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OVC Services Definitions

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1. List of Contributing Members

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

ADVA Optical	Fiberhome
Albis Technologies	HFR, Inc.
Allstream	Huawei Technologies
AT&T	Infinera Corporation
Bell Canada	Omnitron Systems Technology, Inc.
Cable Labs	PLDT Corp. Business Solutions
Calix Networks	RAD Data Communications
Ceragon Networks	Siana Systems
Ciena	Tata Communications
Cisco Systems	The Carrier Ethernet Academy
Colt	Transition Networks
Comcast	Verizon Business
Ericsson AB	XO Communications
EXFO Inc.	

2. Abstract

This document specifies Operator Virtual Connection (OVC) Services based mainly on the service attributes defined in MEF 26.1 [7]; there are also some service attributes defined in this document that go beyond MEF 26.1. The key service constructs are the OVC itself and the OVC End Points at the External Interfaces (EIs) – the External Network Network Interface (ENNI) and the User Network Interface (UNI). Per MEF 26.1 [7], at least one OVC End Point is at an ENNI. Three General OVC 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.

3. Terminology and Acronyms

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

Terms defined in MEF 10.3 [5], MEF 23.1 [6], MEF 26.1 [7], MEF 30.1 [9] and MEF 33 [10] are included in this document by reference and, hence, not repeated in the table below.

Term	Definition	Source
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 E-Access Service is any OVC 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.	MEF 33 [10]
E-Transit Service	An E-Transit Service is any OVC Service that associates only OVC End Points that are at ENNIs.	This document
EI	External Interface	MEF 4 [3]
External Interface	Either a UNI or an ENNI	MEF 4 [3]
General OVC Service	An OVC Service which is an O-Line, an O-LAN, or an O-Tree Service.	This document
Operator	The administrative entity of a CEN	This document
OVC Service	An Ethernet Service based on an Operator Virtual Connection that associates OVC End Points at External Interfaces, at least one of which is at an ENNI.	This document
O-LAN Service	A General OVC Service that uses a Multipoint-to-Multipoint OVC.	This document
O-Line Service	A General OVC Service that uses a Point-to-Point OVC.	This document
O-Tree Service	A General OVC Service that uses a Rooted-Multipoint OVC.	This document
S-Tag	Service VLAN Tag	IEEE 802.1Q™-2014 [1]
SOAM Super Operator	An Operator of a CEN that also monitors a chain of concatenated OVCs in its own and adjacent CENs using SOAM.	This document
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. Scope

This document defines Ethernet Services based on the Operator Virtual Connection (OVC) and External Network Network Interface (ENNI) constructs described in MEF 26.1, *External Network Network Interface – Phase 2* [7], as well as the User Network Interface (UNI) specified in MEF 10.3 [5]. This document uses the attributes defined in MEF 26.1 as the basis for the OVC Service Definitions. It should be noted that the term *OVC Service* is synonymous with *Operator Service*, and refers to a service that is contained within a single Operator CEN. The term *OVC Service* is used throughout this document.

The basic concept for an OVC Service is that an Operator of a Carrier Ethernet Network (CEN) is responsible for the OVC, with all of its related attributes. The Service Provider can use the OVC Service as a component in an end-to-end EVC-based service it offers to the Subscriber. There can be two or more Operator CENs that interconnect OVCs to form any of the EVC-based services defined in MEF 6.2, *EVC Ethernet Services Definitions Phase 3* [4]. Note that the Service Provider need not be an Operator.

In this document, CENs are considered to be disjoint: CENs, and hence OVCs, can be concatenated but cannot be nested, and therefore each CEN is managed by a single Operator. This document also supports a concept of a Service Operations, Administration and Maintenance (SOAM) Super Operator that can manage SOAM across multiple concatenated CENs. See Appendix D for a more detailed use case description.

The scope of this document includes definitions for three General OVC Services. These General OVC Services are differentiated based on OVC Type alone.

- O-Line Service uses a Point-to-Point OVC to associate two OVC End Points.
- O-LAN Service uses a Multipoint-to-Multipoint OVC to associate two or more OVC End Points.
- O-Tree Service uses a Rooted-Multipoint OVC to associate two or more OVC End Points.

Each OVC End Point for an OVC Service can be at one of two types of External Interfaces:

- ENNI is a reference point representing the boundary between two Operator CENs that are operated as separate administrative domains.
- UNI is the physical demarcation point between the responsibility of the Service Provider and the responsibility of the Subscriber.

For a given OVC, at least one OVC End Point is required to be at an ENNI, per MEF 26.1 [7].

Note that this document defines the OVC Services in terms of the OVC attributes, and the OVC End Point per External Interface attributes. It does not define in detail the service attributes for the External Interfaces themselves. It relies on the premise that a MEF-compliant UNI or ENNI is used to support the OVC Service.

In addition to the General OVC Services, two E-Access Services and two E-Transit Services are defined. The term ‘E-Access Service’ is used to describe an OVC Service where at least one OVC End Point at a UNI and at least one OVC End Point at an ENNI are associated by the OVC. The term ‘E-Transit Service’ is used to describe an OVC Service where only OVC End Points at ENNIs are associated by the OVC.

Requirements in this document related to management of the OVC Services are based on the SOAM constructs and requirements specified in MEF 30.1, *Service OAM Fault Management Implementation Agreement: Phase 2* [9], and MEF 35.1, *Service OAM Performance Monitoring Implementation Agreement* [11]. MEF specifications can be found in the MEF public site¹.

5. 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 RFC 2119 [2]. All key words must be in upper case, 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 [CRa]< 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 [CDb]< specifies a Conditional Desirable Requirement that **SHOULD** be followed if the condition(s) following the "<" have been met. A paragraph preceded by [COc]< specifies a Conditional Optional Requirement that **MAY** be followed if the condition(s) following the "<" have been met.

¹ <http://www.mef.net/carrier-ethernet/technical-specifications>

6. Numerical Prefix Conventions

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

Decimal		Binary	
6.1.1.1 Symbol	6.1.1.2 Value	6.1.1.3 Symbol	6.1.1.4 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

7. Introduction

This document defines OVC Services that can be offered by a CEN Operator. These OVC Services are the building blocks that enable a Service Provider (SP) to build an end-to-end Ethernet Virtual Connection (EVC) Service, as defined in MEF 6.2 [4]. Note that the Service Provider in this context need not be an Operator of any of the CENs that make up the EVC Service.

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 ALPHA (the Service Provider). ALPHA is responsible for connecting the sites and for the end-to-end performance of the service.

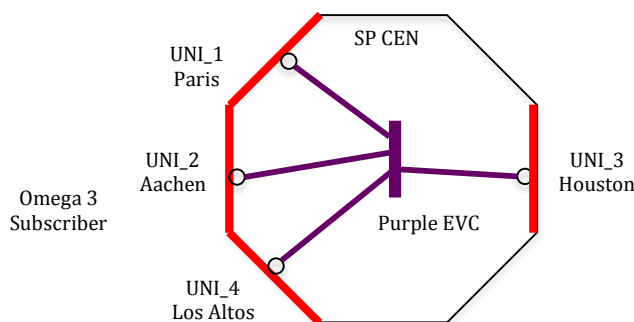


Figure 1: Example of an EP-LAN Service (from a Service Provider-Subscriber View)

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

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

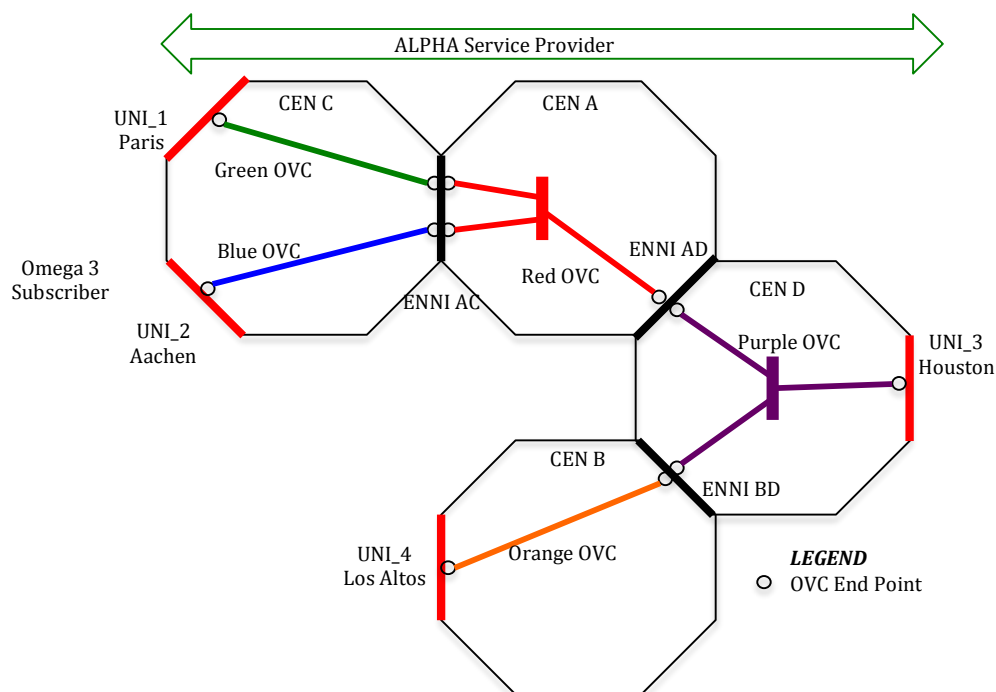


Figure 2: Example of an E-LAN Service (from Service Provider-Operator View)

As can be seen above, it is possible to create an end-to-end service with multiple CENs, and using a different OVC Type in two or more of the Operator's CENs. In this case, ALPHA designs and builds the end-to-end 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 26.1 [7] at ENNI_AC.

It is important to note that the Subscriber, Omega 3, does not need to know about the Operator CENs and the OVCs.

As a special case of this model, we could have an EVC spanning two CENs, where one Operator provides access to a UNI, and the other Operator's CEN is owned by the Service Provider. This special case is described in MEF 33 [10].

This document focuses on defining the OVC Services that a single Operator provides to a Service Provider. The basic service components of the OVC service are the OVC itself and the OVC per External Interface (EI) attributes that apply to the OVC. Note that when connecting multiple OVCs together, it is the responsibility of the Service Provider to work with each Operator to ensure that loops are avoided. It is beyond the scope of this document to define how OVC Services are pieced together, and therefore how to avoid multi-Operator loops.

As defined in MEF 26.1 [7], there are three different OVC Types:

- Point-to-Point
- Multipoint-to-Multipoint

- Rooted-Multipoint

And there are OVC End Point service attributes per one of two different External Interface types, as listed below:

- OVC End Point per ENNI
- OVC End Point per UNI²

Figure 3 below depicts an example of four Operators, six Point-to-Point OVCs and one Multipoint-to-Multipoint OVC. Three ENNIs are used to provide the interconnection between Operators' CENs. In this example, one Multipoint-to-Multipoint EVC Service is supported, providing connectivity among UNIs 1, 2, 3, 4 and 5.

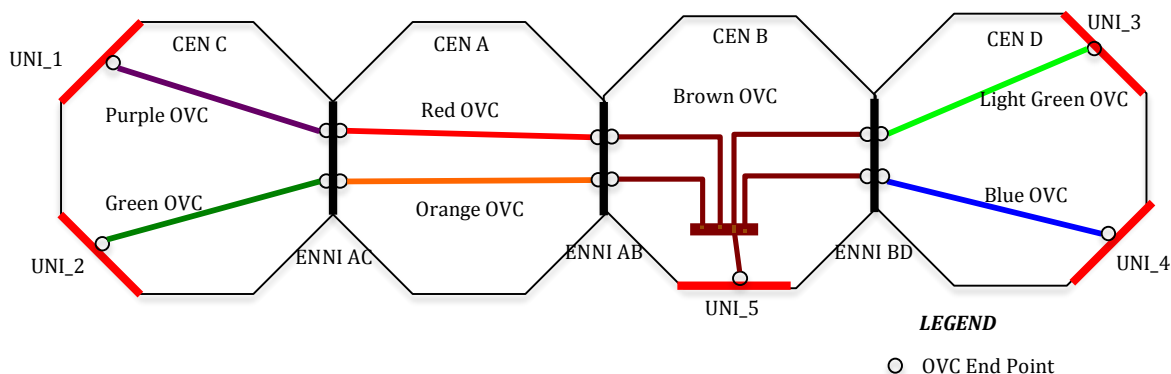


Figure 3: Example of OVCs and the two types of External Interfaces

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

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

Table 3: General OVC Services Taxonomy

The General OVC Services are defined in this document by specifying appropriate constraints on the service attributes defined in MEF 26.1 [7] and this document.

In addition to the General OVC Services, four specific OVC Services are defined, using additional constraints from the General OVC Services for certain service attributes, where appropriate. These services are structured as shown in Table 4 below. Note that a specific service based on the Rooted-Multipoint OVC is beyond the scope of this document.

Type of OVC Service	Point-to-Point OVC	Multipoint-to-Multipoint OVC
E-Access Service (UNI-to-ENNI OVC)	Access E-Line	Access E-LAN
E-Transit Service (ENNI-to-ENNI OVC)	Transit E-Line	Transit E-LAN

Table 4: Specific OVC Services Taxonomy

² The term 'OVC End Point per UNI' is synonymous with the term 'OVC per UNI' used in MEF 26.1.

The remainder of this document is organized as follows: Section 8 provides the set of common requirements for the General OVC Services. Section 9 provides the set of service specific requirements for each of the General OVC Services, i.e., O-Line Service, O-LAN Service and O-Tree Service. Sections 8 & 9 need to be taken together to completely define one of these General OVC Services. Section 10 specifies the E-Access Service definitions for Access E-Line and Access E-LAN Services, and Section 11 specifies the E-Transit Service definitions for Transit E-Line and Transit E-LAN Services. Both Access E-Line and Transit E-Line Services are derivatives of O-Line Service. Similarly, both Access E-LAN and Transit E-LAN Services are derivatives of O-LAN Service. Section 12 provides the references used in this document. Informative appendices are provided at the end to describe: the relationship of EVC and OVC Service Attributes; several use cases relating to how a combination of OVC Services could be used to put together an end-to-end EVC Service; a comparison of Access E-Line Service and the MEF 33 services (Access EPL and Access EVPL); and a SOAM Super Operator Use Case. In this document, the term SOAM Super Operator refers to an Operator of a CEN that also monitors a chain of concatenated OVCs in its own and adjacent CENs using SOAM.

8. Common Requirements

The OVC Services definitions in this document use the service attribute framework from MEF 26.1 as a template. Based on MEF 26.1, three sets of Service Attributes are used to define a given OVC Service – OVC, OVC End Point per ENNI and OVC End Point per UNI. The External Interfaces (i.e., ENNI and/or UNI) are MEF-compliant interfaces.

[R1] For a Service Attribute referenced in this document that is specified in MEF 26.1 [7], the Operator CEN **MUST** meet the mandatory requirements in MEF 26.1 that apply to the Service Attribute.

The following subsections provide a general description of these service attributes and the reference documents where a more detailed description is available. In addition, common requirements are specified for OVC Services³. These common requirements, together with the further constrained requirements for a given OVC Service, can be used as the complete set of requirements for the OVC Service.

It should be noted 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 Service Provider and the Operator.

Common requirements related to SOAM are based on the framework and requirements in MEF 30.1 [9] and MEF 35.1 [11].

[R2] When a MEP is enabled for a MEG that is not completely contained within a single Operator's CEN, the mandatory requirements of MEF 30.1 [9] that apply to that MEG **MUST** be met.

[R3] When a MIP is enabled at an EI, the mandatory requirements of MEF 30.1 [9] that apply to MIPs **MUST** be met.

[D1] When a MEP is enabled for a MEG that is not completely contained within a single Operator's CEN, the Operator **SHOULD** support PM-1 as specified in MEF 35.1 [11] at the MEP.

³ E-Access and E-Transit service definitions might have additional requirements that constrain the common requirements, and are defined separately in Sections 10 and 11.

8.1 OVC Service Attributes and Common Requirements

This subsection describes the OVC Service Attributes, and provides pointers to the reference documents, where appropriate. The reference for all of the OVC Service Attributes is Section 7.2 of MEF 26.1, except for the OVC Available MEG Level Service Attribute, which is defined in this document.

8.1.1 OVC Available MEG Level Service Attribute

The OVC Available MEG Level is the MEG Level that is one MEG Level higher than any MEG level reserved by the Operator for MEGs whose MEPs are contained entirely within the Operator's CEN. The OVC Available MEG Level Service Attribute takes a value of *none* or an *integer from 0 to 7*. The value *none* indicates that SOAM frames are not guaranteed to pass over this OVC at any MEG Level. If an *integer* value is specified, then SOAM Frames at or above that MEG Level are guaranteed to pass over the OVC.

The OVC Available MEG level can be used by the Service Provider or a SOAM Super Operator to determine which MEG levels are available to them that will not conflict with any SOAM used by the Operator within the CEN. When SOAM is used across a chain of OVCs, the OVC with the greatest OVC Available MEG Level value determines the lowest MEG level that could be used by the Service Provider or a SOAM Super Operator.

Note: An OVC Available MEG Level of *x* guarantees that SOAM PDUs at MEG Level *x* or higher will pass through the Operator's OVC. It does not necessarily mean that SOAM PDUs of lower level will be dropped. For example, if an Operator's devices implement the behavior detailed in MEF 30.1 Appendix B, then C-tagged SOAM PDUs of lower MEG Level could pass through that Operator's CEN. But another Operator whose devices do not behave as described in MEF 30.1 Appendix B could drop these same SOAM PDUs. Note also that an Operator may provide a MIP at an OVC End Point for use by a Service Provider, Subscriber or SOAM Super Operator at or above the OVC Available MEG Level.

Appendix D includes a description of how the OVC Available MEG Level can be used for concatenated OVCs.

8.1.2 OVC Service Attributes - Common Requirements

For each OVC Service Attribute, any constraints beyond those in MEF 26.1 [7] and this document are specified by requirements in this section. Note that Layer 2 Control Protocol (L2CP) service attributes are beyond the scope of this document⁴.

Common requirements on OVC Service Attributes are provided in Table 5. This table is organized as follows: the first column lists the OVC Service Attributes and the second column provides a description of the attribute. The third column provides the common requirements for OVC Services defined in this document. These requirements and recommendations apply to each OVC Service defined in this document, except that an OVC 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.

⁴ The appropriate place to specify L2CP requirements for OVC Services would be in a future MEF specification, possibly a revision to MEF 45.

OVC Service Attribute	Description	Common Requirements
OVC Identifier	A unique identifier within the Operator's network for the OVC.	No additional constraints from MEF 26.1
OVC Type	One of three possible types can be specified: <i>Point-to-Point</i> or <i>Multipoint-to-Multipoint</i> or <i>Rooted-Multipoint</i> .	See service specific sections
OVC End Point List	List of OVC End Points ⁵ , with a pair of values per OVC End Point {OVC End Point Identifier, OVC End Point Role}.	See service specific sections
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.	See service specific sections
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).	See service specific sections
OVC MTU size	This is the maximum frame length allowed on the OVC (in Bytes).	No additional constraints from MEF 26.1
CE-VLAN ID Preservation	<i>Yes</i> or <i>No</i> . This attribute determines the preservation of the CE-VLAN ID.	No additional constraints from MEF 26.1
CE-VLAN CoS Preservation	<i>Yes</i> or <i>No</i> . This attribute determines the preservation of the Priority Code Point (PCP) field of the C-Tag.	No additional constraints from MEF 26.1
S-VLAN ID Preservation	<i>Yes</i> or <i>No</i> . This attribute determines the preservation of the S-VLAN ID.	No additional constraints from MEF 26.1
S-VLAN CoS Preservation	<i>Yes</i> or <i>No</i> . This attribute determines the preservation of the PCP field of the S-Tag.	No additional constraints from MEF 26.1
Color Forwarding	<i>Yes</i> or <i>No</i> . This attribute determines whether a frame determined 'Yellow' at ingress can be promoted to 'Green' at the egress ENNI (<i>Yes</i> indicates it cannot be promoted).	[D2] Color Forwarding SHOULD be 'Yes'.

⁵ At least one of the OVC End Points associated by an OVC is required to be at an ENNI, per [R30] of MEF 26.1.

OVC Service Attribute	Description	Common Requirements
Service Level Specification	Any combination of some or all of the eight performance metrics defined in MEF 26.1 can be used in an SLS.	<p>[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 26.1, in an SLS.</p> <p>Note: Operators will need to offer all four metrics to satisfy multiple Service Providers who have different requirements. This also allows for a SP to choose the metrics needed for each OVC in the chain so that the EVC performance could be better estimated.</p> <p>[D4] The Operator SHOULD support the Frame Loss Ratio metric, as specified in MEF 26.1, in an SLS.</p>
Unicast Frame Delivery	<i>Conditional or Unconditional.</i> If <i>Conditional</i> , the conditions need to be specified.	See service specific sections
Multicast Frame Delivery	<i>Conditional or Unconditional.</i> If <i>Conditional</i> , the conditions need to be specified.	See service specific sections
Broadcast Frame Delivery	<i>Conditional or Unconditional.</i> If <i>Conditional</i> , the conditions need to be specified.	See service specific sections

OVC Service Attribute	Description	Common Requirements
OVC Available MEG Level	<p>Specifies the lowest MEG Level available for the Service Provider or SOAM Super Operator.</p> <p>Note: See Section 8.1.1 for the definition of the OVC Available MEG Level Service Attribute. Also, see Appendix D, which describes a use case that provides context for these requirements.</p>	<p>[R4] An Operator for a given OVC MUST support a value of 3 or less for the OVC Available MEG Level.</p> <p>[D5] An Operator for a given OVC SHOULD support a value of 2 for the OVC Available MEG Level.⁶</p> <p>[R5] The OVC Available MEG Level MUST be ≤ 6.</p> <p>Note: Requirements [R4] and [D5] indicate that Operators must offer an OVC Available MEG Level of 3 or lower, however [R3] allows Operators and Service Providers to mutually agree on any other level, so long as that level is not 7.</p>

Table 5: OVC Service Attributes – Requirements for OVC Services

8.2 OVC End Point per ENNI Service Attributes and Common Requirements

This subsection describes the OVC End Point per ENNI Service Attributes, and provides pointers to the reference documents, where appropriate. The reference for all of the OVC End Point per ENNI Service Attributes is Section 7.3 of MEF 26.1, except for two: Maintenance End Point (MEP) List for OVC End Point per ENNI Service Attribute and Maintenance Intermediate Point (MIP) for OVC End Point per ENNI Service Attribute, which are defined in this document.

8.2.1 Maintenance End Point List for OVC End Point per ENNI Service Attribute

The Maintenance End Point (MEP) List for OVC End Point per ENNI Service Attribute is a list of MEPs, with their direction (Up or Down), MEG and MEG level, to be enabled at the OVC End Point per ENNI. It does not include “Operator” level MEPs that monitor a MEG and are completely contained within a single CEN. When the list is not empty, several parameter values need to be determined as described in MEF 30.1 [9].

8.2.2 Maintenance Intermediate Point for OVC End Point per ENNI Service Attribute

The value of the Maintenance Intermediate Point (MIP) for OVC End Point per ENNI Service Attribute can be either 'Enabled' or 'Disabled'.

⁶ This recommendation maximizes the possibility for multiple SOAM Super Operators. The implication is that the Operator can only use MEG Level 1 or 0 for monitoring the OVC, or the Operator does not monitor the OVC with SOAM. Note that this is different than the default MEG Level specified in MEF 30.1 for the Operator MEG.

[R6] When the value of the Maintenance Intermediate Point for OVC End Point per ENNI Service Attribute is 'Enabled', the Operator CEN **MUST** instantiate a Maintenance Intermediate Point as described in MEF 30.1 [9].

Note: this attribute is regarding a MIP on the OVC End Point for use by the SP or the SOAM Super Operator. MIPs per EVC at the OVC End Point are considered out of scope for this document.

When the value of the MIP Service Attribute is 'Enabled', several parameter values need to be determined as described in MEF 30.1 [9].

8.2.3 OVC End Point per ENNI - Common Requirements

For each OVC End Point per ENNI Service Attribute, any constraints beyond those in MEF 26.1 are specified by requirements in this section. This section also includes requirements for SOAM, based on MEF 30.1. These attributes apply to a single OVC End Point at an ENNI.

Common requirements on OVC End Point per ENNI Service Attributes are provided in Table 6. This table is organized as follows: the first column lists the OVC End Point per ENNI Service Attributes and the second column provides a description of the attribute. The third column provides the common requirements for OVC Services defined in this document. These requirements and recommendations apply to each OVC Service defined in this document, except that an OVC 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.

OVC End Point per ENNI Service Attribute	Description	Common Requirements
OVC End Point Identifier	A unique identifier within the Operator's network for the OVC End Point.	No additional constraints from MEF 26.1
Trunk Identifiers	A pair of S-VLAN ID values used on the ENNI for distinguishing between Root and Leaf originated frames. Note: Applicable for Rooted-Multipoint OVC Services having a 'trunk' OVC End Point.	No additional constraints from MEF 26.1
Class of Service Identifier for ENNI Frames	The way that a Class of Service (CoS) Name is determined for ingress ENNI Frames at an ENNI.	No additional constraints from MEF 26.1
Ingress Bandwidth Profile per OVC End Point	Ingress policing by the Operator on all ingress ENNI frames mapped to the OVC End Point.	[R7] Ingress Bandwidth Profile per OVC End Point at the ENNI MUST be 'No'.

OVC End Point per ENNI Service Attribute	Description	Common Requirements
Ingress Bandwidth Profile per Class of Service Identifier	Ingress policing by the Operator on all ingress ENNI frames with the Class of Service Identifier (CoS ID) mapped to the OVC End Point.	<p>[R8] Ingress Bandwidth Profile per CoS ID at the ENNI MUST be 'Parameters', per section 7.6.1 of MEF 26.1 [7].</p> <p>[D6] For each CoS Name in the OVC, the Operator SHOULD support the following values for CIR and EIR, up to the maximum⁷ supported by the Operator for that CoS Name:</p> <ul style="list-style-type: none"> • 0– 10 Mbps in increments of 1 Mbps • 10-100 Mbps in increments of 10 Mbps • 100-1000 Mbps in increments of 100 Mbps • 1 – 10 Gbps in increments of 1 Gbps <p>Note: These recommended values can be subject to limitations⁸ on the upper end of the range offered by the Operator. The wording of this recommendation specifically allows for the Operator and Service Provider to agree on other values of CIR, e.g., above 10 Gbps.</p> <p>Note also that the Operator and Service Provider may agree on parameter values for a given service that can make the service behave as if there is no Ingress Bandwidth Profile applied, e.g., a CIR value could be used that is close to the line rate of the PHY. Operators and Service Providers should be careful with the selection of these parameters so that adverse performance impacts on services using this ENNI are limited.</p>

⁷ The maximum limit could be zero for CIR or for EIR or for both for a given CoS ID. A maximum limit of zero for both CIR and EIR would indicate a discard CoS. Note that the Operator and Service Provider could agree on a 'Best Effort' style service with CIR, CBS = 0 and EIR, EBS > 0.

⁸ Such limitations can include UNI speed, ENNI speed, and any upper limit that an Operator might have for a given CoS Name. For example, one Operator might set a CIR ceiling of 70 Mbps when the service is associated with a 100 Mbps UNI, to control for effects of frame overhead. Another Operator, as another example, might set a ceiling of 100 Mbps for the CoS Name of 'Voice'; and yet another ceiling of 2 Mbps for the CoS Name of 'Synchronization'. See Appendix B of MEF 10.3 for a description of the effects of frame overhead.

OVC End Point per ENNI Service Attribute	Description	Common Requirements
Egress Bandwidth Profile per OVC End Point	Traffic limiting on egress ENNI frames mapped to the OVC End Point (shaping and/or policing could be used in the CEN).	[R9] Egress Bandwidth Profile per OVC End Point at the ENNI MUST be 'No'.
Egress Bandwidth Profile per Class of Service Identifier	Traffic limiting on egress ENNI frames with the CoS ID mapped to the OVC End Point (shaping and/or policing could be used in the CEN).	[D7] The Operator SHOULD support 'Parameters', per section 7.6.1 of MEF 26.1 [7], for the Egress Bandwidth Profile per CoS ID at the ENNI.
Maintenance End Point (MEP) List	A list of MEPs, with their direction (Up or Down), MEG and MEG level.	<p>[D8] For an OVC that has OVC End Points at one or more other ENNIs, the Operator SHOULD support at least one Up MEP at the OVC End Point in the SP MEG(s)⁹.</p> <p>[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.</p> <p>[CD1]<[D8] The MEG Level(s) specified SHOULD NOT be 0, 1 or 7.</p> <p>[D9] The Operator SHOULD support at least one Down MEP at the OVC End Point in the SP MEG¹⁰.</p> <p>[CR2]<[D9] The Operator MUST support all MEG Levels in the range from 3 to 6.</p> <p>[CD2]<[D9] The Operator SHOULD support MEG Level 2.</p> <p>[CD3]<[D9] The MEG Level(s) specified SHOULD NOT be 0, 1 or 7.</p>

⁹ An example of using an Up MEP for an OVC End Point at an ENNI is described in Appendix D. Note, that there could be more than one SP MEG, for example, where SOAM Super Operators are part of the service.

¹⁰ See ENNI_CD in Figure 23 for an example of using a Down MEP, which is briefly described in Appendix D.

OVC End Point per ENNI Service Attribute	Description	Common Requirements
Maintenance Intermediate Point (MIP)	<i>Enabled or Disabled.</i>	<p>[D10] The Operator SHOULD support a value of <i>Enabled</i> for the MIP at the OVC End Point.</p> <p>[CR3]<[D10] 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.</p>

Table 6: OVC End Point per ENNI Service Attributes for OVC Services

Note: MEF 30.1 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.

8.3 OVC End Point per UNI Service Attributes and Common Requirements

This subsection describes the OVC End Point per UNI¹¹ Service Attributes, and provides pointers to the reference documents, where appropriate. The reference for all of the OVC End Point per UNI Service Attributes is Section 7.5 of MEF 26.1, except for two: Maintenance End Point (MEP) for OVC End Point per UNI Service Attribute and Subscriber MEG MIP for OVC End Point per UNI Service Attribute, which are defined in this document.

8.3.1 Maintenance End Point List for OVC End Point per UNI Service Attribute

The Maintenance End Point List for OVC End Point per UNI Service Attribute is a list of MEPs, with their direction (Up or Down), MEG and MEG level, to be enabled at the OVC End Point. It does not include “Operator” level MEPs that monitor a MEG and are completely contained within a single CEN. When the list is not empty, several parameter values need to be determined as described in MEF 30.1 [9]

8.3.2 Subscriber MEG MIP for OVC End Point per UNI Service Attribute

This attribute only applies in cases when the OVC End Point maps to a single EVC. The value of the Subscriber MEG MIP can be either 'Enabled' or 'Disabled'.

[R10] When the value of the Subscriber MEG MIP Service Attribute is 'Enabled', the Operator CEN **MUST** instantiate a Subscriber Level MIP¹² as described in MEF 30.1 [9].

When the Subscriber MEG MIP is 'Enabled', several parameter values need to be determined as described in MEF 30.1 [9].

¹¹ This document uses the term ‘OVC End Point per UNI’ to be consistent with the use of the term ‘OVC End Point per ENNI’. MEF 26.1 uses the term ‘OVC per UNI’, but notes that it is the same as ‘OVC End Point per UNI’.

¹² See Table 22, this document, for guidance on using the same MEG Level needed for the EVC service.

8.3.3 OVC End Point per UNI - Common Requirements

For each OVC End Point per UNI Service Attribute, any constraints beyond those in MEF 26.1 are specified by requirements in this section. This section also includes requirements for SOAM, based on MEF 30.1 [9]. These attributes apply to a single OVC End Point at a UNI.

Common requirements on OVC End Point per UNI Service Attributes are provided in Table 7. This table is organized as follows: the first column lists the OVC End Point per UNI Service Attributes and the second column provides a description of the attribute. The third column provides the common requirements for OVC Services defined in this document. These requirements and recommendations apply to each OVC Service defined in this document, except that an OVC 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 End Point per UNI Service Attribute	Description	Common Requirements
UNI OVC Identifier	A unique identifier within the Operator's network for a specific OVC at the UNI.	No additional constraints from MEF 26.1
OVC End Point Map	The CE-VLAN ID(s) that map to the OVC End Point at the UNI.	No additional constraints from MEF 26.1
Class of Service Identifiers	The way that a Class of Service Name is determined for ingress Service Frames at a UNI.	No additional constraints from MEF 26.1
Ingress Bandwidth Profile per OVC End Point	Ingress policing by the Operator on all ingress frames mapped to the OVC End Point at a UNI.	[R11] Ingress Bandwidth Profile per OVC End Point at the UNI MUST be 'No'.

OVC End Point per UNI Service Attribute	Description	Common Requirements
Ingress Bandwidth Profile per Class of Service Identifier	Ingress policing by the Operator on all ingress frames with the CoS ID for a given OVC End Point at a UNI.	<p>[R12] Ingress Bandwidth Profile per CoS ID at the UNI MUST be 'Parameters', per section 7.5.5 of MEF 26.1 [7].</p> <p>[D11] For each CoS Name in the OVC, the Operator SHOULD support the following values for CIR and EIR, up to the maximum⁷ value supported by the Operator for that CoS Name:</p> <ul style="list-style-type: none"> • 0– 10 Mbps in increments of 1 Mbps • 10-100 Mbps in increments of 10 Mbps • 100-1000 Mbps in increments of 100 Mbps • 1 – 10 Gbps in increments of 1 Gbps <p>Note: These required values can be subject to limitations⁸ on the upper end of the range offered by the Operator. The wording of this requirement specifically allows for the Operator and Service Provider to agree on other values of CIR, e.g., above 10 Gbps.</p> <p>Note also that the Operator and Service Provider may agree on parameter values for a given service that can make the service behave as if there is no Ingress Bandwidth Profile applied, e.g., a CIR value could be used that is close to the line rate of the PHY. Operators and Service Providers should be careful with the selection of these parameters so that adverse performance impacts on services using this UNI are limited.</p>
Egress Bandwidth Profile per OVC End Point	Traffic limiting of egress Service Frames mapped to the OVC End Point at a UNI (shaping and/or policing could be used in the CEN).	<p>[R13] Egress Bandwidth Profile per OVC End Point at the UNI MUST be 'No'.</p>

OVC End Point per UNI Service Attribute	Description	Common Requirements
Egress Bandwidth Profile per Class of Service Identifier	Traffic limiting of egress Service Frames with the CoS ID mapped to the OVC End Point at a UNI (shaping and/or policing could be used in the CEN)	No additional constraints from MEF 26.1
Maintenance End Point (MEP) List	A list of MEPs, with their direction (Up or Down), MEG and MEG level, to be enabled at the OVC End Point.	<p>[D12] The Operator SHOULD support at least two Up MEPs at the OVC End Point.</p> <p>[CR4]<[D12] 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.</p> <p>[CD4]<[D12] The MEG Levels specified SHOULD NOT be 0, 1 or 7.</p>
Subscriber MEG MIP	<i>Enabled or Disabled.</i>	<p>[D13] The Operator SHOULD support a value of <i>Enabled</i> for the Subscriber MEG MIP at the OVC End Point.</p> <p>[CD5]<[D13] The Operator SHOULD support configuration of the MEG Level to any value from 5 to 7.</p>

Table 7: OVC End Point per UNI Service Attributes for OVC Services

Note: MEF 30.1 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.

8.4 External Network Network Interface (ENNI) Service Attributes

This document does not address the ENNI Service Attributes specified in MEF 26.1. For a given OVC Service, MEF 26.1 contains the requirements that apply to the ENNI Service Attributes, e.g., the Physical Layer and the End Point Map (none of the OVC Service Definitions in this document constrain the End Point Map). A MEF-compliant ENNI can be used as part of an OVC Service defined herein, as long as it supports the service being defined.

The following requirement related to the End Point Map attribute clarifies the End Point type with respect to MEF 26.1, which allows more than one End Point type.

[R14] Each S-VLAN ID value associated with an instance of an OVC Service, as defined in this document, **MUST** map to a distinct End Point of Type = ‘OVC’.

This document adds a new ENNI service attribute definition for Color Identifier Mode, in line with expected update in a future revision to MEF 26.1.

8.4.1 Color Identifier Mode for OVC Services Service Attribute

The Color Identifier Mode for OVC Services is the means by which the Color for an ENNI Frame that maps to an OVC End Point is indicated by the content in the ENNI Frame header. It takes on one of two values: “DEI” or “PCP.”

[R15] When the Color Identifier Mode has the value DEI, the Color **MUST** be Green if the DEI value in the S-Tag = 0 and Yellow if the DEI value in the S-Tag = 1.

[R16] When the Color Identifier Mode has the value PCP, the value of the PCP in the S-Tag **MUST** determine the Color of the ENNI Frame.

[R17] When the Color Identifier Mode has the value PCP, each possible PCP value **MUST** map to exactly one Color.

[R17] means that the sets of S-Tag PCP values that map to each Color are disjoint sets and the union of these sets is the set of all possible S-Tag PCP values.

The following example illustrates the CoS Name and color identification at the ENNI. Operator A and B agree to use color identifier mode of PCP on an ENNI interconnecting their CENs. The CoS Name is also determined from the PCP value in each ENNI Frame, as described in MEF 26.1. Operator A offers five CoS Names for a given OVC End Point, and maps PCP values in received ENNI frames to those CoS Names, as follows - this affects how Operator B needs to set the PCP values in frames transmitted across the ENNI to conform to Operator A's policy:

- CoS Extreme: defined as Green only, i.e., EIR=EBS=0. PCP value of 7 in the ENNI frame is used to identify 'Extreme' and all frames carrying this code point are also identified as green.
- Discard: This CoS Name discards all ENNI frames that use the PCP value of 6, i.e., CIR=CBS=EIR=EBS=0. To conform with [R17], each ENNI frame with this PCP value is defined to have color of Yellow¹³.
- CoS Super: defined as Green and Yellow. PCP value of 5 in the ENNI frame is used to identify Green in 'Super'; and PCP value of 4 is used to identify Yellow in 'Super'.
- CoS Enhanced: defined as Green and Yellow. PCP value of 3 in the ENNI frame is used to identify Green in 'Enhanced'; and PCP value of 2 is used to identify Yellow in 'Enhanced'.
- CoS Regular: defined as Green and Yellow. PCP value of 1 in the ENNI frame is used to identify Green in 'Regular'; and PCP value of 0 is used to identify Yellow in 'Regular'.

In the end, Green frames are identified with PCP values of {7,5,3,1} and Yellow frames are identified with PCP values of {6,4,2,0}. Each possible PCP value identifies both a CoS Name and a color.

8.4.2 OVC Services Definitions Requirement for Color Identification

No additional constraints from [R5] of MEF 23.1 [6]. This allows the Operators involved to agree to use either the DEI mode or the PCP mode for all OVC Services at a given ENNI.

¹³ The choice for 'Yellow' for such frames is arbitrary. It really doesn't matter whether the color identifier for such frames are 'Green' or 'Yellow', since these frames will be discarded.

8.5 User Network Interface (UNI) Service Attributes

This document does not address the UNI Service Attributes. Any MEF-compliant UNI can be used as part of an OVC Service defined herein, as long as it supports the service being defined.

9. General OVC Service Definitions

This section defines the General OVC Services, by specifying the constraints from MEF 26.1 for certain service attributes related to the differences among the three General OVC Services. The only differences among the General OVC Services are found in the OVC Service Attributes. So, the following General OVC Service definitions will just specify the service attributes where there are differences. To understand the full extent of a General OVC Service definition, the attributes and common requirements in Section 8 need to be included.

9.1 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 4 below shows an example of eight instances of O-Line Service in four CENs that are used in supporting three instances of E-Line Services (see MEF 6.2 [4] for definition of E-Line services).

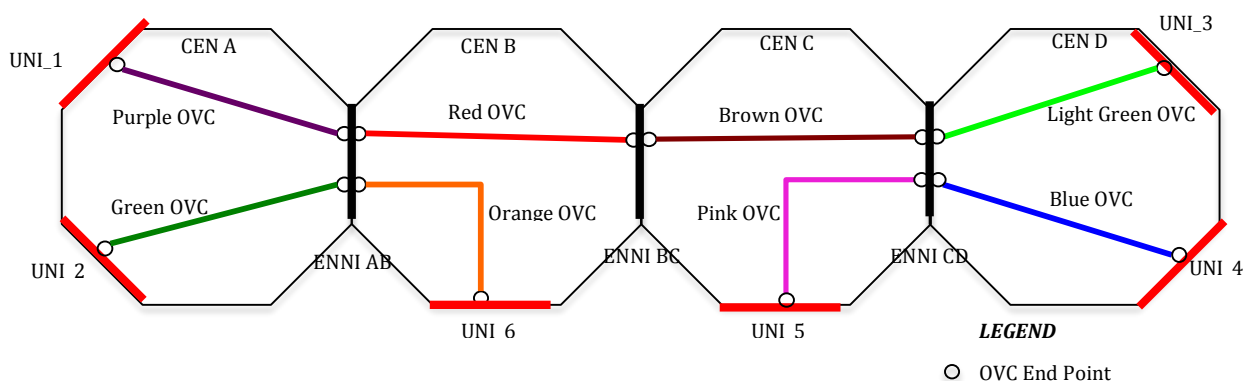


Figure 4: Example of O-Line Services in Operator CENs (Point-to-Point OVC)

In Figure 4 above, the example depicts the various combinations of External Interfaces that could be used as part of an O-Line Service (except for ENNI hairpin switching, which is allowed but not shown). In Figure 4, 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 and Figure 3.

The full set of requirements for O-Line Service consists of the common requirements specified in Section 8, and the constrained requirements specified in Table 8, below. The first column lists the OVC service attribute, and the second column specifies the requirements.

OVC Service Attribute	Constrained Requirements for O-Line Service
OVC Type	[R18] For an O-Line Service, the OVC Type MUST be Point-to-Point.
OVC End Point List	[R19] For an O-Line Service, there MUST be exactly two end points in the OVC End Point List, each with the role of 'Root'. Note: At least one of the OVC End Points associated by an OVC is required to be at an ENNI, per [R30] of MEF 26.1.
Maximum Number of UNI OVC End Points	No additional constraints from MEF 26.1. Note: Since an O-Line Service has type Point-to-Point, and therefore has exactly two OVC End Points, and since at least one of the OVC End Points is at an ENNI, there can be at most one UNI OVC End Point.
Maximum Number of ENNI OVC End Points	No additional constraints from MEF 26.1. Note: Since an O-Line Service has type Point-to-Point, and therefore has exactly two OVC End Points, there can be at most two ENNI OVC End Points.
Service Level Specification	No additional constraints from Table 5. In addition, the following requirement applies: [D14] For an O-Line Service, when a performance metric in the SLS has an objective, then <i>S</i> SHOULD include both ordered OVC End Point pairs. ¹⁴
Unicast Frame Delivery	[R20] For an O-Line Service, the Operator MUST support <i>unconditional</i> unicast frame delivery. ¹⁵
Multicast Frame Delivery	[R21] For an O-Line Service, the Operator MUST support <i>unconditional</i> multicast frame delivery ¹⁶ .
Broadcast Frame Delivery	[R22] For an O-Line Service, the Operator MUST support <i>unconditional</i> broadcast frame delivery ¹⁶ .

Table 8: Constrained OVC Service Attributes and Requirements for O-Line Service

9.2 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 5 below shows an example of two instances of O-LAN Service, one in CEN A to connect UNIs 1 and 2 with ENNI_AB, and one in CEN B to connect one OVC End Point at ENNI_AB, one OVC End Point at UNI_5 and two OVC End Points at ENNI_BC. Two

¹⁴ The parameter *S* is the subset of ordered OVC End Point pairs and is defined in MEF 26.1 [7], section 7.2.16.

¹⁵ 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 per ENNI of a P2P OVC on behalf of the peer Operator, then conditional delivery rules could be applied for that service.

¹⁶ 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.

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].

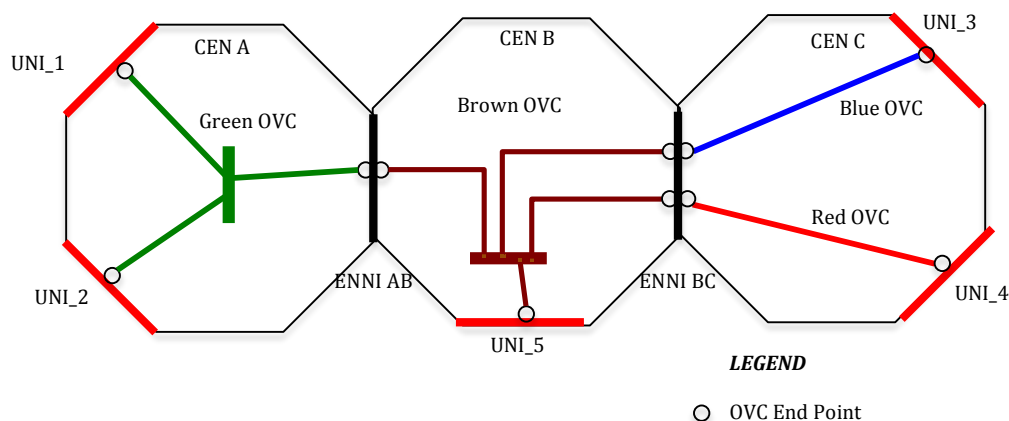


Figure 5: Example of Two O-LAN Services in CEN A and CEN B

The full set of requirements for O-LAN Service consists of the common requirements specified in Section 8, and the constrained requirements specified in Table 9, below. The first column lists the OVC service attribute, and the second column specifies the requirements.

OVC Service Attribute	Constrained Requirements for O-LAN Service
OVC Type	[R23] For an O-LAN Service, the OVC Type MUST be Multipoint-to-Multipoint.
OVC End Point List	[R24] For an O-LAN Service, each of the OVC End Points MUST have role of 'Root'. Note: At least one of the OVC End Points associated by an OVC is required to be at an ENNI, per [R30] of MEF 26.1.
Maximum Number of UNI OVC End Points	No additional constraints from MEF 26.1
Maximum Number of ENNI OVC End Points	No additional constraints from MEF 26.1
Unicast Frame Delivery	[D15] For an O-LAN Service, Unicast Frame Delivery SHOULD be <i>conditional</i> ¹⁷ with the condition that the delivery of unicast frames is subject to the dynamic learning and filtering process as described in IEEE 802.1Q TM -2014 [1] for Independent and Shared VLAN learning bridges.
Multicast Frame Delivery	No additional constraints from MEF 26.1 ¹⁸

¹⁷ 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.

¹⁸ For a Multipoint-to-Multipoint OVC, an ingress frame at a given EI with a multicast MAC DA, or the broadcast MAC DA, would be forwarded to all egress EIs in the OVC. This behavior supports the expectation of basic deployments. Conditional delivery might be used in some cases; such conditions might include multicast pruning on egress or ingress rate limiting of multicast and broadcast frames.

OVC Service Attribute	Constrained Requirements for O-LAN Service
Broadcast Frame Delivery	[D16] For an O-LAN Service, broadcast frame delivery SHOULD be ‘unconditional’. ¹⁸

Table 9: Constrained OVC Service Attributes and Requirements for O-LAN Service

9.3 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 6 below, ALPHA Service Provider provides an E-Tree Service to the Subscriber. The Subscriber wants four UNIs in the Rooted-Multipoint EVC to start, with two Root UNIs and two Leaf UNIs, as shown. The Subscriber can add other UNIs in the future.

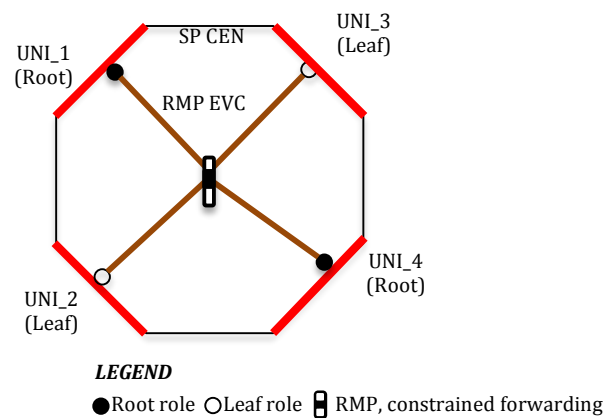


Figure 6: Subscriber View of the E-Tree Service Example

Now, let's assume that ALPHA Service Provider needs to buy OVC 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 7 below, 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.

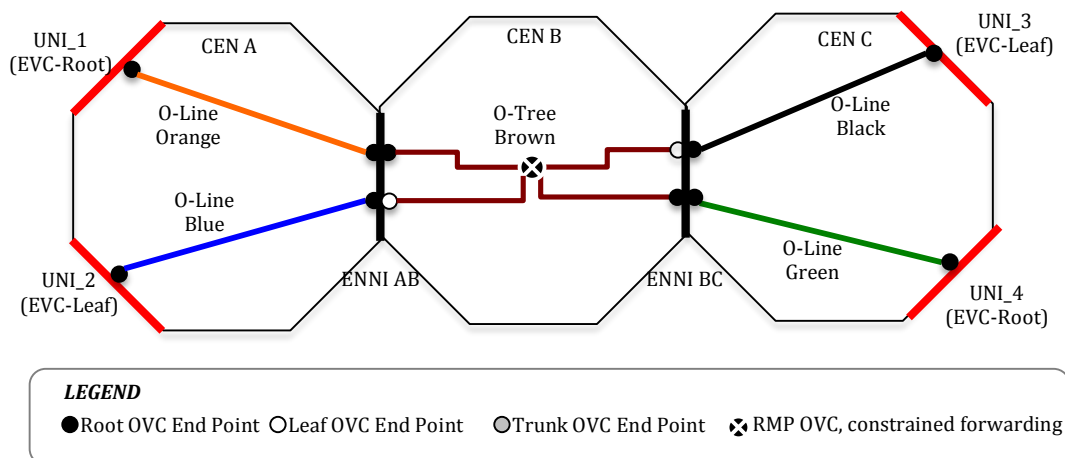


Figure 7: SP-Operator view of an example O-Tree Service in Operator B CEN

Figure 7 depicts the SP-Operator view of the OVC Services in support of the UNI to UNI E-Tree service. Note that the UNI roles shown in Figure 7 are from the SP-Subscriber's view.

The Service Provider uses the following OVC Services to build the end-to-end E-Tree Service:

- O-Line Orange in CEN A connects UNI_1 to ENNI_AB. Both OVC End Points for the OVC have the role of 'Root'.
- O-Line Blue in CEN A connects UNI_2 to ENNI_AB. Both OVC End Points for the OVC have the role of 'Root'.
- O-Line Black in CEN C connects UNI_3 to ENNI_BC. Both OVC End Points for the OVC have the role of 'Root'.
- O-Line Green in CEN C connects UNI_4 to 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 8 below depicts a different arrangement of OVCs to support the same end-to-end E-Tree Service. In this example, the ALPHA Service Provider uses three Rooted-Multipoint OVCs, one in each CEN.

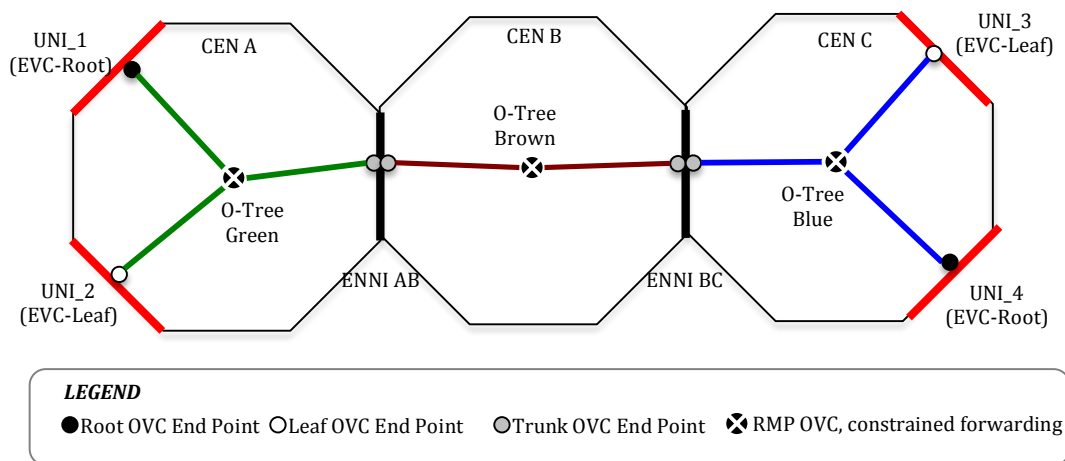


Figure 8: SP-Operator view of an example of O-Tree Services in all three CENs

Note that the UNI roles, EVC-Leaf and EVC-Root, shown in Figure 8 are in the SP-Subscriber view. In the SP-Operator view, the role of each OVC End Point at a UNI is as shown in the Legend. The UNI roles are the same in both the SP-Subscriber and SP-Operator views.

In this example, the Service Provider uses the following OVC Services to build the end-to-end 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 of one of the other CENs (namely, CEN C).

- 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 of one of the other CENs (namely, CEN A).
- O-Tree Brown in CEN B connects ENNI_AB with ENNI_BC. Interestingly, this is a case of a RMP 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 bundling of both S-VLAN IDs (Root/Leaf) at each ENNI. In this arrangement, the bundled Point-to-Point OVC would have ‘Root’ End Points, and would preserve the S-VLAN IDs¹⁹.

The full set of requirements for O-Tree Service consists of the common requirements specified in Section 8, and the constrained requirements specified in Table 10, below. The first column in Table 10 lists the OVC Service Attributes and the second column specifies the constrained requirements for O-Tree Service.

OVC Service Attribute	Constrained Requirements for O-Tree Service
OVC Type	[R25] For an O-Tree Service, the OVC Type MUST be Rooted-Multipoint.
OVC End Point List	No additional constraints from MEF 26.1 As per MEF 26.1, each of the OVC End Points in a Rooted-Multipoint OVC has one of three possible roles: ‘Root’, ‘Leaf’ or ‘Trunk’. Note: At least one of the OVC End Points associated by the OVC is required to be at an ENNI, per [R30] of MEF 26.1.
Maximum Number of UNI OVC End Points	No additional constraints from MEF 26.1
Maximum Number of ENNI OVC End Points	No additional constraints from MEF 26.1
Unicast Frame Delivery	[D17] For an O-Tree Service, Unicast Frame Delivery SHOULD be <i>conditional</i> with the condition that the delivery of unicast frames is subject to the dynamic learning and filtering process as described in IEEE 802.1Q TM -2014 [1] for Independent and Shared VLAN learning bridges. ^{20,21}

¹⁹ See Figure 36 in MEF 26.1 for a more detailed description of this possible arrangement. Appendix B of MEF 26.1 contains additional examples of the use of Rooted-Multipoint OVCs.

²⁰ For a Rooted-Multipoint OVC, forwarding constraints involving roots and leaves, as specified in R33-R36 of MEF 26.1, apply to all frame types – unicast, multicast and broadcast - and apply at all times regardless of the setting of *conditional* or *unconditional frame delivery*.

²¹ 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.

OVC Service Attribute	Constrained Requirements for O-Tree Service
Multicast Frame Delivery	No additional constraints from MEF 26.1. ²⁰
Broadcast Frame Delivery	[D18] For an O-Tree Service, Broadcast Frame Delivery SHOULD be 'unconditional'. ²⁰

Table 10: Constrained OVC Service Attributes and Requirements for O-Tree Service

10. E-Access Services

As defined in Section 5.1 of MEF 33 [10], an "E-Access Service Type is any OVC Service that associates at least one OVC End Point at a UNI and at least one OVC End Point at an 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 [10] defines two E-Access services, Access EPL and Access EVPL. This document defines two additional E-Access services: Access E-Line and Access E-LAN.

10.1 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 could map to a given OVC End Point. At the ENNI, an S-VLAN ID is used to map 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 has a full set of capabilities, allowing for one or more Class of Service Names, and including support for SOAM. It is designed to support the following applications:

- Enhanced version of the Access EPL Service defined in MEF 33 [10]
- Enhanced version of the Access EVPL Service defined in MEF 33 [10]
- The vNID Case A OVC specified in MEF 43 [12]
- Other potential applications requiring point-to-point access

Figure 9 below depicts three examples of Access E-Line Service.

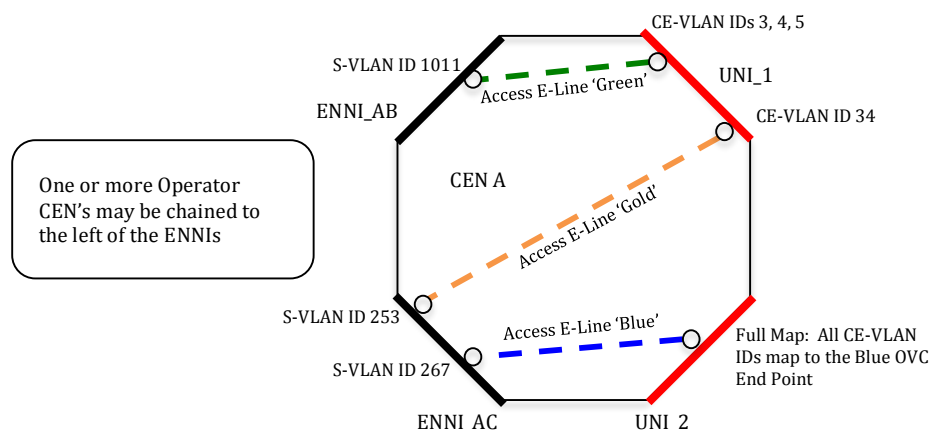


Figure 9: Example of CEN with Three Access E-Line Services

Access E-Line Service provides access to a UNI that is generally capable of more than one virtual connection. It has the capability to map one CE-VLAN ID to an OVC End Point per UNI (see 'Gold' OVC at UNI_1); or, more than one (but not all) CE-VLAN IDs to an OVC End Point per UNI (see 'Green' OVC at UNI_1); or all CE-VLAN IDs to an OVC End Point per 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 ENNI shown in Figure 9 can have any type of OVC Service. Some examples are listed below:

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

The following subsections provide the service definition for Access E-Line Service, structured by the service attribute types that are applicable to this service.

See Appendix C for a comparison of Access E-Line Service as defined in this document and Access EPL Service and Access EVPL Service as defined in MEF 33 [10].

10.1.1 Access E-Line Service: OVC Service Attributes & Requirements

Table 11 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 5 in this document, it is found in Section 8.1. Similarly, where reference is made to Table 8 in this document, it is found in Section 9.1.

OVC Service Attribute	Requirements for Access E-Line Service
OVC ID	Requirements per Table 5, this document
OVC Type	Requirements per Table 8, this document
OVC End Point List	[R26] An Access E-Line Service MUST have one OVC End Point at an ENNI and one OVC End Point at a UNI.
Maximum Number of UNI OVC End Points	[R27] For Access E-Line Service, the maximum number of UNI OVC End Points MUST be one.
Maximum Number of ENNI OVC End Points	[R28] For Access E-Line Service, the maximum number of ENNI OVC End Points MUST be one.
OVC MTU size	Requirements per Table 5, this document

OVC Service Attribute	Requirements for Access E-Line Service
CE-VLAN ID Preservation	<p>[R29] For Access E-Line Service, the Operator MUST support CE-VLAN ID Preservation = ‘Yes’.</p> <p>[D19] For Access E-Line Service, the Operator SHOULD support CE-VLAN ID Preservation = ‘No’.</p> <p>For the case where CE-VLAN ID preservation is 'No' for an EVC, and 'Yes' for all of the Access E-Line services supporting the EVC, then a VUNI (see MEF 28 [8]) would be required to do the necessary CE-VLAN ID translation for the EVC.</p> <p>The following is an example of CE-VLAN ID Preservation = 'No': 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.</p>
CE-VLAN CoS Preservation	<p>[R30] For Access E-Line Service, the Operator MUST support CE-VLAN CoS Preservation = ‘Yes’</p> <p>[D20] For Access E-Line Service, the Operator SHOULD support CE-VLAN CoS Preservation = ‘No’.</p> <p>The following is an example of CE-VLAN CoS Preservation = 'No': Customer uses IP-based devices to connect to the service, and doesn't care about received PCP values (the CE 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.</p>
S-VLAN ID Preservation	Not Applicable
S-VLAN CoS Preservation	Not Applicable
Color Forwarding	Requirements per Table 5, this document
Service Level Specification	Requirements per Table 5, this document.
Unicast Frame Delivery	Requirements per Table 8, this document
Multicast Frame Delivery	Requirements per Table 8, this document
Broadcast Frame Delivery	Requirements per Table 8, this document
OVC Available MEG Level	Requirements per Table 5, this document

Table 11: Constrained OVC Requirements for Access E-Line Service

10.1.2 Access E-Line Service: OVC End Point per ENNI Attributes & Requirements

Table 12 below provides the requirements for Access E-Line Service related to the OVC End Point per ENNI Service Attributes. The first column lists the OVC End Point per ENNI 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 8.2 for the General OVC Services.

OVC End Point per ENNI Service Attribute	Requirements for Access E-Line Service
OVC End Point Identifier	Requirements per Table 6, this document
Trunk Identifiers	Not Applicable
Class of Service Identifiers	Requirements per Table 6 this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 6 this document Note: This attribute is not used. Instead, Ingress Bandwidth Profile per CoS ID is used - a valid CoS ID could be the set of all PCP values mapped to the OVC End Point, which provides equivalent behavior.
Ingress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6 this document.
Egress Bandwidth Profile per OVC End Point	Requirements per Table 6 this document
Egress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6 this document
Maintenance End Point (MEP) List	Requirements per Table 6 this document
Maintenance Intermediate Point (MIP)	Requirements per Table 6 this document

Table 12: Constrained OVC End Point per ENNI Requirements for Access E-Line Service

10.1.3 Access E-Line Service: OVC End Point per UNI Service Attributes & Requirements

Table 13 below provides the requirements for Access E-Line Service related to the OVC End Point per UNI Service Attributes. The first column lists the OVC End Point per UNI Service Attribute, and the second column specifies the requirements. In the case where reference is made to Table 7 in this document, it is found in Section 8.3 for the General OVC Services.

Table 13: Constrained OVC End Point per UNI Requirements for Access E-Line Service

OVC End Point per UNI Service Attribute	Requirements for Access E-Line Service
UNI OVC Identifier	Requirements per Table 7, this document
OVC End Point Map	Requirements per Table 7, this document. In addition, the following requirements apply. [R31] The Operator MUST support a mapping of one CE-VLAN ID to the OVC End Point. [D21] The Operator SHOULD support a mapping of more than one (but not all) CE-VLAN IDs to the OVC End Point. [R32] The Operator MUST support a mapping of all CE-VLAN IDs to the OVC End Point. Note 1: this set of requirements supports vNID Case A [12]. Note 2: the CE-VLAN ID value for untagged/priority tagged Service Frames is specified in Section 9.9 of MEF 10.3 [5]
Class of Service Identifiers	Requirements per Table 7, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document Note: This attribute is not used. Instead, Ingress BWP per CoS ID is used - a valid CoS ID could be the set of all PCP values mapped to the OVC End Point, which provides equivalent behavior.
Ingress Bandwidth Profile per Class of Service Identifier	Requirements per Table 7 this document.
Egress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document.
Egress Bandwidth Profile per Class of Service Identifier	Requirements per Table 7, this document.
Maintenance End Point (MEP) List	Requirements per Table 7, this document.
Subscriber MEG Maintenance Intermediate Point (MIP)	Requirements per Table 7, this document.

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

No additional constraints from Section 8.4 of this document

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

No additional constraints from Section 8.5 of this document

10.2 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 10 below depicts an example of Access E-LAN Service.

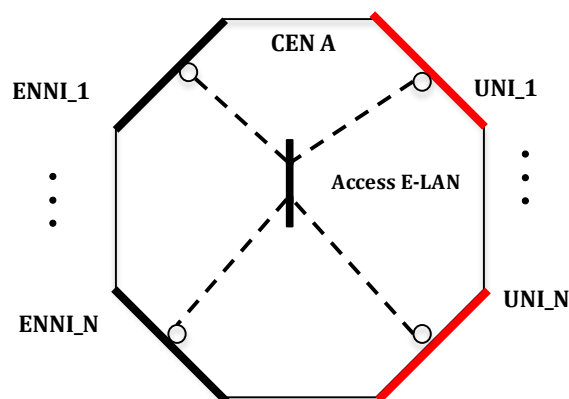


Figure 10: Example of Access E-LAN Service

Two possible applications for Access E-LAN Service are depicted in Figure 11 below, and then briefly described.

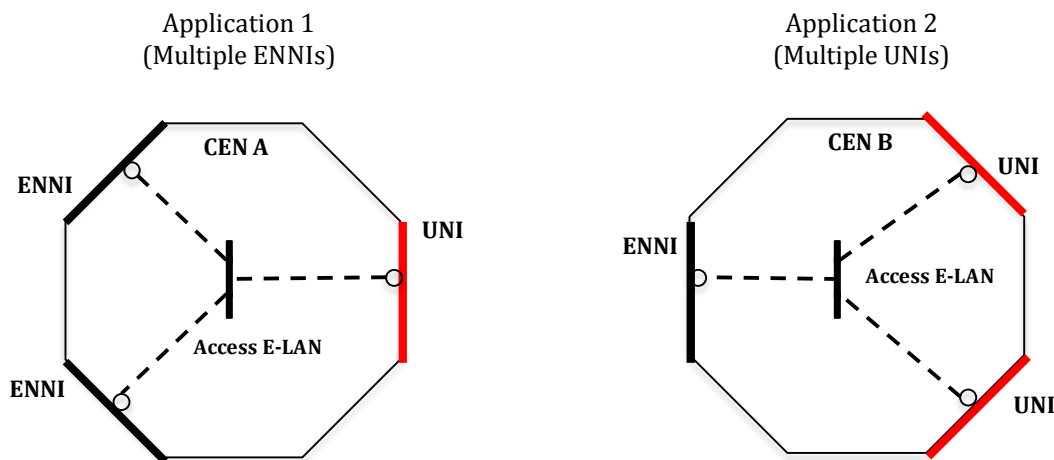


Figure 11: Two Example Applications for Access E-LAN Services

Application 1: Single UNI, Multiple ENNIs

In this application, depicted in CEN_A in Figure 11 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 OVC 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 Service Providers requiring enhanced reliability for services at the UNI.

Application 2: Multiple UNIs, single ENNI

In this application, depicted in CEN_B in Figure 11 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 12, is described below.

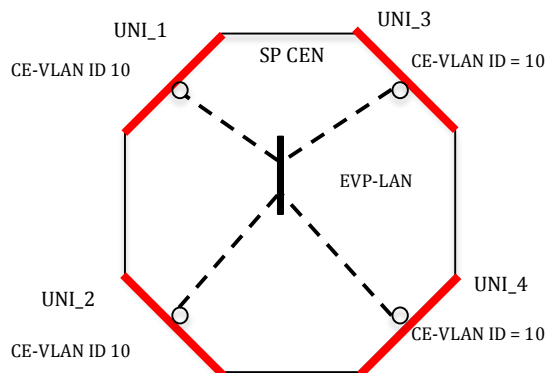


Figure 12: Example of EVP-LAN Service, with CE-VLAN ID preservation = ‘Yes’

In this example, the Subscriber wants a bridged service, with preservation of the CE-VLAN ID (CE-VLAN ID 10 at each of the four UNIs identifies the service). Figure 12 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 in both to support the EVP-LAN Service. This is shown in Figure 13, below.

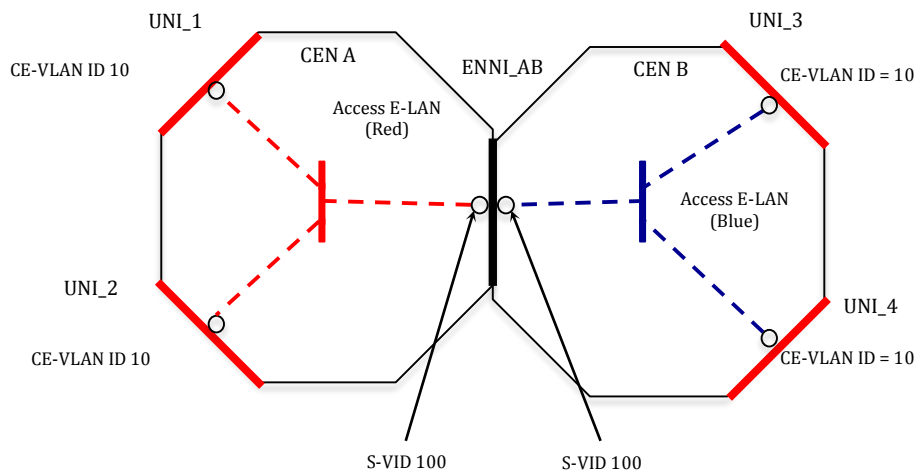


Figure 13: Example of two Access E-LAN Services supporting the EVP-LAN Service

Figure 13 depicts the OVC 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 14 below.

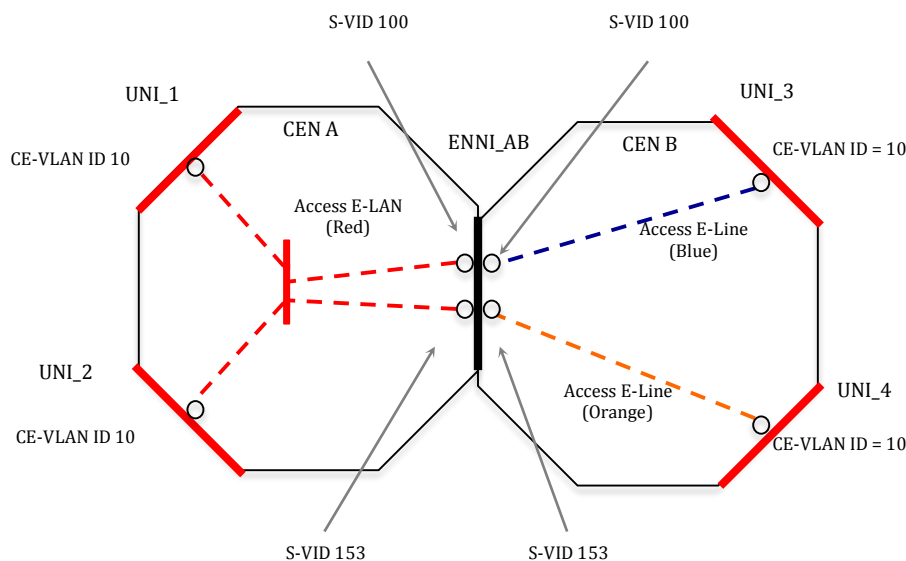


Figure 14: Example of one Access E-LAN Service supporting the EVP-LAN Service

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 (Orange) provides connectivity to UNI_4. The EVC-based bridging service is operationally simplified – there's only one OVC providing the bridging, 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 provide the service definition for Access E-LAN Service, structured by the service attribute types that are applicable to this service.

10.2.1 Access E-LAN Service: OVC Service Attributes & Requirements

Table 14 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 5 in this document, it is found in Section 8.1. Similarly, where reference is made to Table 9 in this document, it is found in Section 9.2.

OVC Service Attribute	Requirements for Access E-LAN Service
OVC ID	Requirements per Table 5, this document
OVC Type	Requirements per Table 9, this document

OVC Service Attribute	Requirements for Access E-LAN Service
OVC End Point List	Requirements per Table 9, this document. In addition, the following requirement applies. [R33] An Access E-LAN Service MUST have at least one OVC End Point at an ENNI and at least one OVC End Point at a UNI.
Maximum Number of UNI OVC End Points	[R34] 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 5, this document
OVC MTU size	Requirements per Table 5, this document
CE-VLAN ID Preservation	Requirements per Table 5, this document
CE-VLAN CoS Preservation	Requirements per Table 5, this document
S-VLAN ID Preservation	Requirements per Table 5, this document
S-VLAN CoS Preservation	Requirements per Table 5, this document
Color Forwarding	Requirements per Table 5, this document
Service Level Specification	Requirements per Table 5, this document
Unicast Frame Delivery	Requirements per Table 9, this document
Multicast Frame Delivery	Requirements per Table 5, this document
Broadcast Frame Delivery	Requirements per Table 9, this document
OVC Available MEG Level	Requirements per Table 5, this document

Table 14: Constrained OVC Requirements for Access E-LAN Service

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

Table 15 below provides the requirements for Access E-LAN Service related to the OVC End Point per ENNI Service Attributes. The first column lists the OVC End Point per ENNI 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 8.2 for the General OVC Services.

OVC End Point per ENNI Service Attribute	Requirements for Access E-LAN Service
OVC End Point Identifier	Requirements per Table 6 this document
Trunk Identifiers	Not Applicable
Class of Service Identifiers	Requirements per Table 6 this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 6 this document
Ingress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6 this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 6 this document

OVC End Point per ENNI Service Attribute	Requirements for Access E-LAN Service
Egress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6 this document
Maintenance End Point (MEP) List	Requirements per Table 6 this document
Maintenance Intermediate Point (MIP)	Requirements per Table 6 this document

Table 15: Constrained OVC End Point per ENNI Requirements for Access E-LAN Service

10.2.3 Access E-LAN Service: OVC End Point per UNI Service Attributes & Requirements

Table 16 below provides the requirements for Access E-LAN Service related to the OVC End Point per UNI Service Attributes. The first column lists the OVC End Point per UNI Service Attribute, and the second column specifies the requirements. In the case where reference is made to Table 7 in this document, it is found in Section 8.3 for the General OVC Services.

OVC End Point per UNI Service Attribute	Requirements for Access E-LAN Service
UNI OVC Identifier	Requirements per Table 7, this document
OVC End Point Map	Requirements per Table 7, this document. In addition, the following requirements apply: [R35] The Operator MUST support a mapping of one CE-VLAN ID to the OVC End Point. [D22] The Operator SHOULD support a mapping of more than one (but not all) CE-VLAN IDs to the OVC End Point. [R36] The Operator MUST support a mapping of all CE-VLAN IDs to the OVC End Point. Note: the CE-VLAN ID value for untagged/priority tagged Service Frames is specified in Section 9.9 of MEF 10.3 [5].
Class of Service Identifiers	Requirements per Table 7, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document
Ingress Bandwidth Profile per Class of Service Identifier	Requirements per Table 7 this document.
Egress Bandwidth Profile per OVC End Point	Requirements per Table 7, this document.
Egress Bandwidth Profile per Class of Service Identifier	Requirements per Table 7, this document.
Maintenance End Point (MEP) List	Requirements per Table 7, this document.
Subscriber MEG Maintenance Intermediate Point (MIP)	Requirements per Table 7, this document.

Table 16: Constrained OVC End Point per UNI Requirements for Access E-LAN Service

10.2.4 Access E-LAN Service: ENNI Service Attributes & Requirements

No additional constraints from Section 8.4 of this document

10.2.5 Access E-LAN Service: UNI Service Attributes & Requirements

No additional constraints from Section 8.5 of this document.

11. E-Transit Services

An E-Transit Service is any OVC Service that associates only ENNIs. This section defines two E-Transit services: Transit E-Line Service and Transit E-LAN Service.

11.1 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 both the CE-VLAN ID and CE-VLAN CoS (PCP) 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 15 below depicts two examples of Transit E-Line Service.

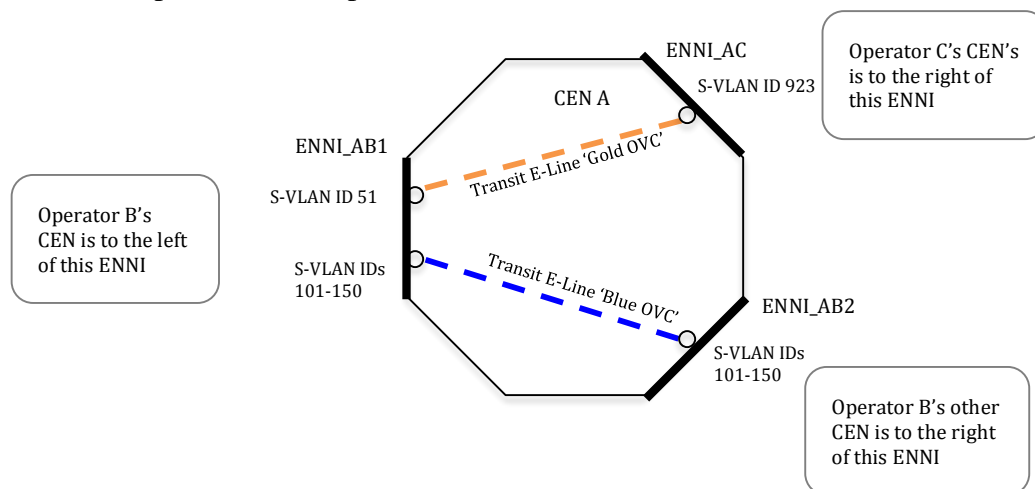


Figure 15: Examples of Transit E-Line Service

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 15), or multiple S-VLAN IDs per OVC End Point at each ENNI (see Blue OVC in Figure 15). 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 15 can have any OVC Service. Some examples where the Transit E-Line Service can be used for providing transit service include:

- Interconnection of CENs through an intermediate CEN, e.g., an Ethernet Exchange type CEN.

- Connecting 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
- As a special case of interconnection, a chain of CENs providing access to a Subscriber’s UNI could take advantage of this service.

The following subsections provide the service definition for Transit E-Line Service, structured by the service attribute types that are applicable to this service.

11.1.1 Transit E-Line Service: OVC Service Attributes & Requirements

Table 17 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 5 in this document, it is found in Section 8.1. Similarly, where reference is made to Table 8 in this document, it is found in Section 9.1.

OVC Service Attribute	Requirements for Transit E-Line Service
OVC ID	Requirements per Table 5, this document
OVC Type	Requirements per Table 8, this document
OVC End Point List	Requirements per Table 8, this document. In addition, the following requirement applies: [R37] For Transit E-Line Service, each OVC End Point MUST be at an ENNI.
Maximum Number of UNI OVC End Points	[R38] For Transit E-Line Service, the maximum number of UNI OVC End Points MUST be zero.
Maximum Number of ENNI OVC End Points	[R39] For Transit E-Line Service, the maximum number of ENNI OVC End Points MUST be two.
OVC MTU size	Requirements per Table 5, this document
CE-VLAN ID Preservation	[R40] For Transit E-Line Service, CE-VLAN ID Preservation MUST be ‘Yes’.
CE-VLAN CoS Preservation	[R41] For Transit E-Line Service, CE-VLAN CoS Preservation MUST be ‘Yes’.
S-VLAN ID Preservation	Requirements per Table 5, this document
S-VLAN CoS Preservation	Requirements per Table 5, this document
Color Forwarding	Requirements per Table 5, this document
Service Level Specification	Requirements per Table 8, this document.
Unicast Frame Delivery	Requirements per Table 8, this document
Multicast Frame Delivery	Requirements per Table 8, this document
Broadcast Frame Delivery	Requirements per Table 8, this document
OVC Available MEG Level	Requirements per Table 5, this document

Table 17: Constrained OVC Requirements for Transit E-Line Service

11.1.2 Transit E-Line Service: OVC End Point per ENNI Attributes & Requirements

Table 18 below provides the requirements for Transit E-Line Service related to the OVC End Point per ENNI Service Attributes. The first column lists the OVC End Point per ENNI 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 8.2 for the General OVC Services.

OVC End Point per ENNI Service Attribute	Requirements for Transit E-Line Service
OVC End Point Identifier	Requirements per Table 6 this document
Trunk Identifiers	Not Applicable
Class of Service Identifiers	Requirements per Table 6 this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 6 this document
Ingress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6 this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 6 this document
Egress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6 this document
Maintenance End Point (MEP) List	Requirements per Table 6 this document
Maintenance Intermediate Point (MIP)	Requirements per Table 6 this document

Table 18: Constrained OVC End Point per ENNI Requirements, Transit E-Line Service

11.1.3 Transit E-Line Service: OVC End Point per UNI Service Attributes & Requirements

Not applicable for this service.

11.1.4 Transit E-Line Service: ENNI Service Attributes & Requirements

No additional constraints from Section 8.4 of this document.

11.1.5 Transit E-Line Service: UNI Service Attributes & Requirements

Not applicable for this service.

11.2 Transit E-LAN Service Definition

The Transit E-LAN Service provides a Multipoint-to-Multipoint OVC connecting OVC End Points at one or more ENNIs. Transit E-LAN Service includes preservation of both the CE-VLAN ID and CE-VLAN CoS (PCP) 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 OVC Services could be confined to one CEN, enabling one Operator to completely control the service, e.g., filtering of ingress frames, conditional forwarding (e.g., rate limit policies for broadcast and multicast frames),

etc. Other CENs could provide access to this CEN with OVC Services based on Point-to-Point OVCs. In this type of service, support for one or more Class of Service Names can be valuable, not just for the Operator, but also for the Subscriber, since it can help to manage and prioritize merging traffic at an egress OVC End Point.

Figure 16 below depicts an example of Transit E-LAN Service.

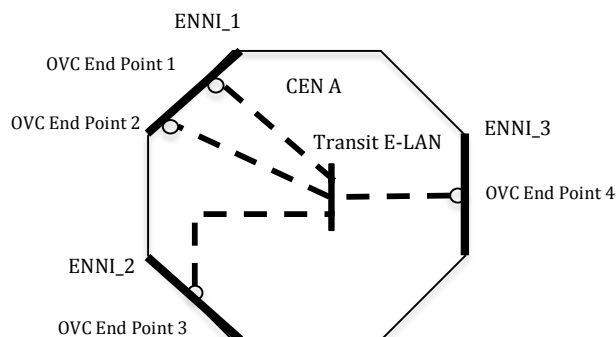


Figure 16: Example of Transit E-LAN Service (Multipoint OVC Transit Service)

In the above example, Transit E-LAN Service provides a multipoint OVC connecting four OVC End Points at three ENNIs. ENNI_1 has two of the OVC End Points, and is providing hairpin 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 16 above. This could be an example of the Service Provider 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 provide the service definition for Transit E-LAN Service, structured by the service attribute types that are applicable to this service.

11.2.1 Transit E-LAN Service: OVC Service Attributes & Requirements

Table 19 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 5 in this document, it is found in Section 8.1. Similarly, where reference is made to Table 9 in this document, it is found in Section 9.2.

OVC Service Attribute	Requirements for Transit E-LAN Service
OVC ID	Requirements per Table 5, this document
OVC Type	Requirements per Table 9, this document
OVC End Point List	Requirements per Table 9, this document. In addition, the following requirement applies: [R42] For Transit E-LAN Service, each of the OVC End Points in the list MUST be at an ENNI.
Maximum Number of UNI OVC End Points	[R43] For Transit E-LAN Service, the maximum number of UNI OVC End Points MUST be 0.

OVC Service Attribute	Requirements for Transit E-LAN Service
Maximum Number of ENNI OVC End Points	[R44] For Transit E-LAN Service, the maximum number of ENNI OVC End Points MUST be \geq three ²² .
OVC MTU size	Requirements per Table 5, this document
CE-VLAN ID Preservation	[R45] For Transit E-LAN Service, CE-VLAN ID Preservation MUST be 'Yes'.
CE-VLAN CoS Preservation	[R46] For Transit E-LAN Service, CE-VLAN CoS Preservation MUST be 'Yes'.
S-VLAN ID Preservation	Requirements per Table 5, this document
S-VLAN CoS Preservation	Requirements per Table 5, this document
Color Forwarding	Requirements per Table 5, this document
Service Level Specification	Requirements per Table 5, this document
Unicast Frame Delivery	Requirements per Table 9, this document
Multicast Frame Delivery	Requirements per Table 9, this document
Broadcast Frame Delivery	Requirements per Table 9, this document
OVC Available MEG Level	Requirements per Table 5, this document

Table 19: Constrained OVC Requirements for Transit E-LAN Service

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

Table 20 below provides the requirements for Transit E-LAN Service related to the OVC End Point per ENNI Service Attributes. 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 8.2.

OVC End Point per ENNI Service Attribute	Requirements for Transit E-LAN Service
OVC End Point Identifier	Requirements per Table 6, this document
Trunk Identifiers	Not Applicable
Class of Service Identifiers	Requirements per Table 6, this document
Ingress Bandwidth Profile per OVC End Point	Requirements per Table 6, this document
Ingress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6, this document
Egress Bandwidth Profile per OVC End Point	Requirements per Table 6, this document
Egress Bandwidth Profile per Class of Service Identifier	Requirements per Table 6, this document
Maintenance End Point (MEP) List	Requirements per Table 6, this document
Maintenance Intermediate Point (MIP)	Requirements per Table 6, this document

²² Since Transit E-LAN only involves ENNIs, the quantity in question is equal to the maximum number of OVC End Points that the OVC can associate. From the definition of Point-to-Point in MEF 26.1 (see section 7.2.6), a value of two means a Point-to-Point OVC; so, maximum number of OVC End Points for a Multipoint-to-Multipoint OVC must be ≥ 3 . A given service instance of a Multipoint-to-Multipoint OVC might have just two OVC End Points at a certain time, but the maximum allowed is three or more.

Table 20: Constrained OVC End Point per ENNI Requirements, Transit E-LAN Service**11.2.3 Transit E-LAN Service: OVC End Point per UNI Service Attributes & Requirements**

Not applicable for this service.

11.2.4 Transit E-LAN Service: ENNI Service Attributes & Requirements

No additional constraints from Section 8.4 of this document.

11.2.5 Transit E-LAN Service: UNI Service Attributes & Requirements

Not applicable for this service.

12. References

- [1] IEEE Std 802.1Q™ – 2014, IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridge Local Area Networks, January 2014
- [2] Internet Engineering Task Force RFC 2119. Key words for use in RFCs to Indicate Requirement Levels, March 1997
- [3] MEF Forum, MEF 4, Metro Ethernet Network Architecture Framework - Part 1: Generic Framework, May 2004
- [4] MEF Forum, MEF 6.2, EVC Ethernet Services Definitions Phase 3, July 2014
- [5] MEF Forum, MEF 10.3, Ethernet Services Attributes Phase 3, October 2013
- [6] MEF Forum, MEF 23.1, Carrier Ethernet Class of Service Phase 2, January 2012
- [7] MEF Forum, MEF 26.1, External Network Network Interface (ENNI), January 2012
- [8] MEF Forum, MEF 28, External Network Network Interface Support for UNI Tunnel Access and Virtual UNI, October 2010
- [9] MEF Forum, MEF 30.1, Service OAM Fault Management Implementation Agreement: Phase 2, April, 2013
- [10] MEF Forum, MEF 33, Ethernet Access Services Definition, January 2012
- [11] MEF Forum, MEF 35.1, Service OAM Performance Monitoring Implementation Agreement, April, 2015
- [12] MEF Forum, MEF 43, Virtual NID Functionality for E-Access Services, April 2014.

Appendix A. Relationship of EVC and OVC Services (Informative)

This appendix is intended to give guidance to Service Providers and Operators who need to buy or sell OVC Services. The case in point is where the EVC Service is composed of multiple OVC Services. We sometimes refer to a ‘chain’ of OVC Services that are concatenated to form an EVC Service. It is the Service Provider’s responsibility to make sure that the OVC Services can support the EVC Service being sold to the Subscriber. Note that the scope of this document is the definition of OVC Services only (EVC Services are not in scope). This section describes how the OVC Services that are defined in this document, can be used to support the EVC Services defined in MEF 6.2.

Special care needs to be taken when configuring an OVC End Point at a UNI - the configuration parameters for an OVC End Point at a UNI may not be the same as for the EVC at the UNI that the OVC is supporting. Furthermore, an NMS/OSS that configures the EVC Service for the Service Provider may not be the same as the NMS/OSS that configures the OVC service (the Service Provider is likely a different organization than the Operator responsible for the OVC service). It should be noted that NMS/OSS is not in scope of OVC Services.

The following relationships are considered in this Appendix:

- Relationship of EVC Service Attributes and OVC Service Attributes
- Relationship of EVC per UNI Service Attributes and OVC End Point per UNI Service Attributes

These are shown in an example in Figure 17, below.

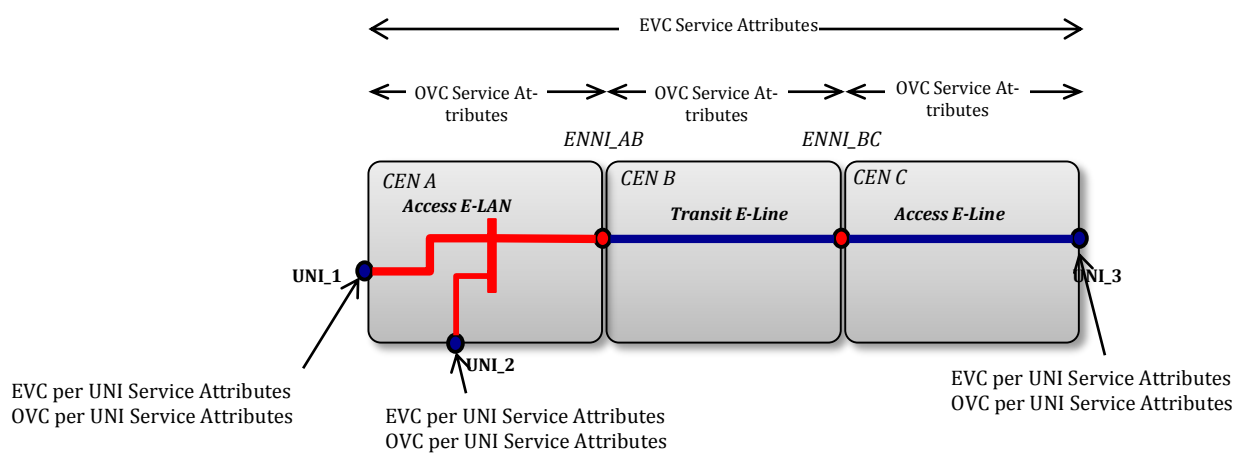


Figure 17: Relationship of EVC and OVC Attributes under consideration

The key assumptions that guide the content of this appendix are:

- MEF 26.1 is the foundation that provides the service attribute definitions that OVC Services are built on. In addition, this document fills the gap with certain specific service attribute definitions
- Only those service attributes that are related are considered, for example
 - OVC End Point per UNI is addressed; OVC End Point per ENNI is not
 - There's a relationship between some of the EVC and OVC Service Attributes, but not all – e.g., the type of xVC is addressed, the EVC ID and OVC ID are not addressed
- UNI Service Attributes are addressed in Section 8.5.
- For OVC End Point per UNI Service Attributes, generally MEF 6.2 EVC per UNI attributes are compared, unless otherwise noted
- If an attribute value is not supported in either MEF 6.2 or this document, it is not addressed, for example
 - Ingress or Egress Bandwidth Profiles based on multiple Bandwidth Profile Flows per envelope are addressed in MEF 6.2, but not in this document, so they are not addressed in this appendix
 - Ingress Bandwidth Profile per EVC and Ingress Bandwidth Profile per OVC are not allowed in either specification
 - Source MAC Address Limit is addressed in MEF 6.2, but not in this document, so it is not considered

First, we'll consider the relationship of EVC Service Attributes with OVC Service Attributes. In Table 21 below, the first column lists the EVC Service Attribute²³ and the second column lists the related OVC Service Attribute. The third column lists the EVC Service Attribute value – each of the possible attribute values are considered separately. The fourth column provides guidance as to the appropriate OVC Service Attribute value.

EVC Service Attribute	Related OVC Service Attribute	EVC Service Attribute Value	Guidance as to OVC Service Attribute Value
EVC Type	OVC Type	Point-to-Point	It is sufficient to support Point-to-Point EVC by using Point-to-Point OVCs.
		Multipoint-to-Multipoint	It is sufficient to support a Multipoint-to-Multipoint EVC by using at least one Multipoint-to-Multipoint OVC(s). Other OVCs in the chain can be either Point-to-Point or Multipoint-to-Multipoint.
		Rooted-Multipoint	It is sufficient to support a Rooted-Multipoint EVC by using one (or more) Rooted-Multipoint OVC(s). Other OVCs in the chain can be either Point-to-Point, Rooted-Multipoint or Multipoint-to-Multipoint (in certain corner cases).
EVC Maximum Service Frame Size	OVC MTU Size	X (bytes)	It is sufficient to use X+8 or greater for each OVC in the chain. X+8 covers the case where a C-Tag is added to an untagged service frame (somewhere in the CEN) and then forwarded across the ENNI with an added S-Tag, resulting in an additional 8 bytes.
CE-VLAN ID Preservation	CE-VLAN ID Preservation	Enabled	It is sufficient that each of the OVC Services in the chain used to implement the EVC Service have OVC CE-VLAN ID Preservation = 'Yes'. (Note: See the text following Table 8 in MEF 26.1)
		Disabled	By R25 of MEF 10.3, this can only happen with an EVC that has a single CE-VLAN ID mapping to it at the UNIs associated by the EVC. If the EVC Service Attribute CE-VLAN ID Preservation is 'No', then usually there will be one or more UNIs where the CE-VLAN ID mapped to the EVC differs from the CE-VLAN ID being mapped to the EVC at other UNIs. In such a case, the Service Provider needs to ensure that appropriate CE-VLAN ID transformations are performed, and one consequence is that at least one OVC used to implement the EVC will need to have the CE-VLAN ID Preservation service attribute set to 'No'.
CE-VLAN CoS Preservation	CE-VLAN CoS Preservation	Enabled	It is sufficient that all OVCs used to implement the EVC have OVC CE-VLAN CoS Preservation = 'Yes'.
		Disabled	Having at least one OVC with OVC CE-VLAN CoS Preservation = 'No' among the OVCs used to implement such an EVC allows the CE-VLAN CoS of an egress Service Frame

²³ This table presents a subset of EVC Service Attributes used in the MEF 6.2 [4] EVC Service definitions. The EVC Service Attributes not included in this table are intentionally omitted either because there is no equivalent OVC service attribute, or if there is, there is no influence on the value of the related OVC service attribute.

EVC Service Attribute	Related OVC Service Attribute	EVC Service Attribute Value	Guidance as to OVC Service Attribute Value
			to be different than the CE-VLAN CoS of the corresponding ingress Service Frame.
EVC Performance	Service Level Specification (SLS)	Objective for a given metric	It is sufficient for the OVC SLS for each OVC in the chain to include an objective for each metric required in the EVC SLS, and that the objectives for each OVC be stringent enough so that the EVC objective can be met.
		CoS Name	The OVC SLS can be based on any CoS Name (including any CoS Label). The CoS Name for the OVC may be unrelated to the CoS Name(s) for the EVC.
		Note: The Service Provider needs to carefully discuss with the Operator the metrics and objectives for each CoS Name for a given OVC service to ensure it supports the EVC performance objectives.	
Unicast Service Frame Delivery	Unicast Frame Delivery	Unconditional	It is sufficient that each OVC in the chain have 'Unconditional' Unicast Frame Delivery.
		Conditional	It is sufficient if each OVC in the chain implements the set of conditions agreed to by the Service Provider and the Operator for each of the OVCs, and that no OVC imposes any other conditions. Note that each OVC in the chain may have a different set of agreed conditions. It is up to the Service Provider to ensure that the chain of OVCs supporting the EVC provides the required conditional delivery for the EVC Service.
Multicast Service Frame Delivery	Multicast Frame Delivery	Unconditional	It is sufficient that each OVC in the chain have 'Unconditional' Multicast Frame Delivery.
		Conditional	It is sufficient if each OVC in the chain implements the set of conditions agreed to by the Service Provider and the Operator for each of the OVCs, and that no OVC imposes any other conditions. Note that each OVC in the chain may have a different set of agreed conditions. It is up to the Service Provider to ensure that the chain of OVCs supporting the EVC provides the required conditional delivery for the EVC Service.
Broadcast Service Frame Delivery	Broadcast Frame Delivery	Unconditional	It is sufficient that each OVC in the chain have 'Unconditional' Broadcast Frame Delivery
		Conditional	It is sufficient if each OVC in the chain implements the set of conditions agreed to by the Service Provider and the Operator for each of the OVCs, and that no OVC imposes any other conditions. Note that each OVC in the chain may have a different set of agreed conditions. It is up to the Service Provider to ensure that the chain of OVCs supporting the EVC provides the required conditional delivery for the EVC Service.

Table 21: Relationship of EVC Service Attributes and OVC Service Attributes

Next, the relationship of EVC per UNI Service Attributes with OVC End Point per UNI Service Attributes is considered. In Table 22 below, the first column lists the EVC per UNI Service Attribute²⁴ and the second column lists the related OVC End Point per UNI Service Attribute. The third column lists the EVC per UNI Service Attribute value – each of the possible attribute values are considered separately. The fourth column provides guidance as to the appropriate OVC End Point per UNI Service Attribute value.

EVC per UNI Service Attribute	Related OVC End Point per UNI Service Attribute	EVC per UNI Service Attribute Value	Guidance as to OVC Service Attribute Value
CE-VLAN ID / EVC Map ²⁵	OVC End Point Map at the UNI	Map a set ²⁶ of CE-VLAN IDs to the EVC	<p>At a given UNI, the map for an OVC End Point may not have a 1:1 relationship with the map for an EVC that is carried by the OVC. This is because an OVC End Point could map more than one CE-VLAN ID, each of which could identify a separate EVC.</p> <p>If an EVC is carried over an OVC, then the CE-VLAN IDs that map to that EVC in the CE-VLAN ID/EVC Map are also mapped to the OVC End Point in the OVC End Point Map.</p> <p>Note: the CE-VLAN ID value for untagged/priority tagged Service Frames is specified in Section 9.9 of MEF 10.3 [5].</p>
Class of Service ID for Service Frames ²⁷	Class of Service Identifiers	EVC	It is sufficient if the CoS ID for each OVC End Point at the UNIs for each of the Access Services involved have a value of ‘OVC End Point’.
		EVC + PCP	It is sufficient if all of the PCP values used to map to a given CoS Name for an EVC at the UNI are mapped to a CoS Name for the OVC End Point at that UNI; and that all of the PCP values not mapped to ‘Discard’ for the EVC also not map to ‘Discard’ for the OVC End Point.
		EVC + DSCP	<p>It is sufficient if all of the DSCP values used to map to a given CoS Name for an EVC at the UNI are mapped to a CoS Name for the OVC End Point at that UNI; and that all of the DSCP values not mapped to ‘Discard’ for the EVC also not map to ‘Discard’ for the OVC End Point.</p> <p>Note: See Section 8.4 of MEF 35.1 [11] for discussion of possible impact of using CoS ID of EVC+DSCP on SOAM-PM, depending on technology used in the CEN.</p>
		Note: In general, there is no required (or recommended) relationship between CoS ID for EVC and CoS ID for OVC End Point. The Service Provider selects	

²⁴ This table presents a subset of EVC per UNI Service Attributes used in the MEF 6.2 [4] EVC Service definitions. The EVC per UNI Service Attributes not included in this table are intentionally omitted either because there is no equivalent OVC End Point per UNI service attribute, or if there is, there is no influence on the value of the related OVC End Point per UNI service attribute.

²⁵ As defined in MEF 10.3, this is a UNI service attribute. For the purpose of this analysis and recommendation, we are considering just the entry in that map for a single EVC.

²⁶ The set of CE-VLAN IDs could be one value, or several, or all.

²⁷ The CoS ID in this document applies to all Service Frames mapped to the OVC End Point. We don’t distinguish between Data, L2CP and SOAM SFs, as is done in MEF 10.3/MEF 6.2.

EVC per UNI Service Attribute	Related OVC End Point per UNI Service Attribute	EVC per UNI Service Attribute Value	Guidance as to OVC Service Attribute Value
		<p>one or more CoS Names for the OVC End Point at a UNI to support one or more CoS Names for the EVC at the UNI, to achieve the end-to-end performance of the CoS Name in the EVC.</p> <p>The OVC can have a different set of CoS Names than the EVC has. For example, a CoS ID of OVC End Point could be used for the Access Service, while a more granular CoS ID, e.g., based on PCP values, could be implemented in another CEN for the EVC(s).</p>	
Ingress Bandwidth Profile per Class of Service ID	Ingress Bandwidth Profile per Class of Service ID		<p>Since the CoS IDs may be different, the Ingress Bandwidth Profile parameter values may be different.</p> <p>For example, an EVC with 3 CoS Names may use an OVC End Point with a single CoS Name at the UNI: then the CIR, EIR, CBS, and EBS values for the OVC Service may be different from the values used for the EVC. Consider two alternative practical scenarios:</p> <ul style="list-style-type: none"> Alternative 1: We assume that a VUNI-like function (see MEF 28 [8]) is used in another CEN, and that the E-Access Service uses a single CoS Name with sufficient performance objectives to carry all of the EVC CoS Names; and that the CIR value for the Ingress Bandwidth Profile for the OVC CoS Name would be at least as large as the aggregate CIR value for the Ingress Bandwidth Profiles for the EVC. In this scenario, we also assume that CE-VLAN CoS Preservation = 'Yes', and that the other CEN with the VUNI-like function is performing more granular rate enforcement. Alternative 2: We assume that there is no VUNI-like function in another CEN, and that the Ingress Bandwidth Profile for each EVC CoS Name is done at the OVC End Point at the UNI. The Ingress Bandwidth Profile for each of the EVC CoS Names would map to the same OVC CoS Name. <p>Where an OVC supports a single EVC, and when there is a 1:1 correspondence between EVC CoS Names and OVC CoS Names, and the same CoS IDs are used for the EVC and OVC End Point at the UNI, then it is sufficient that the {CIR, CBS, EIR, EBS} Ingress Bandwidth Profile parameter values for each CoS Name associated with the OVC End Point at the UNI should be the same or higher than the corresponding values for the EVC at that UNI.</p> <p>Other cases are for further study.</p>
Subscriber MEG MIP	Subscriber MEG MIP	Enabled	<p>For the case where a single OVC End Point at the UNI supports a single EVC, it is sufficient if the OVC End Point at that UNI supports a Subscriber MEG MIP at the same MEG Level needed for the EVC Service.</p> <p>The case where the OVC End Point maps to more than one EVC is beyond the scope of this document.</p>
		Disabled	Disabled

Table 22: Relationship of EVC per UNI and OVC End Point per UNI Service Attributes

Appendix B. Practical Examples of Ethernet Services (Informative)

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

B.1 EVPL Service Using Access and Transit OVC Services

The Subscriber 'Omega 3' needs to connect two remote sites to its headquarters site, and asks Service Provider 'Alpha' to offer a solution using a typical hub and spoke model, based on EVPL services. Figure 18 below depicts the EVC connectivity agreed to by 'Omega 3' and 'Alpha'.

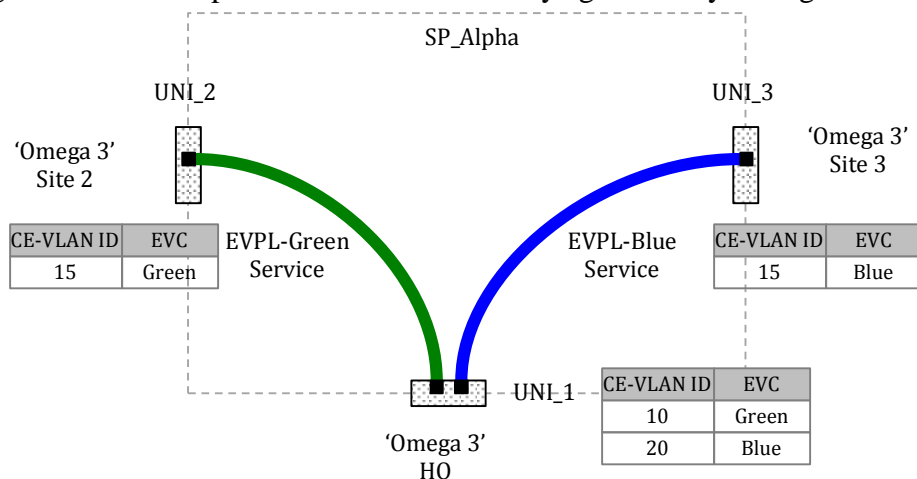


Figure 18: Example of two EVPL Services

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 Green EVC maps to CE-VLAN ID 10 at UNI_1 and to CE-VLAN ID 15 at UNI_2. The Blue EVC maps to CE-VLAN ID 20 at UNI_1 and to CE-VLAN ID 15 at UNI_3. Note that in this example, the customer equipment configuration at Sites 2 and 3 are simplified since the same CE-VLAN ID is used at each.

Service Provider 'Alpha' buys six OVC Services from four different Operators. This set of OVC Services is shown in Figure 19, below.

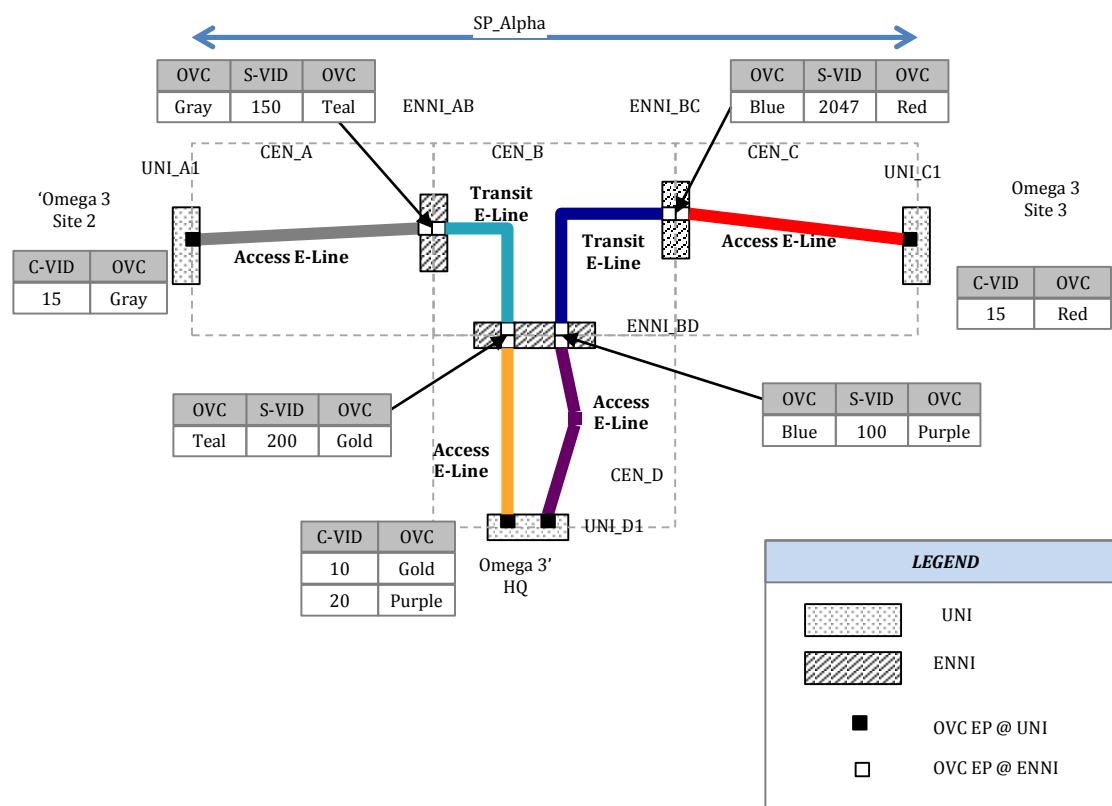


Figure 19: Example of two EVPL Services using Access and Transit OVC Services

In this scenario, Service Provider 'Alpha' uses three OVC Services to create connectivity for the Green EVC shown in Figure 18; and three different OVC Services to create connectivity for the Blue EVC shown also in Figure 18. The OVC 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

By Service Provider 'Alpha' negotiating the OVC End Point maps for each OVC appropriately at each of the ENNIs and/or UNIs involved, as seen in Figure 19, Subscriber 'Omega 3' gets the EVPL services he needs. It is important to note that the Service Provider 'Alpha' can provide the EVPL services needed by the Subscriber 'Omega 3' just by buying components from different CEN Operators.

B.2 EP-LAN Service Using Access and Transit OVC Services

In this use case, the Subscriber 'Omega 3' needs to connect two remote sites and its headquarters site with any-to-any connectivity, and asks Service Provider 'Alpha' to offer a solution using a transparent E-LAN type service. Service Provider 'Alpha' offers an EP-LAN service.

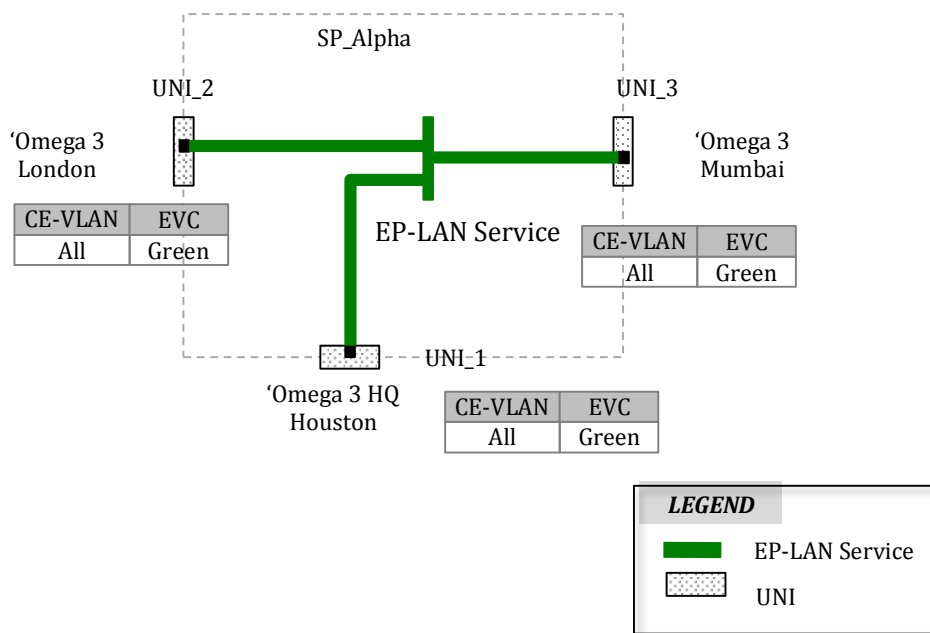


Figure 20: Example of EP-LAN Service

In this example, a single Green EVC connects the three UNIs at sites 1, 2 and 3. All to One Bundling is enabled at each of the UNIs, providing CE-VLAN ID and CE-VLAN CoS preservation.

For this service, Service Provider '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 OVC 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 CENs A, C and D

Alternative 1 is shown in Figure 21 below.

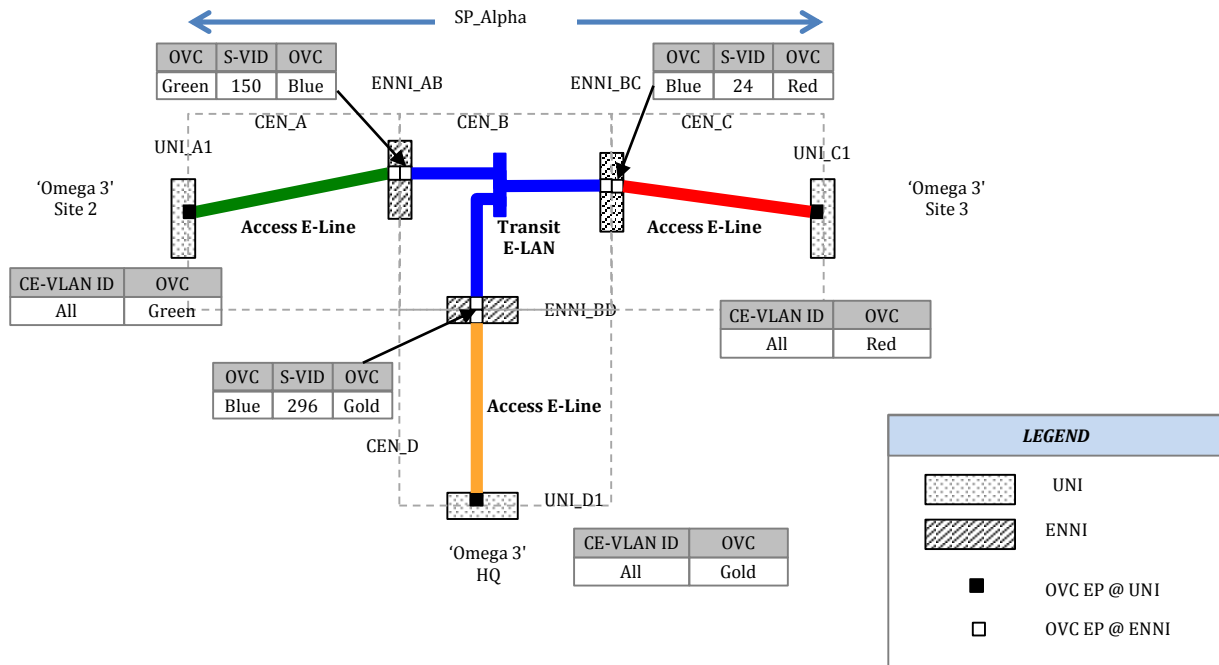


Figure 21: Example of EP-LAN Service using a Transit E-LAN Service

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, CE-VLAN ID Preservation = 'Yes' and CE-VLAN CoS Preservation = 'Yes'. The Transit E-LAN service in CEN-B provides the bridging capability among the three OVC End Points, with CE-VLAN ID Preservation = 'Yes' and CE-VLAN CoS Preservation = 'Yes'. Thus, the combination of these four OVCs supports the end-to-end EP-LAN Service.

For Alternative 2, five OVC 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 22 below.

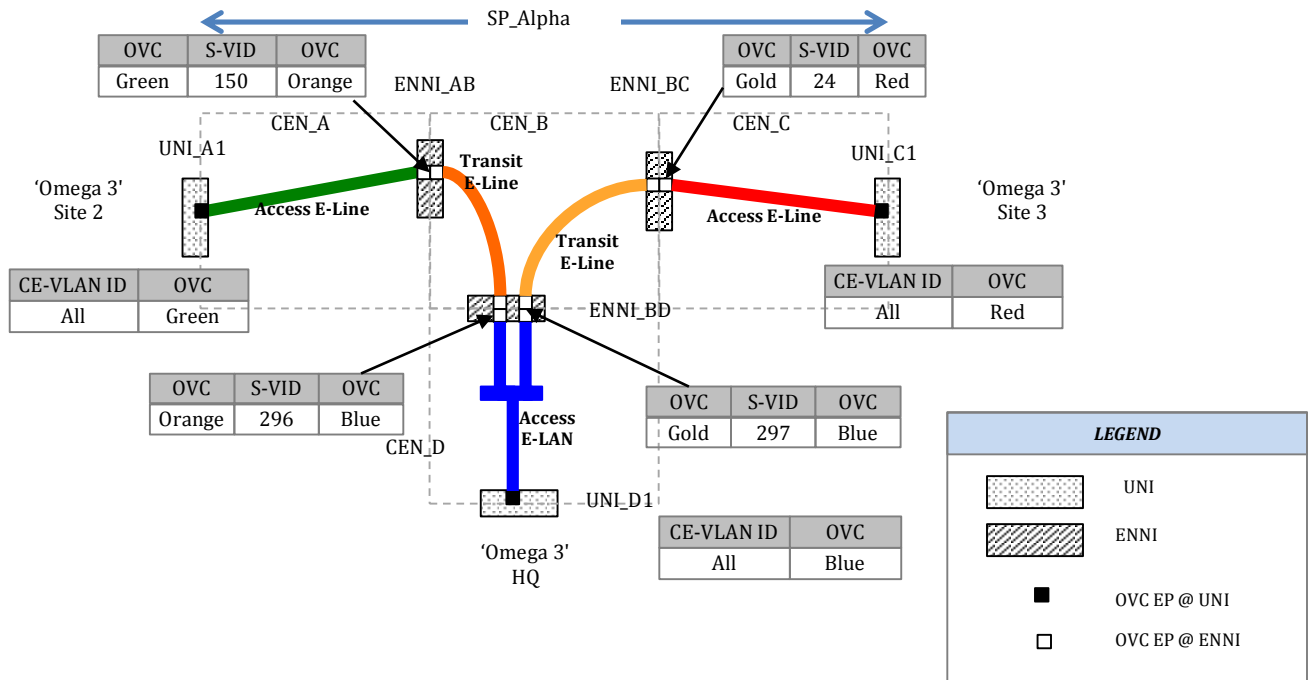


Figure 22: Example of EP-LAN Service using an Access E-LAN Service

In Alternative 2, CENs A and C provide Access E-Line Services from the UNIs to the ENNIs to CEN_B, as shown above. CEN_B can be thought of as an exchange Operator providing point-to-point connectivity from CENs A and C 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 Gold 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 C. Comparing Access Service Attributes (Informative)

This appendix compares service attribute values specified for Access E-Line Service with those specified for Access EPL Service and Access EVPL Service, as defined in MEF 33 [10]. This is organized around the three major areas of service attributes - OVC, OVC End Point per ENNI and OVC End Point per UNI.

OVC Service Attributes

Table 23 below describes the set of OVC Service Attributes and the values specified for each of the services. The first column lists the OVC Service Attributes, and the second column provides a list of the OVC Service Attribute values specified in this document for Access E-Line Service. If more than one attribute value is allowed, the allowed attribute values are shown within curly brackets separated by a comma, e.g., {X, Y}. A bolded attribute value indicates that this value is the recommended value, e.g., when values 'X' and 'Y' are both allowed, but 'Y' is recommended, then the following notation is used {X, **Y**}. The third and fourth columns provide a the list of the OVC Service Attribute values specified in MEF 33 [10] for Access EPL and Access EVPL services. An X in those columns indicate that the attribute value(s) is the same as for Access E-Line.

OVC Service Attribute	Access E-Line Attribute Values	MEF 33 Attribute Values	
		Access EPL	Access EVPL
OVC ID	Character string	X	X
OVC Type	Point-to-Point	X	X
OVC End Point List	Need to specify	X	X
Maximum Number of UNI OVC End Points	1	X	X
Maximum Number of ENNI OVC End Points	1	X	X
OVC MTU size	Number of Bytes	X	X
CE-VLAN ID Preservation	{Yes, No}	Yes	Yes
CE-VLAN CoS Preservation	{Yes, No}	Yes	Yes
S-VLAN ID Preservation	Not Applicable	-	-
S-VLAN CoS Preservation	Not Applicable	-	-
Color Forwarding	{Yes, No}	X	X
Service Level Specification	Any of the metrics may be specified. The Operator should support <i>FLR</i> and following Delay metrics <i>{FD, FDR, MFD, IFDV}</i> .	Any of the metrics may be specified.	Any of the metrics may be specified.
Unicast Frame Delivery	Unconditional	X	X
Multicast Frame Delivery	Unconditional	X	X
Broadcast Frame Delivery	Unconditional	X	X
OVC Available MEG Level	MEG Levels {2,3,4,5,6}	Not specified	Not specified

Table 23: A Comparison of Access Services: OVC Attributes

OVC End Point per ENNI Service Attributes

Table 24 below describes the set of OVC End Point per ENNI Service Attributes and the values specified for each of the services. The first column lists the OVC End Point per ENNI Service Attributes, and the second column provides a list of the OVC End Point per ENNI Service Attribute values specified in this document for Access E-Line Service. If more than one attribute value is allowed, the allowed attribute values are shown within curly brackets separated by a comma, e.g., {X, Y}. A bolded attribute value indicates that this value is the recommended value, e.g., when values 'X' and 'Y' are both allowed, but 'Y' is recommended, then the following notation is used {X, **Y**}. The third and fourth columns provide a the list of the OVC End Point per ENNI Service Attribute values specified in MEF 33 [10] for Access EPL and Access EVPL services. An X in those columns indicate that the attribute value(s) is the same as for Access E-Line.

OVC End Point per ENNI Service Attribute	Description of Options	Access E-Line configuration for	
		Access EPL	Access EVPL
OVC End Point Identifier	Character string	X	X
Trunk Identifiers	Not applicable	X	X
Class of Service Identifiers	OVC End Point plus non-overlapping set of S-Tag PCP values per CoS Name	1 CoS Name S-Tag PCP values (0-7)	1 CoS Name S-Tag PCP values (0-7)
Ingress Bandwidth Profile per OVC End Point	<i>No</i>	Required Need to negotiate upper CIR limit and all other parameter values	Required Need to negotiate upper CIR limit and all other parameter values
Ingress Bandwidth Profile per Class of Service Identifier	<i>Parameters</i>	Access E-Line provides equivalent CIR values as specified in MEF 33. Need to negotiate upper CIR limit and all other parameter values	Access E-Line provides equivalent CIR values as specified in MEF 33. Need to negotiate upper CIR limit and all other parameter values
Egress Bandwidth Profile per OVC End Point	<i>No</i>	X	X
Egress Bandwidth Profile per Class of Service Identifier	{ <i>Parameters, No</i> }	'No'	'No'
Maintenance End Point (MEP) List	Down MEP in the SP MEG is recommended	Not addressed	Not addressed
Maintenance Intermediate Point (MIP)	MIP recommended at configurable MEG level	Not addressed	Not addressed

Table 24: A Comparison of Access Services: OVC End Point per ENNI Attributes

OVC End Point per UNI Service Attributes

Table 25 below describes the set of OVC End Point per UNI Service Attributes and the values specified for each of the services. The first column lists the OVC End Point per UNI Service Attributes, and the second column provides a list of the OVC End Point per UNI Service Attribute values specified in this document for Access E-Line Service. If more than one attribute value is allowed, the allowed attribute values are shown within curly brackets separated by a comma, e.g., {X, Y}. A bolded attribute value indicates that this value is the recommended value, e.g., when values 'X' and 'Y' are both allowed, but 'Y' is recommended, then the following notation is used {X, **Y**}. The third and fourth columns provide a the list of the OVC End Point per UNI Service Attribute values specified in MEF 33 [10] for Access EPL and Access EVPL services. An X in those columns indicate that the attribute value(s) is the same as for Access E-Line.

OVC End Point per UNI Service Attribute	Description of Options	Access E-Line configuration for	
		Access EPL	Access EVPL
UNI OVC Identifier	Character string	X	X
OVC End Point Map	Number of CE-VLAN IDs that can map to OVC End Point {1, >1, All}	All	{1, >1}
Class of Service Identifiers	{OVC End Point, OVC End Point + PCP, OVC End Point + DSCP} per CoS Name	OVC End Point	OVC End Point
Ingress Bandwidth Profile per OVC End Point	Not allowed	Required	Required
Ingress Bandwidth Profile per Class of Service Identifier	Mandated; CIR values same as MEF 33; other parameter values not constrained	Access E-Line provides equivalent CIR values as specified in MEF 33. Need to negotiate upper CIR limit and all other parameter values	Access E-Line provides equivalent CIR values as specified in MEF 33. Need to negotiate upper CIR limit and all other parameter values
Egress Bandwidth Profile per OVC End Point	Not allowed	X	X
Egress Bandwidth Profile per Class of Service Identifier	{Yes, No}	'No'	'No'
Maintenance End Point (MEP) List	Two Up MEPs recommended (e.g., EVC and SP MEGs); configurable MEG levels {from OVC Available MEG Level through MEG Level 6}	Not addressed	Not addressed
Subscriber MEG Maintenance Intermediate Point (MIP)	MIP recommended at configurable MEG levels {5, 6, 7}	Not addressed	Not addressed

Table 25: A Comparison of Access Services: OVC End Point per UNI Attributes

Appendix D. SOAM Super Operator Use Case (Informative)

The typical SOAM [9] architectural requirements and recommendations support EVC Services spanning multiple Carrier Ethernet Networks, where each Operator of a CEN can monitor its OVC in the chain, typically using the Operator MEG. This leaves the EVC MEG for the Service Provider to use, UNI to UNI. Provision is also made to use one or more intermediate MEGs (e.g., one or more SP MEGs) for special cases. A SOAM Super Operator is one such special case.

The term 'SOAM Super Operator' is used to describe an Operator who is responsible for managing more than a single OVC. In some cases, there could be nested SOAM Super Operators, e.g., one responsible for managing/monitoring OVCs concatenated across two CENs and another responsible for managing/monitoring OVCs concatenated across three CENs. The OVC Available MEG Level Service Attribute, while strictly a per OVC service attribute, can be applied to a concatenated set of OVCs, as discussed in this section. An example of a Use Case involving two SOAM Super Operators is depicted in Figure 23 below.

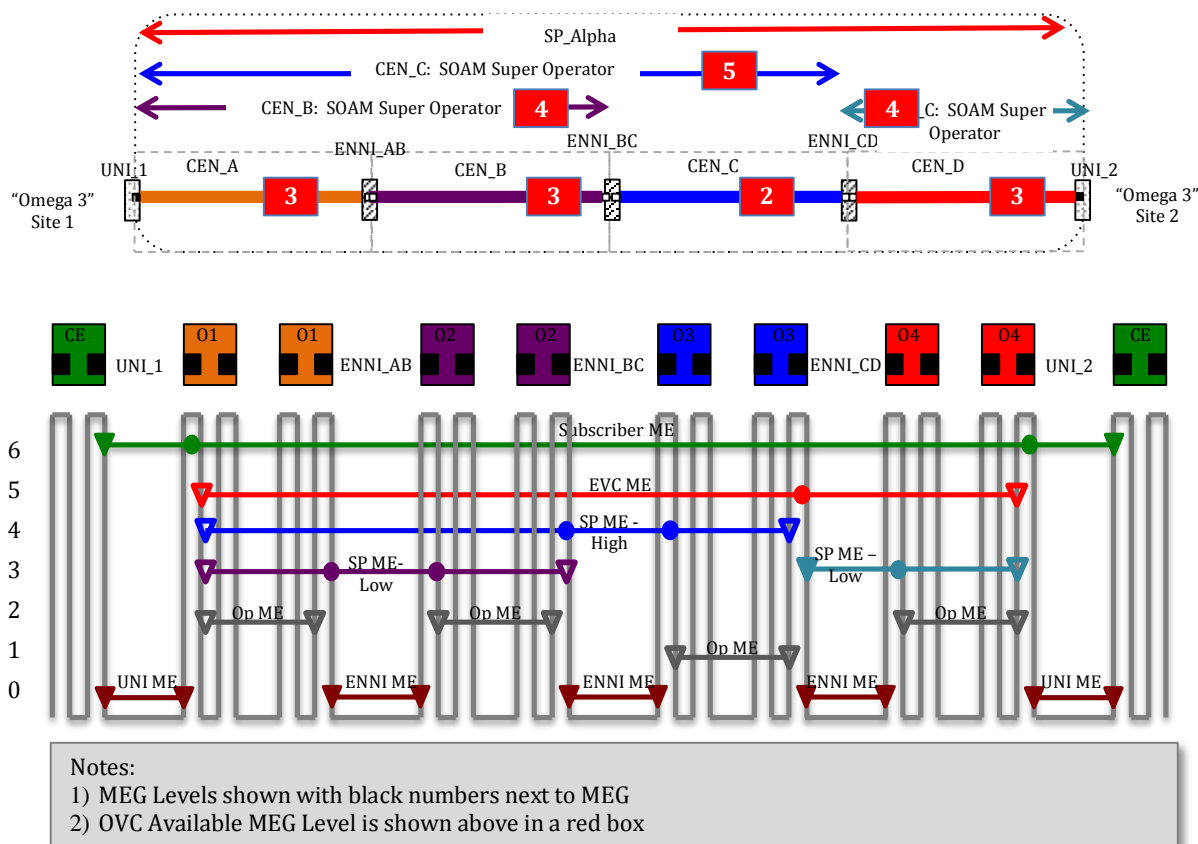


Figure 23: Use Case for two SOAM Super Operators

In this example, four Operators are involved in the UNI to UNI service.

- Operator C is a SOAM Super Operator responsible to the Service Provider for managing/monitoring the service in both directions from CEN_C, all the way to the UNIs. Operator C also provides an E-Transit service interconnecting ENNI_BC and ENNI_CD. The OVC Available MEG Level for this OVC is 2, since the Operator MEG chosen to be used inside CEN C is at MEG Level 1²⁸.
- Operator B is also a SOAM Super Operator (of lesser scope) responsible to SOAM Super Operator C for managing/monitoring the service across CENs A and B, to UNI_1. Operator B also provides an E-Transit service interconnecting ENNI_AB and ENNI_BC. The OVC Available MEG Level for this OVC is 3 since the Operator MEG chosen to be used inside CEN B is at MEG Level 2.

²⁸ Note that this arrangement prevents Operator C from using a combination of LAG MEG and LAG Link MEG for a LAG inside the CEN.

- Operator A is responsible for providing an E-Access service to connect UNI_1 with ENNI_AB, and uses an Operator MEG to manage/monitor the OVC. The OVC Available MEG Level for this OVC is 3 since the Operator MEG chosen to be used inside CEN A is at MEG Level 2.
- Operator D is responsible for providing an E-Access service to connect UNI_2 with ENNI_CD, and uses an Operator MEG to manage/monitor the OVC. The OVC Available MEG Level for this OVC is 3 since the Operator MEG chosen to be used inside CEN D is at MEG Level 2.

Other than the UNI or ENNI MEGs, which are not OVC service related, the MEGs considered in the use case illustrated in Figure 23 are:

- Operator MEG: The Operator MEG is shown in gray in each CEN in Figure 23 above, and is used by each Operator for managing/monitoring the OVC 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.
- SP MEG-Low: There are two MEGs using SP MEG-Low in this example, and they are both at MEG Level 3, the lowest MEG Level allowed by the OVC Available MEG Level of the underlying Operators. In the first case, CEN_B SOAM Super Operator uses an SP MEG-Low for managing the smaller chain of OVCs to the left (see the Gold and Purple OVCs in the above figure). An Up MEP for this SP MEG is used for the OVC End Point at UNI_1, and also for the OVC End Point at ENNI_BC. SOAM Super Operator B uses a MIP at the OVC End Points on either side of ENNI_AB. In the second case, the Turquoise SP MEG to the right (see Red OVC in the above figure) is used for managing the Red OVC across ENNI_CD²⁹. In this case, CEN_C SOAM Super Operator uses an SP MEG-Low for managing the OVC service in CEN D and the connection across ENNI_CD. The CEN_C Super Operator uses a Down MEP in CEN_C at ENNI_CD and an Up MEP for the OVC End Point at UNI_2 provided by Operator D. A MIP is used in CEN_D at ENNI_CD to facilitate troubleshooting by the CEN_C SOAM Super Operator.
- SP MEG-High: The SP MEG-High is at level 4, the lowest MEG level allowed by the underlying SOAM Super Operators and is limited by the Available MEG Level of underlying SOAM Super Operator B. In the above figure, SOAM Super Operator C uses the Blue SP MEG-High for managing the chain of OVCs to the left (e.g., see the Gold, Purple and Blue OVCs in). An Up MEP is used for the OVC End Point at UNI_1 and another Up MEP is used for the OVC End Point at ENNI_CD. SOAM Super Operator C uses a MIP at the OVC End Points on either side of ENNI_BC to facilitate troubleshooting.
- EVC MEG: The EVC MEG is at level 5, the lowest MEG level allowed by the Available MEG Levels of the underlying SOAM Super Operators. The Service Provider uses an Up MEP on the OVC End Point at each UNI for managing/monitoring the EVC. In this example, the Service Provider uses a MIP on the EVC MEG for the OVC End Point at ENNI_CD to facilitate troubleshooting.

²⁹ The Red OVC shown in Figure 23 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 Red OVC.

- **Subscriber MEG:** The Subscriber MEG is at level 6, the lowest MEG level allowed by the Service Provider due to the Available MEG Level for the EVC ME (MEG Level 5). The OVC End Point at the UNI has a Subscriber MEG MIP instantiated, enabling troubleshooting by the Subscriber.

Note that for this service shown above, the OVC End Point at UNI_1 has four MEPs (an extreme example), each at different MEG levels, and one MIP. Also, in this service, OVC End Points at ENNI have from one or three MEPs, and one MIP. An important aspect to note is the back-to-back SP MEPs at ENNI CD in CEN C: the Up MEP is used for managing the chain of three OVCs (Blue, Purple and Gold) going left, and the Down MEP is used for managing the Red OVC to the right plus the connection across ENNI CD. So, even though the MEPs are at the same ENNI and are both SP MEs for the same end-to-end service, they are each associated with different OVCs.