-VLAN IDs per OVC End Point at each ENNI (see Blue OVC in Figure 14). It can support one or more Class of Service Names, which is important for flexibility and efficiency in handling different traffic types. Interconnected Operator CENs to the left or right of the ENNIs shown in Figure 14 can have any Operator Ethernet Service. Some examples where the Transit E-Line Service can be used for providing transit service include:

- Interconnection of CENs through an intermediate CEN.
- Connecting an Operator's disparate CENs together – in the example shown above, Operator B has remote CENs to the left and right of Operator A's CEN and uses Operator A's

CEN to connect those networks together. In this example, Operator B requires a bundle of S-VLAN IDs to be connected across Operator A's CEN.

- Interconnection of a chain of CENs to access a UNI.

The following subsections specify the Transit E-Line Service definition in terms of the service attribute values.

10.1.1 Transit E-Line Service: OVC Requirements

Table 18 below provides the full set of OVC Service Attributes and associated requirements for Transit E-Line Service. The first column lists the OVC Service Attribute, and the second column specifies the requirements. Where reference is made to Table 6 in this document, it is found in Section 7.2 and where reference is made to Table 9, it is found in Section 8.1.

OVC Service Attribute	Requirements for Transit E-Line Service
OVC ID	Requirements per Table 6, this document
OVC Type	Requirements per Table 9, this document
OVC End Point List	Requirements per Table 9, this document. Note that all the OVC End Points in the OVC End Point List are at ENNIs, by definition.
Maximum Number of UNI OVC End Points	**[R26]** For Transit E-Line Service, the maximum number of UNI OVC End Points **MUST** be zero.
Maximum Number of ENNI OVC End Points	**[R27]** For Transit E-Line Service, the maximum number of ENNI OVC End Points **MUST** be two.
OVC Maximum Frame Size	Requirements per Table 6, this document
OVC CE-VLAN ID Preservation	**[R28]** For Transit E-Line Service, CE-VLAN ID Preservation **MUST** be *Preserve*.[11]
OVC CE-VLAN PCP Preservation	**[R29]** For Transit E-Line Service, CE-VLAN PCP Preservation **MUST** be *Enabled*.[11]
OVC CE-VLAN DEI Preservation	**[R30]** For Transit E-Line Service, CE-VLAN DEI Preservation **MUST** be *Enabled*.[11]
OVC S-VLAN PCP Preservation	Requirements per Table 6, this document
OVC S-VLAN DEI Preservation	Requirements per Table 6, this document
OVC List of Class of Service Names	Requirements per Table 6, this document
OVC Service Level Specification	Requirements per Table 9, this document.
OVC Frame Delivery	Requirements per Table 9, this document
OVC Available MEG Level	Requirements per Table 6, this document
OVC L2CP Address Set	Requirements per Table 6, this document

Table 18 – Constraining OVC Service Attribute Requirements for Transit E-Line Service

10.1.2 Transit E-Line Service: OVC End Point at ENNI Requirements

Table 19 below provides the requirements for Transit E-Line Service for the OVC End Point at an ENNI. The first column lists the OVC End Point Service Attributes, and the second column specifies the requirements for an OVC End Point at an ENNI. In the case where reference is made to Table 7 in this document, it is found in Section 7.3.

[11] For Transit E-Line Service, the value of this attribute has no impact on the service behavior, due to [R76] of MEF 26.2 and the fact that the services defined by this document do not include a VUNI. The requirement is specified to simplify ordering and testing.

OVC End Point Service Attribute	Requirements for Transit E-Line Service for OVC End Point at an ENNI
OVC End Point Identifier	Requirements per Table 7 this document
OVC End Point External Interface Type	Requirements per Table 7, this document
OVC End Point External Interface Identifier	Requirements per Table 7, this document
OVC End Point Role	Requirements per Table 7, this document
OVC End Point Map	Requirements per Table 7, this document The value of the OVC End Point Map Service Attribute for an OVC End Point at an ENNI is *Form E*, due to [R138] of MEF 26.2 [7] and the following conditions imposed by this service definition: 1) services defined by this document do not include a VUNI, 2) the OVC End Point Role is Root and 3) the OVC End Point External Interface Type is ENNI.
OVC End Point Class of Service Identifier	Requirements per Table 7, this document
OVC End Point Color Identifier	Requirements per Table 7, this document
OVC End Point Egress Map	Requirements per Table 7, this document
OVC End Point Egress Equivalence Identifier	Requirements per Table 7, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Ingress Bandwidth Profile per Class of Service Name	Requirements per Table 7, this document
Egress Bandwidth Profile per Egress Equivalence Name	Requirements per Table 7, this document
OVC End Point Aggregation Link Depth	Requirements per Table 7, this document
OVC End Point Source MAC Address Limit	Requirements per Table 7, this document
OVC End Point MIP	Requirements per Table 7, this document
OVC End Point MEP List	Requirements per Table 7, this document

Table 19 – Constraining OVC End Point at ENNI Requirements, Transit E-Line Service

10.1.3 Transit E-Line Service: OVC End Point at UNI Requirements

Not applicable for this service.

10.1.4 Transit E-Line Service: ENNI Requirements

No additional constraints from Section 7.5 of this document.

10.1.5 Transit E-Line Service: UNI Requirements

Not applicable for this service.

10.2 Transit E-LAN Service Definition

The Transit E-LAN Service provides a Multipoint-to-Multipoint OVC that associates OVC End Points at one or more ENNIs. It has the capability to map a single S-VLAN ID per OVC End Point at each ENNI, or multiple S-VLAN IDs per OVC End Point at each ENNI. Transit E-LAN Service includes preservation of CE-VLAN ID, CE-VLAN PCP and CE-VLAN DEI, and allows for one or more Class of Service Names. It also includes SOAM support. Note that a Transit E-LAN Service is an O-LAN Service with additional constraints specified in this section.

In deployments of E-LAN service across multiple CENs, multipoint Operator Ethernet Services could be confined to one CEN, allowing bridging functions such as Source MAC Address learning and conditional delivery (e.g., rate limit policies for broadcast and multicast frames) to be performed by just one Operator. Other CENs could provide access to this CEN with Operator Ethernet Services based on Point-to-Point OVCs. In this type of service, support for one or more Class of Service Names can be valuable since it can help to manage and prioritize merging traffic at an egress OVC End Point.

Figure 15 below depicts an example of Transit E-LAN Service.

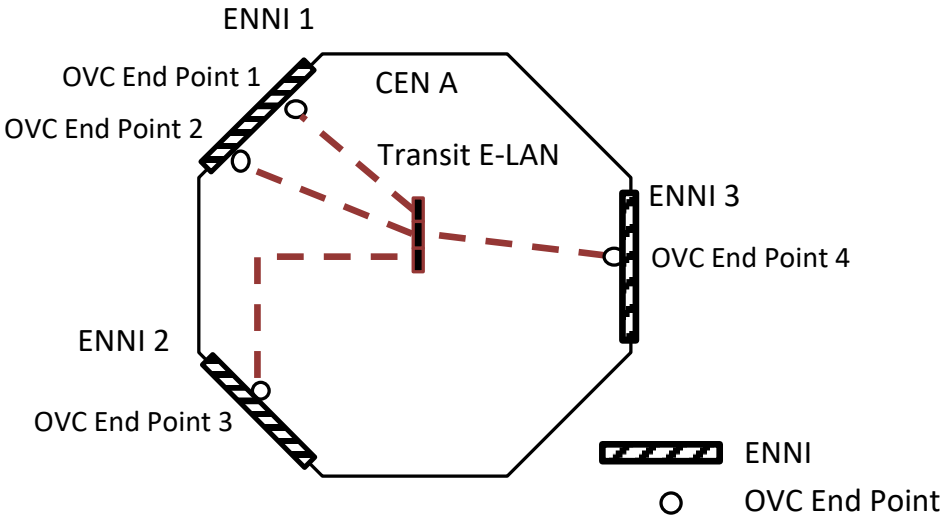

Figure 15 – Example of Transit E-LAN Service (Multipoint OVC Transit Service)

In the above example, Transit E-LAN Service provides a multipoint OVC that associates four OVC End Points at three ENNIs. ENNI 1 has two of the OVC End Points and is providing hair-pin switching for the service. In its simplest form, we can envision four Point-to-Point OVCs in the three adjacent CENs connecting to the three ENNIs shown in Figure 15 above. This could be an example of the SP/SO choosing just one CEN to control the forwarding, Class of Service Names, and Frame Delivery requirements for an end-to-end E-LAN service. Some inefficiency

may be introduced due to the hairpin switching at ENNI 1, but the benefit (control of the multipoint service) can outweigh the inefficiency.

The following subsections specify the Transit E-LAN Service definition in terms of the service attribute values.

10.2.1 Transit E-LAN Service: OVC Requirements

Table 20 below provides the full set of OVC Service Attributes and associated requirements for Transit E-LAN Service. The first column lists the OVC Service Attribute, and the second column specifies the requirements. In the case where reference is made to Table 6 in this document, it is found in Section 7.2, and where reference is made to Table 10, it is found in Section 8.2.

OVC Service Attribute	Requirements for Transit E-LAN Service
OVC ID	Requirements per Table 6, this document
OVC Type	Requirements per Table 10, this document
OVC End Point List	Requirements per Table 10, this document. Note that all the OVC End Points in the OVC End Point List are at ENNIs, by definition.
Maximum Number of UNI OVC End Points	**[R31]** For Transit E-LAN Service, the maximum number of UNI OVC End Points **MUST** be zero.
Maximum Number of ENNI OVC End Points	**[R32]** For Transit E-LAN Service, the maximum number of ENNI OVC End Points **MUST** be ≥ 3.
OVC Maximum Frame Size	Requirements per Table 6, this document
OVC CE-VLAN ID Preservation	**[R33]** For Transit E-LAN Service, CE-VLAN ID Preservation **MUST** be *Preserve*.[12]
OVC CE-VLAN PCP Preservation	**[R34]** For Transit E-LAN Service, CE-VLAN PCP Preservation **MUST** be *Enabled*.[12]
OVC CE-VLAN DEI Preservation	**[R35]** For Transit E-LAN Service, CE-VLAN DEI Preservation **MUST** be *Enabled*.[12]
OVC S-VLAN PCP Preservation	Requirements per Table 6, this document
OVC S-VLAN DEI Preservation	Requirements per Table 6, this document
OVC List of Class of Service Names	Requirements per Table 6, this document
OVC Service Level Specification	Requirements per Table 10, this document
OVC Frame Delivery	Requirements per Table 10, this document
OVC Available MEG Level	Requirements per Table 6, this document
OVC L2CP Address Set	Requirements per Table 6, this document

Table 20 – Constraining OVC Requirements for Transit E-LAN Service

[12] For Transit E-LAN Service, the value of this attribute has no impact on the service behavior, due to [R76] of MEF 26.2 and the fact that the services defined by this document do not include a VUNI. The requirement is specified to simplify ordering and testing.

10.2.2 Transit E-LAN Service: OVC End Point per ENNI Service Attributes & Requirements

Table 21 below provides the requirements for Transit E-LAN Service for the OVC End Point at an ENNI. The first column lists the OVC End Point Service Attributes, and the second column specifies the requirements for an OVC End Point at an ENNI. In the case where reference is made to Table 7 in this document, it is found in Section 7.3.

OVC End Point Service Attribute	Requirements for Transit E-LAN Service for OVC End Point at an ENNI
OVC End Point Identifier	Requirements per Table 7, this document
OVC End Point External Interface Type	Requirements per Table 7, this document
OVC End Point External Interface Identifier	Requirements per Table 7, this document
OVC End Point Role	Requirements per Table 7, this document
OVC End Point Map	Requirements per Table 7, this document. The value of the OVC End Point Map Service Attribute for an OVC End Point at an ENNI is *Form E*, due to [R138] of MEF 26.2 [7] and the following conditions imposed by this service definition: 1) services defined by this document do not include a VUNI, 2) the OVC End Point Role is Root and 3) the OVC End Point External Interface Type is ENNI.
OVC End Point Class of Service Identifier	Requirements per Table 7, this document
OVC End Point Color Identifier	Requirements per Table 7, this document
OVC End Point Egress Map	Requirements per Table 7, this document
OVC End Point Egress Equivalence Class Identifier	Requirements per Table 7, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Ingress Bandwidth Profile per Class of Service Name	Requirements per Table 7, this document
Egress Bandwidth Profile per Egress Equivalence Class Name	Requirements per Table 7, this document
OVC End Point Aggregation Link Depth	Requirements per Table 7, this document
OVC End Point Source MAC Address Limit	Requirements per Table 7, this document
OVC End Point MIP	Requirements per Table 7, this document
OVC End Point MEP List	Requirements per Table 7, this document

Table 21 – Constraining OVC End Point at ENNI Requirements, Transit E-LAN Service

10.2.3 Transit E-LAN Service: OVC End Point per UNI Requirements

Not applicable for this service.

10.2.4 Transit E-LAN Service: ENNI Requirements

No additional constraints from Section 7.5 of this document.

10.2.5 Transit E-LAN Service: UNI Requirements

Not applicable for this service.

11 References

[1] IEEE Std 802.1Q™ – 2018, IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks, May 2018

[2] IETF RFC 2119, Key words for use in RFCs to Indicate Requirement Levels, March 1997

[3] IETF RFC 8174, Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words, May 2017

[4] MEF 6.2, EVC Ethernet Services Definitions Phase 3, July 2014

[5] MEF 10.4, Subscriber Ethernet Service Attributes, December 2018

[6] MEF 26.1, External Network Network Interface (ENNI) - Phase 2, August 2016

[7] MEF 26.2, External Network Network Interfaces (ENNI) and Operator Service Attributes, August 2016

[8] MEF 30.1, Service OAM Fault Management Implementation Agreement: Phase 2, April 2013

[9] MEF 33, Ethernet Access Services Definition, January 2012

[10] MEF 35.1, Service OAM Performance Monitoring Implementation Agreement, April 2015

[11] MEF 51, OVC Services Definitions, August 2015

[12] MEF 45.1, Layer 2 Control Protocols in Ethernet Services, December 2018

Appendix A Practical Examples of Ethernet Services (Informative)

The following examples show how a set of Operator Ethernet Services can be used to support an end-to-end EVC Service.

A.1 EVPL Service Using Access and Transit Operator Ethernet Services

The Subscriber *Omega 3* needs to connect two remote sites to its headquarters site, and asks Service Provider, *SP Alpha*, to offer a solution using a typical hub and spoke model, based on EVPL services. Figure 16 below depicts the EVC connectivity agreed to by *Omega 3* and *SP Alpha*.

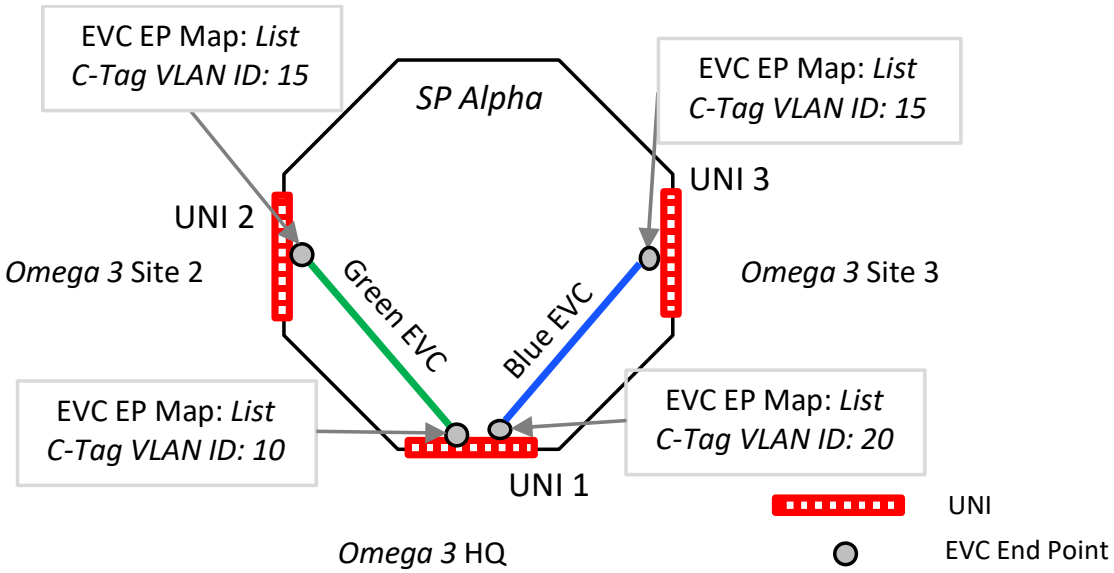

Figure 16 – Example of two EVPL Services

In this example, the Green EVC connects UNI 1 (the headquarters site) with UNI 2 (site 2), and the Blue EVC connects UNI 1 with UNI 3 (site 3). The EVC EP Map is *List* for each of the EVC End Points. At UNI 1, C-Tag VLAN ID 10 maps to the Green EVC End Point and C-Tag VLAN ID 20 maps to the Blue EVC End Point. At UNI 2, C-Tag VLAN ID 15 maps to the Green EVC End Point and at UNI 3, C-Tag VLAN ID 15 maps to the Blue EVC End Point. Note that in this example, the customer equipment configuration at Sites 2 and 3 are simplified since the same C-Tag VLAN ID value is used at each.

SP Alpha buys six Operator Ethernet Services from four different Operators. This set of Operator Ethernet Services is shown in Figure 17, below.

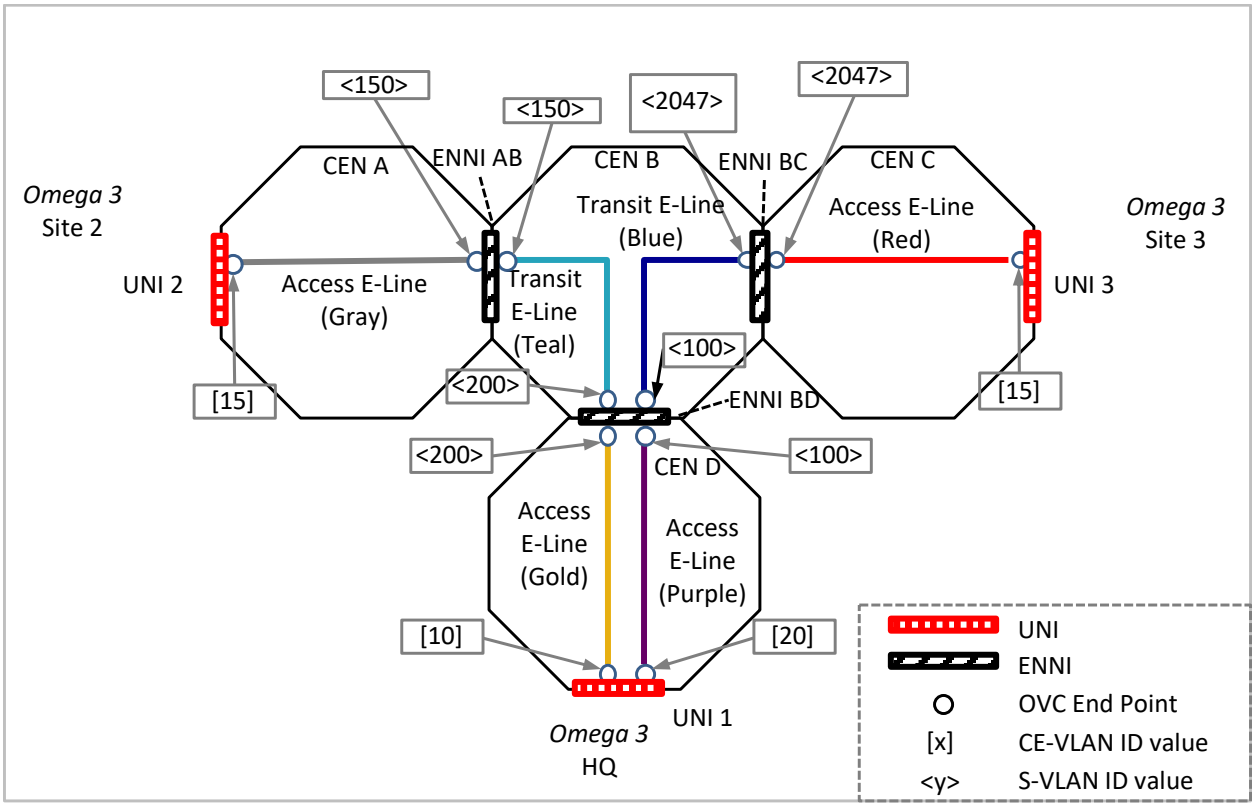

Figure 17 – Example of two EVPL Services using Access and Transit Operator Ethernet Services

In this scenario, *SP Alpha* uses three Operator Ethernet Services to create connectivity for the Green EVC shown in Figure 16; and three different Operator Ethernet Services to create connectivity for the Blue EVC shown also in Figure 16. The Operator Ethernet Services are summarized below:

- CEN D Operator provides two Access E-Line Services (Gold and Purple) from UNI D1 to ENNI BD
- CEN B Operator provides one Transit E-Line Service (Teal) from ENNI BD to ENNI AB; and one Transit E-Line Service (Blue) from ENNI BD to ENNI BC
- CEN A Operator provides an Access E-Line Service (Gray) from UNI A1 to ENNI AB
- CEN C Operator provides an Access E-Line Service (Red) from UNI C1 to ENNI BC

SP Alpha negotiates the OVC End Point maps for each OVC appropriately at each of the ENNIs and/or UNIs involved, as seen in Figure 17, and *Omega 3* gets the needed EVPL services.

A.2 EP-LAN Service Using Access and Transit Operator Ethernet Services

In this use case, *Omega 3* needs to connect two remote sites and its headquarters site with any-to-any connectivity and asks *SP Alpha* to offer a solution using a transparent E-LAN type service. *SP Alpha* offers an EP-LAN service, as shown in Figure 18 below.

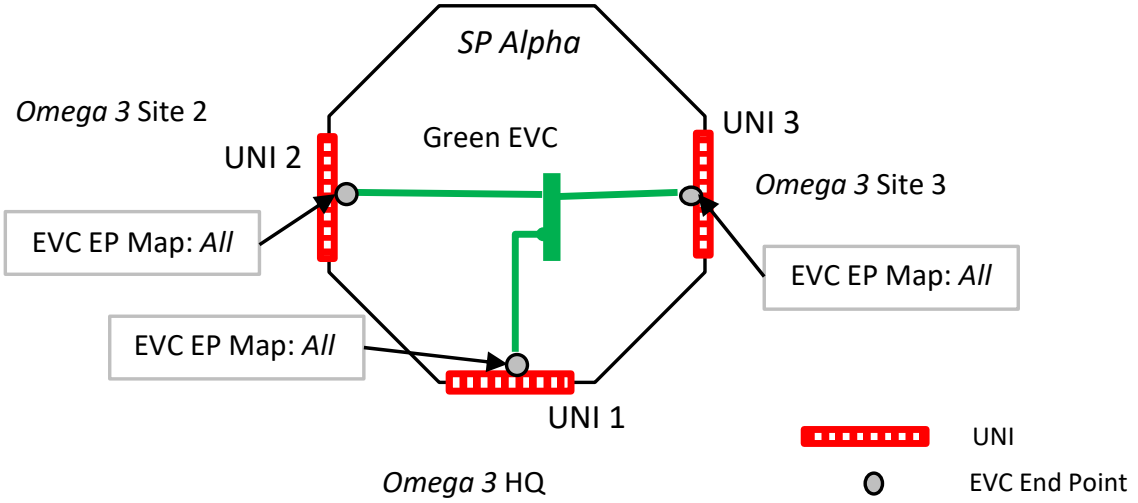

Figure 18 – Example of EP-LAN Service

In this example, a single Green EVC connects the three UNIs at sites 1, 2 and 3. The EVC EP Map at each UNI is *All*, which results in preservation of the C-Tag VLAN IDs.

For this service, *SP Alpha* considers two alternative service models based on a combination of Point-to-Point and Multipoint-to-Multipoint OVCs from different Operators.

For Alternative 1, four Operator Ethernet Services are used to deliver the end-to-end EP-LAN Service, consisting of:

- One Transit E-LAN Service in CEN B, and
- Three Access E-Line Services in CEN A, CEN C and CEN D

Alternative 1 is shown in Figure 19 below.

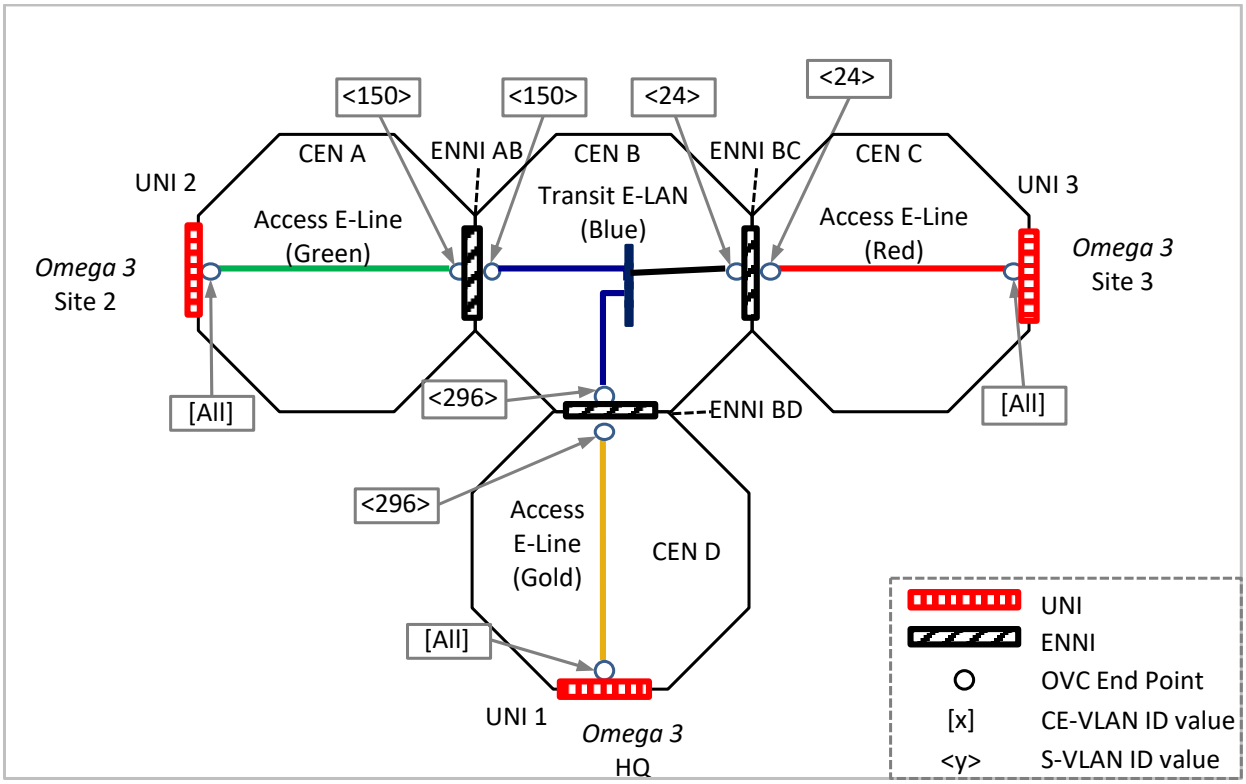

Figure 19 – Example of EP-LAN Service using a Transit E-LAN Service

In Alternative 1, each of the Access E-Line services use a full map of CE-VLAN IDs to OVC End Point at each of the UNIs. In addition, OVC CE-VLAN ID Preservation = *Preserve* and OVC CE-VLAN PCP Preservation = *Enabled* for each of the OVCs. The Transit E-LAN service in CEN B provides the bridging capability among the three OVC End Points, with OVC CE-VLAN ID Preservation = *Preserve* and OVC CE-VLAN PCP Preservation = *Enabled* for the Blue OVC. Thus, the combination of these four OVCs supports the end-to-end EP-LAN Service.

For Alternative 2, five Operator Ethernet Services are used to deliver the end-to-end EP-LAN Service, consisting of:

- Two Access E-Line Services, one in CEN A and one in CEN C
- Two Transit E-Line Services, both in CEN B, and
- One Access E-LAN Service in CEN D

Alternative 2 is shown in Figure 20 below.

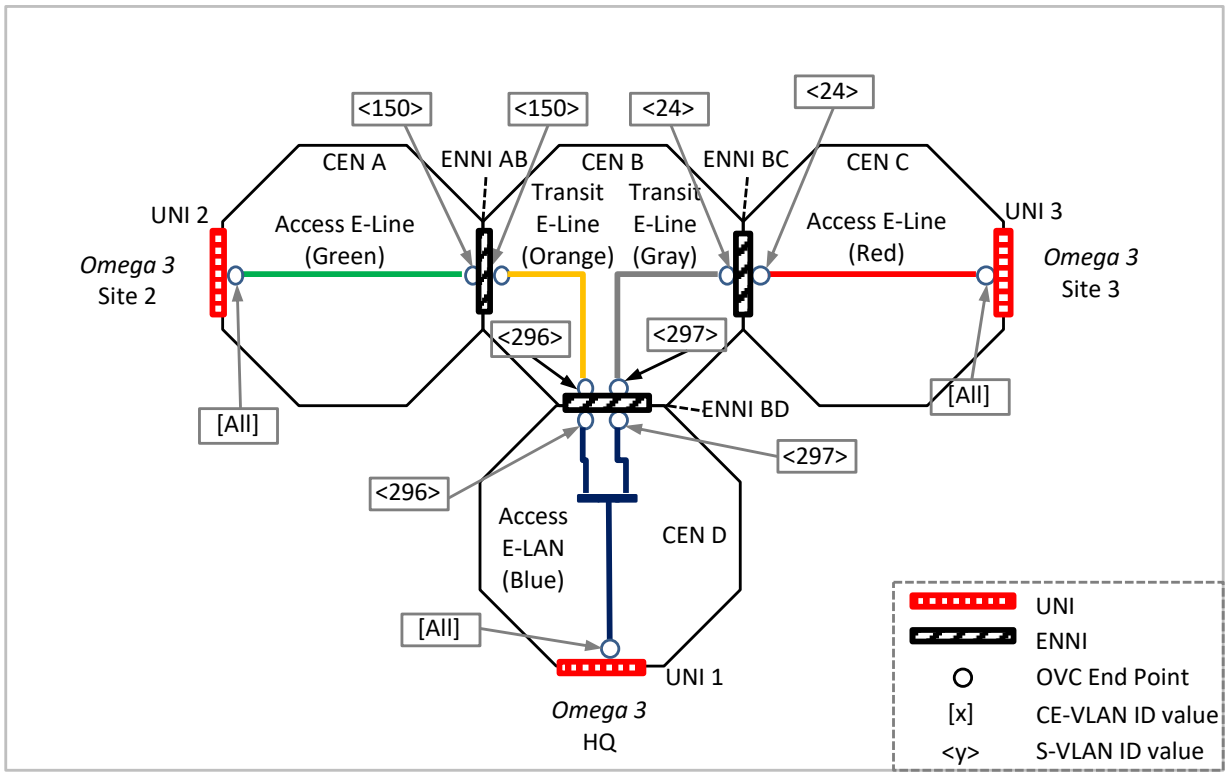

Figure 20 – Example of EP-LAN Service using an Access E-LAN Service

In Alternative 2, CEN A and CEN C provide Access E-Line Services from the UNIs to the ENNIs to CEN B, as shown above. CEN B provides Transit E-Line services from CEN A to CEN C and from CEN A to CEN D. CEN D provides an Access E-LAN Service, connecting the UNI in CEN D with the two OVC End Points at ENNI BD. The CEN D Operator provides the bridging capability using the Blue OVC, and also provides hairpin-switching functionality, allowing ENNI frames to transit between the Orange and Gray OVC End Points at ENNI BD, through the Blue OVC in CEN D. Thus, the combination of these five OVCs supports the end-to-end EP-LAN Service.

Appendix B SOAM Use Case (Informative)

The SOAM, MEF 30.1 [8], architectural requirements and recommendations support EVC Services spanning multiple Operators. The Subscriber can monitor the EVC using the Subscriber MEG. The Service Provider can monitor the EVC Service using the EVC MEG. When a SP/SO provides an OVC Service by contracting with one or more Operators, that OVC Service can be monitored with an SP MEG. When an Operator provides an OVC Service without contracting another Operator, that OVC Service can be monitored with an Operator MEG.

An example involving two nested SOs (*Beta* and *Gamma*) is depicted in Figure 21 below.

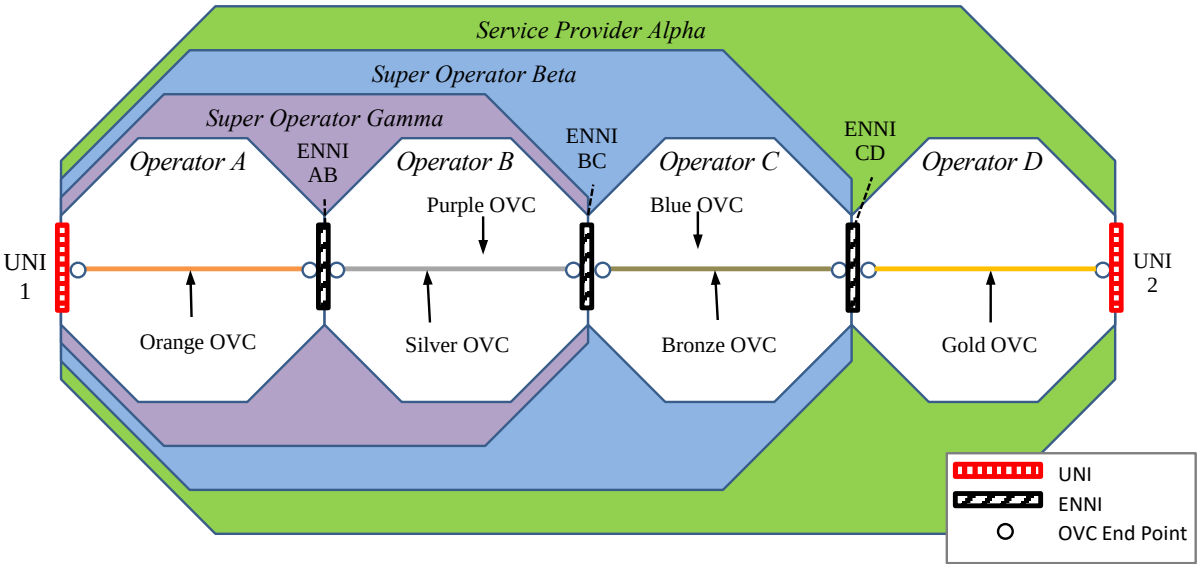

Figure 21 – OVCs associated with the EVC Service between UNI 1 and UNI 2

In this example, *SP Alpha* has contracted with two Operators: *SO Beta* and *Operator D*, in order to implement an end-to-end service between UNI 1 and UNI 2. *SO Beta*, acting as an SO, has in turn contracted with two Operators, *SO Gamma* and *Operator C*, to implement the service they are providing to *SP Alpha*. Finally, *SO Gamma* is also acting as an SO and has contracted with *Operator A* and *Operator B* in order to implement the service they are providing to *SO Beta*.

In Figure 21 above, *SO Beta* provides the Blue OVC and *SO Gamma* provides the Purple OVC. *Operators A, B, C* and *D* provide the Orange, Silver, Bronze and Gold OVCs, respectively. Table 22 below summarizes the OVCs and associated OVC Available MEG Level provided by the Operators and Super Operators. The first column identifies the Operator contract and the second and third columns identify the OVC and the associated OVC Available MEG Level.

Operator Contracts	OVC and OVC Available MEG Level (OAML)	
	OVC	OAML
SP Alpha-SO Beta	Blue	5
SP Alpha-Operator D	Gold	3
SO Beta-SO Gamma	Purple	4
SO Beta-Operator C	Bronze	2
SO Gamma-Operator A	Orange	3
SO Gamma-Operator B	Silver	3

Table 22 – OVC Available MEG Level per OVC by Operator contract

Note that in column 1, the SP/SO shown first is the entity purchasing the OVC listed in column 2. Similarly, the Operator / Super Operator shown last in column 1 is the entity selling the OVC listed in column 2.

Figure 22 below depicts the use of SOAM for managing the Operator and Super Operator OVCs.

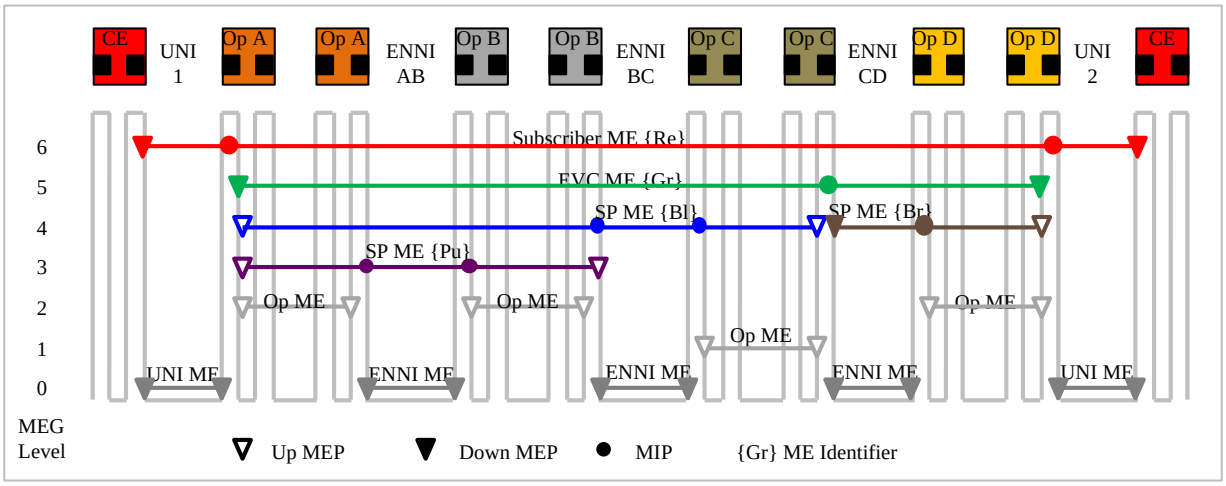

Figure 22 – SOAM Use Case involving nested Super Operators

Table 23 below provides a summary of the SOAM MEP and MIP details associated with each Operator contract.

Operator Contracts	Maintenance Points - OVC End Point @				
	UNI 1	ENNI AB	ENNI BC	ENNI CD	UNI 2
SP Alpha-SO Beta	SMM(6){Re} UpMEP(5){Gr}			MIP(5){Gr} Down MEP(4){Br}	
SP Alpha-Operator D				MIP (4){Br}	SMM (6){Re} Up MEP (5){Gr} Up MEP (4){Br}
SO Beta-SO Gamma	SMM (6){Re} Up MEP(5){Gr} Up MEP(4){Bl}		MIP(4){Bl}		
SO Beta-Operator C			MIP(4){Bl}	MIP(5){Gr} Up MEP(4){Bl} Down MEP(4){Br}	
SO Gamma-Operator A	SMM(6){Re} Up MEP(5){Gr} Up MEP(4){Bl} Up MEP(3){Pu}	MIP(3){Pu}			
SO Gamma-Operator B		MIP(3){Pu}	MIP(4){Bl} Up MEP(3){Pu}		

Notes:

1) The MEG Level used for MEPs and MIPs is shown in parentheses (n)
2) The ME for each MEP or MIP is shown in brackets, e.g., {Gr} and is also shown in color, e.g., Green, and refers to the ME in Figure 22.
3) Subscriber MEG MIP is abbreviated as SMM
4) Some of the MEPs and MIPs may be listed multiple times depending on the number of contracts involved. For example, the Green Up MEP at UNI 1 (MEG Level 5) needs to be in three contracts to be instantiated in CEN A: *SP Alpha* contracts with *SO Beta*, who then contracts with *SO Gamma*, who then contracts with *Operator A*.

Table 23 – Summary of SOAM MEP and MIP configurations by Operator contract

Other than the UNI or ENNI MEGs, which are not Operator Ethernet Service related, the MEGs considered in the use case, as illustrated in Figure 22, are:

- Operator MEG: The Operator MEG is shown in gray in each CEN, and is used by each Operator for managing/monitoring the Operator Ethernet Service within its CEN. In the above example, Operator C uses MEG Level 1 and Operators A, B and D use MEG Level 2 for the Operator MEG.
- Purple SP MEG: The Purple SP MEG uses MEG Level 3. *SO Gamma* uses this MEG for managing the Purple OVC. An Up MEP is used for the OVC End Points at UNI 1 and at ENNI BC. A MIP is provided at the OVC End Points on either side of ENNI AB to facilitate troubleshooting by *SO Gamma*.

- Blue SP MEG: The Blue SP MEG uses MEG Level 4. *SO Beta* uses this MEG for managing the Blue OVC. An Up MEP is used for the OVC End Points at UNI 1 and at ENNI CD. A MIP is provided at the OVC End Points on either side of ENNI BC to facilitate troubleshooting by *SO Beta*.
- Brown SP MEG: The Brown SP MEG uses MEG Level 4. *SP Alpha* uses this MEG for managing the Gold OVC from across ENNI CD[13]. *SP Alpha* uses a Down MEP at ENNI CD in CEN C, which is provided by *SO Beta*, and an Up MEP for the OVC End Point at UNI 2 provided by Operator D. A MIP is provided for the OVC End Point at ENNI CD in CEN D to facilitate troubleshooting by *SP Alpha*.
- Green EVC MEG: The Green EVC MEG uses MEG Level 5. *SP Alpha* uses this MEG for managing the EVC between UNI 1 and UNI 2. An Up MEP is provided for the OVC End Points at UNI 1 and UNI 2, as well as a MIP for the OVC End Point at ENNI CD to facilitate troubleshooting by *SP Alpha*.
- Subscriber MEG: The Subscriber MEG uses MEG Level 6, which is constrained by the use of MEG Level 5 for the EVC MEG. A Subscriber MEG MIP is provided for the OVC End Points at UNI 1 and UNI 2 to facilitate troubleshooting by the Subscriber.

Note that the OVC End Point at UNI 1 has four Up MEPs, as shown in Figure 22, each at a different MEG Level (including the Operator MEG, which is not shown in Table 23). It also has a Down MEP in the UNI MEG. This is clearly an extreme example. Note the back-to-back SP MEG MEPs at ENNI CD in CEN C: The Up MEP is used for managing the Blue OVC, and the Down MEP is used for managing the Gold OVC to the right plus the connection across ENNI CD. So, even though the MEPs are at the same ENNI and are both SP MEGs associated with the same end-to-end service, they are each associated with different OVCs at ENNI CD in CEN C.

[13] The Gold OVC plus the connection across the ENNI can be considered a chain, as well, since the scope of the service management is more than just the Gold OVC.

Appendix C Changes from MEF 51 (Informative)

This appendix describes the changes in this revision as compared to MEF 51 [11].

New Concepts

MEF 26.2 [7] introduced the concept of a *Super Operator*, which allows for the possibility of nesting Operator Ethernet Services from several *Operators*, some of which can be *Super Operators*. A given *Operator* offering an Operator Ethernet Service may not be aware of other *Operators*/*Super Operators* involved. Because of this, there are two significant changes in this document:

- OVC Available MEG Level: Two requirements related to the OVC Available MEG Level were removed - [R4] and [D5] of MEF 51 [11], and informative text was added to encourage *Operators* to offer lower levels. Note that [R6] from MEF 51 [11] remains.
- SOAM Use Case: the SOAM Use Case in Appendix B of this document is significantly changed from Appendix D of MEF 51 [11] to clarify the business relationships among *Operators* and *Super Operators* and to provide SOAM details associated with each bilateral contract.

Unlike MEF 51 [11], this document supersedes MEF 33 [9].

Clarifications

- The term *OVC Service* has been changed throughout to *Operator Ethernet Service* to align with MEF terminology updates.
- The relationship of General and Specific Operator Ethernet Services (see Introduction) are clarified.
- Informative text was added to clarify that the common requirements apply to the General Operator Ethernet Service definitions, and that the Specific Operator Ethernet Service definitions are derivatives of the General Operator Ethernet Service definitions and that they could further constrain the common requirements.
- The Ingress Bandwidth Profile per CoS Name requirement for OVC End Points at an ENNI was updated to clarify that it applies to each CoS Name, except *Discard*, in the OVC End Point Class of Service Identifier for the OVC End Point.
- The Ingress Bandwidth Profile per CoS Name requirement for OVC End Points at a UNI was updated to clarify that it applies to each CoS Name, except *Discard*, in the OVC End Point Class of Service Identifier for the OVC End Point.
- The Egress Bandwidth Profile per EEC Name requirement for OVC End Points at an ENNI was updated to clarify that it applies to each EEC Name in the OVC End Point EEC Identifier for the OVC End Point.
- The bandwidth granularity recommendations in MEF 51 [11] were updated in this document to clarify that the recommended values apply to CIR, EIR, CIR_{max} and EIR_{max}, and that the context is an OVC End Point. See Section 7.1.
- Appendix A of MEF 51 [11] (Relationship of EVC and OVC Services) was deleted since Appendix H of MEF 26.2 [7] (Comparison of Service Attribute Values) now addresses this relationship in more detail.

- Appendix D in this document was updated from Appendix C of MEF 51 [11] to clarify how to set Access E-Line service attribute values to get the behavior mandated by Access E-Line Service as defined in MEF 51 [11] and the behavior mandated by Access EPL and Access EVPL services as defined in MEF 33 [9].

New Service Attributes

MEF 26.2 [7] introduced 13 new service attributes. As a result, this document includes requirements related to each of these.

New OVC Service Attributes:

- OVC L2CP Address Set - requirements per MEF 45.1 [12]
- OVC CE-VLAN DEI Preservation - added requirements for Access E-Line Service (mandates Operator support for Enabled and recommends Operator support for Disabled) and Transit E-Line service (mandates Enabled).
- OVC S-VLAN DEI Preservation - Enabled or Disabled per MEF 26.2 [7]
- OVC List of Class of Service Names - requirements per MEF 26.2 [7]

New OVC End Point Service Attributes:

- OVC End Point External Interface Type - mandates ENNI for OVC End Points at an ENNI and UNI for OVC End Points at a UNI
- OVC End Point External Interface Identifier - requirements per MEF 26.2 [7]
- OVC End Point Role - this service attribute replaced the need to include the role in for each OVC End Point in the OVC End Point List. Requirements related to the role have been removed, with informative text referencing Section 12.2 of MEF 26.2 [7], i.e., the OVC End Point Role is constrained by the OVC Type and the OVC End Point External Interface Type.
- OVC End Point Map - mandates the use of either Form E or Form T for OVC End Points at an ENNI (i.e., Form V is not allowed, since VUNIs are not involved in any of these services). Note that this was a valid service attribute in MEF 51 [11], but only for the OVC End Point at a UNI, so this is new for the OVC End Point at an ENNI.
- OVC End Point Color Identifier - recommends DEI for an OVC End Point at an ENNI
- OVC End Point Egress Map - requirements per MEF 26.2 [7]
- OVC End Point Egress Equivalence Class Identifier - requirements per MEF 26.2 [7]
- OVC End Point Aggregation Link Depth - requirements per MEF 26.2 [7]
- OVC End Point Source MAC Address Limit - requirements per MEF 26.2 [7]

Service Attributes that have been removed

Three Service Attributes were removed

- Color Forwarding - the need for this Service Attribute was replaced by the OVC End Point Egress Map Service Attribute. MEF 51 [11] recommended Color Forwarding = Yes. This document does not have a recommendation that results in a similar behavior, but, through the use of the OVC End Point Egress Map Service Attribute, the SP/SO and Operator can agree to an egress map that meets the needs of a given service, including meeting the Color Forwarding recommendation in MEF 51 [11].
- S-VLAN ID Preservation - the need for this was replaced by the OVC End Point Map.
- Trunk Identifiers - the need for this was replaced by the OVC End Point Map, which includes Form T for OVC End Points at an ENNI that have the OVC End Point Role = Trunk.

Appendix D Implementing Legacy Point-to-Point Access Services (Informative)

This appendix describes how to set Access E-Line Service Attribute values, as defined in this document, to achieve the required behavior of:

- Access E-Line Service, as specified in MEF 51 [11], and
- Access EPL Service, as specified in MEF 33 [9], and
- Access EVPL Service, as specified in MEF 33 [9].

This analysis is organized around the three major areas of service attributes - OVC Service Attributes, OVC End Point Service Attributes for an OVC End Point at an ENNI, and OVC End Point Service Attributes for an OVC End Point at a UNI.

OVC Service Attribute Values

Table 24 below describes how to set the OVC Service Attribute values, as defined in this document for Access E-Line Service, to achieve the required behavior of previously defined Access E-Line services. The first column lists the OVC Service Attributes used in this document (from MEF 26.2 [7]). The second column summarizes the OVC Service Attribute values specified in this document for Access E-Line Service. The third column identifies the OVC Service Attribute values that are needed to achieve the behavior required by MEF 51 [11] for an Access E-Line Service. The fourth column identifies the OVC Service Attribute values that are needed to achieve the behavior required by MEF 33 [9] for an Access EPL or Access EVPL Service.

OVC Service Attribute	**Access E-Line Service Attribute Value (this document)**	**Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service**	**Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service**
OVC ID	*Character string*	*Character string*	*Character string*
OVC Type	*Point-to-Point*	*Point-to-Point*	*Point-to-Point*
OVC End Point List	*1@UNI and 1@ENNI*[14]	*1@UNI and 1@ENNI*[14]	*1@UNI and 1@ENNI*[14]
Maximum Number of UNI OVC End Points	*1*	*1*	*1*
Maximum Number of ENNI OVC End Points	*1*	*1*	*1*
OVC Maximum Frame Size	*Number of Bytes*	*Number of Bytes*	*Number of Bytes*
OVC CE-VLAN ID Preservation <*Preserve*, *Strip* or *Retain*>	*Preserve* or *Strip*	*Preserve* or *Strip*	*Preserve*

[14] 1@UNI means that one of the OVC End Points identified in the value of the OVC End Point List Service Attribute has the value of the OVC End Point External Interface Type Service Attribute = *UNI*. 1@ENNI means the same as 1@UNI with *UNI* replaced by *ENNI*.

OVC Service Attribute	Access E-Line Service Attribute Value (this document)	Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service	Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service
OVC CE-VLAN PCP Preservation <*Enable* or *Disable*>	*Enable* or *Disable*	*Enable* or *Disable*	*Enable*
OVC CE-VLAN DEI Preservation <*Enable* or *Disable*>	*Enable* or *Disable*	*Enable* or *Disable*	*Enable* or *Disable*
OVC S-VLAN PCP Preservation	*Not Applicable*	*Not Applicable*	*Not Applicable*
OVC S-VLAN DEI Preservation	*Not Applicable*	*Not Applicable*	*Not Applicable*
OVC List of Class of Service Names	*List of one or more CoS Names*	*List of one or more CoS Names*	*One CoS Name*
OVC Service Level Specification *None* or *4-tuple* $\langle ts, T, CN, PM \rangle$	*Any value* Recommends the following metrics: *FLR*, *FD*, *FDR*, *MFD* and *IFDV*. Recommends: *S: both ordered OVC End Point pairs*	*Any value* The recommendations in MEF 51 can be met by using the values recommended in this document.	*Any value*
OVC Frame Delivery for unicast, multicast and broadcast frames <*Unconditional, Conditional* or *Discard*>	*Unconditional, Conditional* or *Discard*	*Unconditional, Conditional* or *Discard*	*Access EPL: Unconditional* Access EVPL: *Unconditional* or *Conditional*
OVC Available MEG Level *None* or *Integer from 0 to 7*	Any integer from *0* to *6*	Any integer from *0* to *6*	Any integer from *0* to *6*
OVC L2CP Address Set	*CTA, CTB,* or *CTB-2* (depends on OVC End Point map @ UNI)	*CTA, CTB,* or *CTB-2* (depending on OVC End Point map)	*CTA, CTB,* or *CTB-2* (depending on OVC End Point map)

Table 24 – OVC Service Attribute Values

OVC End Point Service Attribute values for an OVC End Point at an ENNI

Table 25 below describes how to set the OVC End Point Service Attribute values for an OVC End Point at an ENNI, as defined in this document for Access E-Line Service, to achieve the required behavior of previously defined Access E-Line services. The first column lists the OVC End Point Service Attributes used in this document (from MEF 26.2 [7]) for an OVC End Point at an ENNI. The second column summarizes the OVC End Point Service Attribute values for an OVC End Point at an ENNI specified in this document for Access E-Line Service. The third

column identifies the OVC End Point Service Attribute values for an OVC End Point at an ENNI that are needed to achieve the behavior required by MEF 51 [11] for an Access E-Line Service. The fourth column identifies the OVC End Point Service Attribute values for an OVC End Point at an ENNI that are needed to achieve the behavior required by MEF 33 [9] for an Access EPL or Access EVPL Service.

OVC End Point Service Attribute for an OVC End Point at an ENNI	**Access E-Line Service Attribute Values (this document)**	**Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service**	**Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service**
OVC End Point Identifier	*Character string*	*Character string*	*Character string*
OVC End Point External Interface Type	*ENNI*	*ENNI*	*ENNI*
OVC End Point External Interface Identifier	*Character string*	*Character string*	*Character string*
OVC End Point Role	*Root*	*Root*	*Root*
OVC End Point Map	*Form E*	*Form E*	*Form E*
OVC End Point Class of Service Identifier <*F,M,P*>	*F = S-Tag PCP* *M: Can include one or more CoS Names* *P = Any value*	*F = S-Tag PCP* *M: Can include one or more CoS Names* *P = Any value*	*F = S-Tag PCP* *M: Single CoS Name* *P = Any value*
OVC End Point Color Identifier <F,M> F: <*OVC End Point*, *S-Tag PCP* or *S-Tag DEI*>	*F = OVC End Point, S-Tag PCP* or *S-Tag DEI* *M = Any value*	*F = OVC End Point, S-Tag PCP* or *S-Tag DEI* *M = Any value*	*F = OVC End Point, S-Tag PCP* or *S-Tag DEI* *M = Any value*

OVC End Point Service Attribute for an OVC End Point at an ENNI	**Access E-Line Service Attribute Values (this document)**	**Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service**	**Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service**
OVC End Point Egress Map <*CN→S-Tag PCP*, *CC→S-Tag DEI*, and/or *CC→S-Tag PCP*>	<*CN→S-Tag PCP*, *CC→S-Tag DEI*, and/or *CC→S-Tag PCP*>	*Any value* The recommendations of MEF 51 can be met by setting an egress map such that any Service Frames identified as Yellow on ingress at the UNI are not assigned an S-Tag PCP or S-Tag DEI value that is interpreted as Green by the receiving Operator at the ENNI. This addresses the color forwarding recommendation in MEF 51.	*Any value* such that when Ingress Bandwidth Profile for OVC End Point at the UNI has EIR=0, then all egress ENNI frames are assigned an S-Tag PCP or S-Tag DEI value that is interpreted as Green by the receiving Operator at the ENNI. The recommendations of MEF 33 can be met by setting an egress map such that any Service Frames identified as Yellow on ingress at the UNI are not assigned an S-Tag PCP or S-Tag DEI value that is interpreted as Green by the receiving Operator at the ENNI. This addresses the color forwarding requirements in MEF 33.
OVC End Point Egress Equivalence Class Identifier <*F,M,P*>	*F = S-Tag PCP* *M = Any value* *P = Any value*	*F = S-Tag PCP* *M = Any value* *P = Any value*	*F = S-Tag PCP* *M = Any value* *P = Any value*
Ingress Bandwidth Profile per OVC End Point <*Parameters* or *Disabled*>	*Disabled*	*Disabled*	*Disabled*
Egress Bandwidth Profile per OVC End Point <*Parameters* or *Disabled*>	*Disabled*	*Disabled*	*Disabled*

OVC End Point Service Attribute for an OVC End Point at an ENNI	Access E-Line Service Attribute Values (this document)	Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service	Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service
Ingress Bandwidth Profile per Class of Service Name <*x,y*> *x = CoS Name* *y = Parameters* or *Disabled*	For each x, y = *Parameters.*	For each x, y = *Parameters.* Additional constraints: a) one Bandwidth Profile Flow per Envelope b) $CF^0 = 0$; c) $F^i = 0$; d) $CIR_{max} \geq CIR$ e) $EIR_{max} \geq EIR$	For x, y = *Parameters.* Note that *x* can take only one value since the OVC List of Class of Service Names Service Attribute can only have one entry. Additional constraints: a) one Bandwidth Profile Flow per Envelope b) $CF^0 = 0$; c) $F^i = 0$; d) $CIR_{max} \geq CIR$ e) $EIR_{max} \geq EIR$ f) $CBS \geq 12{,}176B$
Egress Bandwidth Profile per Egress Equivalence Class Name <*x,y*> *x = EEC Name* *y = Parameters* or *Disabled*	Any value	For each x, y = *Parameters* or *Disabled* If *Parameters,* additional constraints: apply a) one Bandwidth Profile Flow per Envelope b) $CF^0 = 0$; c) $F^i = 0$; d) $CIR_{max} \geq CIR$ e) $EIR_{max} \geq EIR$	For each *x*, y = *Disabled*
OVC End Point Aggregation Link Depth <*s,n*>	For each S-VLAN ID, any number from 1 to the number of ENNI links	For each S-VLAN ID, any number from 1 to the number of ENNI links	For each S-VLAN ID, any number from 1 to the number of ENNI links
OVC End Point Source MAC Address Limit <*N,τ*> or *Disabled*	*Disabled* or <*N,τ*>	*Disabled* or <*N,τ*>	Access EPL: *Disabled* Access EVPL: *Disabled* or <*N,τ*>
OVC End Point MIP <*Enabled* or *Disabled*>	*Enabled* or *Disabled*	*Enabled* or *Disabled*	*Enabled* or *Disabled*
OVC End Point MEP List <*l,d*>	List may be empty or not	List may be empty or not	List may be empty or not

Table 25 – OVC End Point Service Attribute Values for an OVC End Point at an ENNI

OVC End Point Service Attribute values for an OVC End Point at a UNI

Table 26 below describes how to set the OVC End Point Service Attribute values for an OVC End Point at a UNI, as defined in this document for Access E-Line Service, to achieve the re-

quired behavior of previously defined Access E-Line services. The first column lists the OVC End Point Service Attributes used in this document (from MEF 26.2 [7]) for an OVC End Point at a UNI. The second column summarizes the OVC End Point Service Attribute values for an OVC End Point at a UNI specified in this document for Access E-Line Service. The third column identifies the OVC End Point Service Attribute values for an OVC End Point at a UNI that are needed to achieve the behavior required by MEF 51 [11] for an Access E-Line Service. The fourth column identifies the OVC End Point Service Attribute values for an OVC End Point at a UNI that are needed to achieve the behavior required by MEF 33 [9] for an Access EPL or Access EVPL Service.

OVC End Point Service Attribute for an OVC End Point at a UNI	**Access E-Line Service Attribute Values (this document)**	**Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service**	**Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service**
OVC End Point Identifier	*Character string*	*Character string*	*Character string*
OVC End Point External Interface Type	*UNI*	*UNI*	*UNI*
OVC End Point External Interface Identifier	*Character string*	*Character string*	*Character string*
OVC End Point Role	*Root*	*Root*	*Root*
OVC End Point Map	*Form U*	*Form U*	*Form U* Access EPL: mandates all CE-VLAN IDs map to the OVC End Point Access EVPL: mandates not all CE-VLAN IDs map to the OVC End Point
OVC End Point Class of Service Identifier <*F,M,P*> F: <OVC End Point, C-Tag PCP, or DSCP>	*F = <OVC End Point, C-Tag PCP, or DSCP>* *M: Can include one or more CoS Names* *P = Any value*	*F = <OVC End Point, C-Tag PCP, or DSCP>* *M: Can include one or more CoS Names* *P = Any value*	*F = OVC End Point* *M: Single CoS Name* *P = Any value*
OVC End Point Color Identifier <F,M> F = <*OVC End Point, C-Tag PCP, C-Tag DEI or DSCP*>	*F = <OVC End Point, C-Tag PCP, C-Tag DEI or DSCP>* *M = Any value*	*F = <OVC End Point, C-Tag PCP, C-Tag DEI or DSCP>* *M = Any value*	*F = <OVC End Point, C-Tag PCP or C-Tag DEI>* *M = Any value*
OVC End Point Egress Map *None*, or <*CN →C-Tag PCP*, *CC →C-Tag DEI*, and/or *CC →C-Tag PCP*>	*Any value*	*Any value*	Access EPL*: None or CC →C-Tag DEI* Access EVPL*: Any value*

OVC End Point Service Attribute for an OVC End Point at a UNI	**Access E-Line Service Attribute Values (this document)**	**Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service**	**Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service**
OVC End Point Egress Equivalence Class Identifier *<F,M,P>*	*F = C-Tag PCP or DSCP* *M = Any value* *P = Any value*	*F = C-Tag PCP or DSCP* *M = Any value* *P = Any value*	*F = C-Tag PCP or DSCP* *M = Any value* *P = Any value*
Ingress Bandwidth Profile per OVC End Point < *Parameters* or *Disabled*>	*Disabled*	*Disabled*	*Disabled*
Egress Bandwidth Profile per OVC End Point < *Parameters* or *Disabled*>	*Disabled*	*Disabled*	*Disabled*
Ingress Bandwidth Profile per Class of Service Name *<x,y>* x = *CoS Name* y = *Parameters* or *Disabled*	For each x, y = *Parameters*	For each x, y = *Parameters* Additional constraints: a) one Bandwidth Profile Flow per Envelope b) $CF^0 = 0$; c) $F^i = 0$; d) $CIR_{max} \geq CIR$ e) $EIR_{max} \geq EIR$	For x, y = *Parameters* Note that *x* can take only one value since the OVC List of Class of Service Names Service Attribute can only have one entry. Additional constraints: a) one Bandwidth Profile Flow per Envelope b) $CF^0 = 0$; c) $F^i = 0$; d) $CIR_{max} \geq CIR$ e) $EIR_{max} \geq EIR$ f) $CBS \geq 12{,}176B$
Egress Bandwidth Profile per Egress Equivalence Class Name *<x,y>* *x = EEC Name* *y = Parameters* or *Disabled*	For each x, y = *Parameters* or *Disabled*	For each x, y = *Parameters* or *Disabled* If *Parameters*, additional constraints: *a)* one Bandwidth Profile Flow per Envelope *b)* $CF^0 = 0$; *c)* $F^i = 0$; *d)* $CIR_{max} \geq CIR$ *e)* $EIR_{max} \geq EIR$	For each x, y = *Disabled*
OVC End Point Aggregation Link Depth	*Not Applicable*	*Not Applicable*	*Not Applicable*
OVC End Point Source MAC Address Limit *<N,τ>* or *Disabled*	*Disabled* or *<N,τ>*	*Disabled* or *<N,τ>*	Access EPL: *Disabled* Access EVPL: *Disabled* or *<N,τ>*

OVC End Point Service Attribute for an OVC End Point at a UNI	Access E-Line Service Attribute Values (this document)	Service Attribute values needed to achieve the behavior required by MEF 51 for an Access E-Line Service	Service Attribute values needed to achieve the behavior required by MEF 33 for an Access EPL or Access EVPL Service
OVC End Point MIP (also known as, Subscriber MEG MIP) <*Enabled* or *Disabled*>	*Enabled* or *Disabled*	*Enabled* or *Disabled*	*Enabled* or *Disabled*
OVC End Point MEP List <*l,d*>	List may be empty or not	List may be empty or not	List may be empty or not

Table 26 – OVC End Point Service Attribute Values for an OVC End Point at a UNI