



## **Technical Specification**

### **MEF 28**

# **External Network Network Interface (ENNI) Support for UNI Tunnel Access and Virtual UNI**

**October 2010**

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## 1 Abstract

The External Network Network Interface (ENNI) is a reference point that describes the interface between two Metro Ethernet Networks (MENs) and is intended to support the transparent extension of Ethernet services across multiple Network Operator MENs, where each Network Operator MEN is under the control of a distinct administrative authority. This Technical Specification extends the ENNI by defining the UNI Tunnel Access (UTA) which associates a Virtual UNI (VUNI), a remote UNI, and at least one supporting OVC.

This Technical Specification specifies:

- The requirements for the UNI Tunnel Access (UTA) in sufficient detail to ensure interoperability between MENs.
- The service attributes necessary to realize UTA.
- The Virtual UNI (VUNI), remote UNI constraints, and related service attributes.

## 2 Terminology

Note: Terms defined in the ENNI document [MEF 26] are not repeated here.

Term	Definition	Source
Remote UNI	Remote UNI is a UNI serving as the UTA component consisting of a collection of service attributes in the UNI within an Operator's MEN. The remote UNI is paired with a VUNI in a VUNI Provider's MEN. At the remote UNI, Service Frames are exchanged between the Subscriber and the Network Operator MEN. <sup>1</sup>	This document
UTA	The UNI Tunnel Access (UTA) associates a VUNI and remote UNI and is composed of VUNI and remote UNI Components and at least one supporting OVC <sup>2</sup> .	This document
UTA Component	A specific set of capabilities which may be used as part of UTA.	This document
UTA OVC	An OVC in the Network Operator's MEN that provides an association of a remote UNI with an ENNI in support of UTA.	This document

<sup>1</sup> For this initial phase, the remote UNI is supported by a Network Operator MEN as a UNI with specific attribute constraints (as described in this document) that is not aware of the EVC services. For future phases, an EVC service aware remote UNI may be considered.

<sup>2</sup> UTA is minimally supported by the UTA OVC within the Network Operator MEN that provides the remote UNI. Future versions of UTA may additionally be supported by OVCs traversing intermediate providers in order to "extend" the tunnel. See Appendix B.

Term	Definition	Source
VUNI	Virtual UNI (VUNI) is the component consisting of a collection of service attributes in the VUNI Provider’s MEN. The VUNI is paired with a remote UNI in a Network Operator’s MEN. The main function of the VUNI is to map frames between a set of one or more OVCs present in the VUNI Provider domain and a single UTA.	This document
VUNI End Point	An End Point at the VUNI Provider’s side of a specific ENNI that associates the ENNI with a VUNI in support of UTA.	This document
VUNI Provider	The Operator MEN providing the VUNI.	This document

Table 1: Acronyms and Definitions

### 3 Scope and Key Concepts

Service providers need a way to extend their reach to subscribers outside of their immediate serving area. The UNI Tunnel Access (UTA) provides a means for the Service Frames of EVCs associated with a remote subscriber’s UNI to be tunneled through a Network Operator’s MEN to an ENNI connecting a Network Operator’s MEN with the VUNI Provider’s MEN. With this arrangement, the Network Operator provides the OVC for transfer of Service Frames between the remote UNI and the ENNI. In addition, the service attributes related to the Subscriber service are distributed between the remote UNI and the Virtual UNI (VUNI). Figure 1 provides a model showing the context for the UTA between a Network Operator and the VUNI Provider.

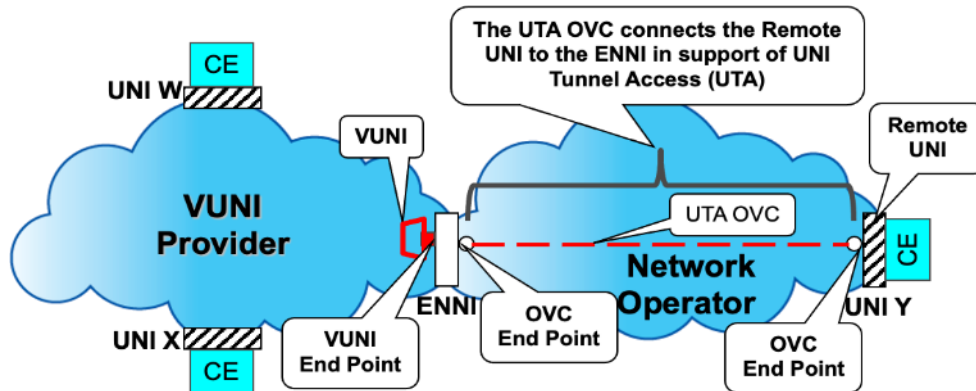


Figure 1 - UNI Tunnel Access Model<sup>3</sup>

The VUNI in the VUNI Provider’s MEN has service attributes similar to those of a UNI, and is paired with a remote UNI in the Network Operator’s MEN. The VUNI is associated with a VUNI End Point at the VUNI Provider’s side of an ENNI. Its main function is to specify the processing rules applicable to ENNI frames present in the VUNI Provider domain and associate them with a given UTA instance.

<sup>3</sup> While the remote UNI is shown in Figure 1 is adjacent to the CE, UTA also allows (but does not require) a Service Provider to support UNI-UNI service level monitoring by placing a capability between the Remote UNI and the CE (e.g., implemented within a network interface device) for Service Level verification.

Figure 2 below shows an example of a UTA between a VUNI and remote UNI (UNI Y). In this figure, EVC1, EVC2, and EVC3 are available to the Subscriber at the remote UNI. However, the Network Operator supporting the remote UNI is not responsible for the management of the EVCs across the Network Operator’s MEN. The Network Operator is responsible for management of the UTA OVC between its side of the ENNI and the remote UNI, including the service attributes of the remote UNI. For this initial phase, the remote UNI supports only very basic service attributes and is not aware of the details of the services for the Subscriber, e.g., the number of EVCs seen by the Subscriber.

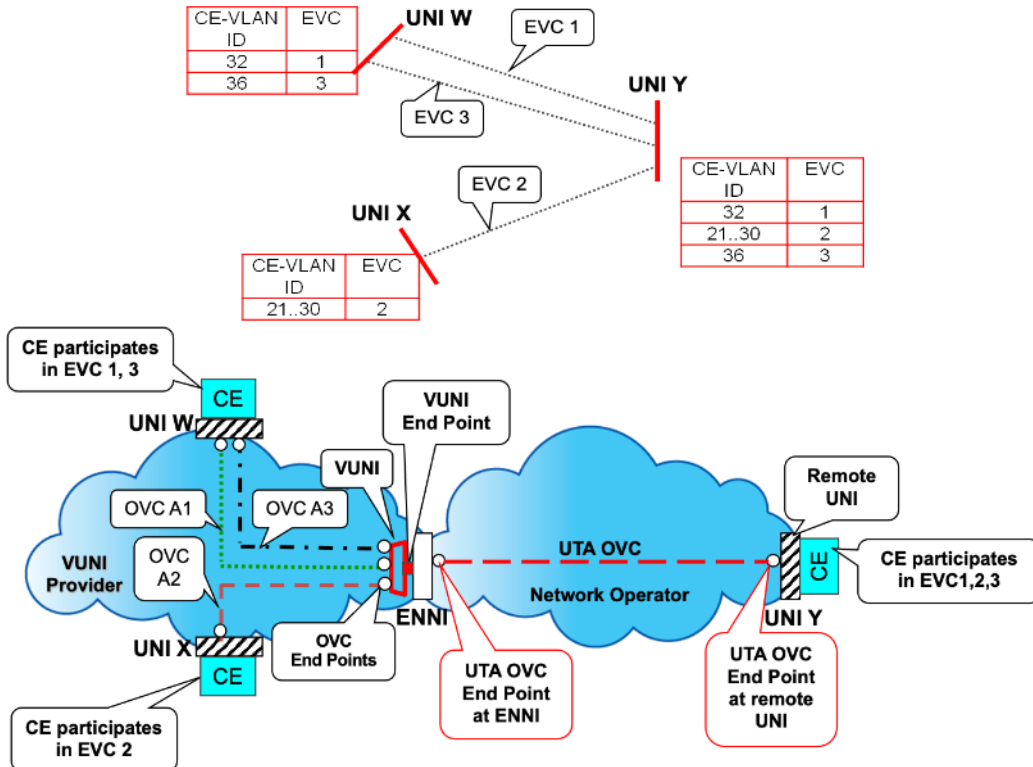


Figure 2 – EVCs Implemented Using VUNI, UTA OVC, and remote UNI<sup>4</sup>

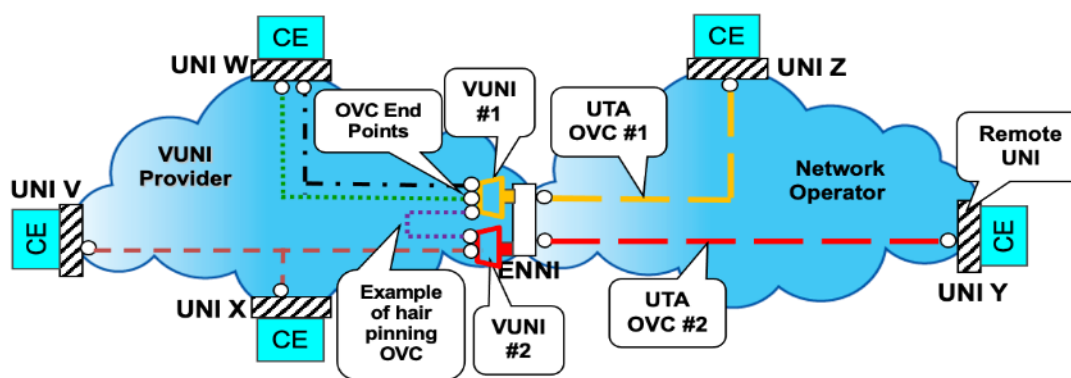
In Figure 2, the CE at UNI Y participates in EVCs 1, 2, and 3. These EVCs have the Service Provider agreed Bandwidth Profile Attributes, and CoS markings. At the remote UNI, Service Frames of EVC 1, 2, and 3 are exchanged with the CE. Such frames may be C-tagged, priority tagged, or untagged. The remote UNI is instantiated by the Network Operator as a UNI where the Network Operator maps all Service Frames to the single OVC End Point supporting the UTA OVC. A single bandwidth profile and CoS may be applied at this remote UNI OVC End Point. At the UTA OVC End Point at the Network Operator’s side of the ENNI, an S-VLAN ID is used to map ENNI Frames to the OVC End Point supporting the UTA, and applies a UTA specific single bandwidth profile and CoS.

<sup>4</sup> The OVC End Points associated by a VUNI in this figure represent the association of OVC A1, A2, and A3 with the ENNI as specified in [MEF 26].

In the VUNI Provider's network, the relationship between the UTA OVC and the VUNI is realized by an S-VLAN ID present at the ENNI, whose value is negotiated between the VUNI Provider and the Network Operator. At the ENNI, when receiving an ENNI Frame, the VUNI Provider maps (using the End Point Map) a single S-VLAN ID to a VUNI End Point associated with a VUNI. The VUNI then maps frames based on their CE-VLAN ID to the appropriate OVC End Point for OVCs A1, A2 and A3. In the reverse direction, the VUNI multiplexes frames from OVCs A1, A2, and A3 into a tunnel denoted by a unique S-VLAN ID, which is associated with the Network Operator's UTA OVC. Note that A1, A2 and A3 have non-overlapping CE-VLAN IDs at the VUNI.

An ENNI can support more than one VUNI.

Figure 3 provides an example that shows multiple VUNIs associated with a single ENNI.



**Figure 3 – Example with Multiple VUNIs Associated with a Single ENNI<sup>5</sup>**

This technical specification assumes the following business model: The Subscriber contracts with a Service Provider (who either acts as the VUNI Provider, or contracts with the VUNI Provider) to provide Ethernet Services among UNIs, including those UNIs outside of the Service Provider's serving area. That is, the EVC Service Level Specification (SLS) remains UNI to UNI. The Service Provider, in turn, selects and contracts with one or more Network Operators to provide one UTA OVC to reach each remote UNI. It is the responsibility of the Service Provider to ensure the appropriate connectivity properties for each UTA such that the UNI-to-UNI service features purchased by the Subscriber can be delivered.

A service arrangement involving one or more "Intermediate Network Operators" between the VUNI Provider MEN and the Network Operator MEN supporting the remote UNI is a possible extension to the service model; however, details around this Use Case are left as a "For Future Study" (FFS) item. Appendix B provides a model along with some examples of how the multi-MEN extensions may be realized.

<sup>5</sup> The OVC End Points associated by each VUNI in this figure represent the association of OVCs with the ENNI as specified in [MEF 26].



### 3.1 UTA Components

The UTA, defined in this technical specification, is composed of a UTA OVC Component (in the Network Operator MEN) and associated VUNI (in the VUNI Provider MEN) and remote UNI (in the Network Operator MEN) Components. The UTA OVC and remote UNI components may be provided as a service offered by the Network Operator to a Service Provider.

#### 3.1.1 UTA OVC Component

This Technical Specification defines requirements that detail the attributes that are supported by a Network Operator MEN providing the UTA OVC.

The UTA OVC associates the remote UNI with an ENNI (connecting the Network Operator and the VUNI Provider in Figure 1). The UTA OVC service attributes represent the service capabilities that the Service Provider purchases from a Network Operator, and describe what is needed to instantiate the UTA OVC supporting the Subscriber services of a distant UNI (UNI Y in Figure 1).

#### 3.1.2 Remote UNI Component

The remote UNI requirements detail the behavior of the remote UNI at the Network Operator side of the UNI that is attached to the Subscriber (remote UNI attributes at UNI Y in Figure 1). The remote UNI supports a portion of the UNI service attributes. This Specification addresses remote UNI service attributes in a manner that is not aware of Subscriber service details. That is, it is assumed that the remote UNI has no knowledge of the individual Subscriber's EVCs. Note that from the Subscriber's perspective, the UNI can be perceived as a service multiplexed UNI.

#### 3.1.3 VUNI Component

This Specification details the behavior of the VUNI that is associated with the ENNI related to the UTA at the Network Operator's side of an ENNI (VUNI at the ENNI in Figure 1). The VUNI attributes include: mapping of the VUNI to the End Point associated with the UTA OVC at the opposite side of the ENNI; and mapping of ENNI Frames to one or more VUNI Provider OVC End Points in support of Subscriber services.

## 4 Compliance Levels

The keywords **MUST**, **MUST NOT**, **REQUIRED**, **SHALL**, **SHALL NOT**, **SHOULD**, **SHOULD NOT**, **RECOMMENDED**, **MAY**, and **OPTIONAL**, when they appear in this document, are to be interpreted as described in RFC 2119.

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

## 5 Requirements for the UTA OVC Component

The UTA OVC is an OVC in the Network Operator's MEN that associates a remote UNI with an ENNI in support of the UTA. The UTA OVC Service Attributes describe the possible behaviors seen by an observer (e.g., the VUNI Provider) external to the Network Operator MEN at and between the external interfaces (remote UNI and ENNI).

The implementation of a UTA OVC within the Network Operator MEN is opaque to the VUNI Provider and the Subscriber. What is important is the observed behavior of the UTA OVC between the remote UNI and ENNI. These behaviors can be described by the following sets of service attribute constraints:

- UTA OVC service attributes constraints are presented in Section 5.1.
- OVC End Point at the remote UNI service attribute constraints for the UTA OVC are presented in Section 5.2.
- OVC End Point at the ENNI service attribute constraints for the UTA OVC are presented in Section 5.3.
- Service attribute constraints for the ENNI participating in the UTA OVC are presented in Section 5.4.

### 5.1 UTA OVC

The UTA OVC applies the OVC Service Attributes and Requirements as defined in Section 7.2 of [MEF 26]. However some specific service attributes have been further constrained and are described in the requirements below.

[R1] A UTA OVC **MUST** assign OVC service attributes and values according to Table 2.

OVC Service Attribute Name	Additional Constraints for UTA OVC
OVC Identifier	<i>No additional constraints</i>
OVC Type	<b>MUST</b> be Point-to-Point
OVC End Point List	The list <b>MUST</b> identify exactly two OVC End Points: Exactly one of the OVC End Points <b>MUST</b> be at a remote UNI; and Exactly one of the OVC End Points <b>MUST</b> be at the Network Operator side of an ENNI.
Maximum Number of UNI OVC End Points	<b>MUST</b> be 1
Maximum Number ENNI OVC End Points	<b>MUST</b> be 1

OVC Service Attribute Name	Additional Constraints for UTA OVC
OVC Maximum Transmission Unit Size	<i>No additional constraints</i>
S-VLAN ID Preservation	<i>No additional constraints</i> <sup>6</sup>
S-VLAN CoS Preservation	<i>No additional constraints</i> <sup>7</sup>
CE-VLAN ID Preservation	<b>MUST</b> be Yes
CE-VLAN CoS Preservation	<b>MUST</b> be Yes
Color Forwarding	<b>MUST</b> be No <sup>8</sup>
SLS	<i>No additional constraints</i>
Unicast Service Frame Delivery	<b>MUST</b> Deliver Unconditionally
Multicast Service Frame Delivery	<b>MUST</b> Deliver Unconditionally
Broadcast Service Frame Delivery	<b>MUST</b> Deliver Unconditionally

**Table 2: OVC Service Attributes Constraints for UTA OVC**

## 5.2 UTA OVC End Point at the Remote UNI

The UTA OVC applies the OVC End Point per UNI Service Attributes and Requirements as defined in Section 7.5 of [MEF 26]. However some specific service attributes have been further constrained and are described in the requirements below.

- [R2]** An OVC End Point supporting the UTA at a remote UNI **MUST** assign service attributes and values according to Table 3.

Note that because the OVC End Point at the remote UNI is a special constrained case of an OVC End Point at a UNI, the UNI terminology of [MEF 26] refers to remote UNI in Table 3.

<sup>6</sup> The value of the S-VLAN ID Preservation attribute does not affect the behavior of the UTA OVC.

<sup>7</sup> The value of the S-VLAN ID COS Preservation attribute does not affect the behavior of the UTA OVC.

<sup>8</sup> Color Forwarding is replaced by the color marking behavior for egress ENNI Frames as described in Section 5.3.1

OVC End Point per UNI Service Attribute	Additional Constraints for the UTA OVC End Point at the Remote UNI
UNI OVC Identifier	<i>No additional constraints</i>
OVC End Point Map	All CE-VLAN ID values at the remote UNI <b>MUST</b> map to the single OVC End Point
Class of Service Identifiers	<b>MUST</b> provide only a single Class of Service Identifier <sup>9</sup>
Ingress Bandwidth Profile Per OVC End Point at a UNI (remote UNI)	If an Ingress Bandwidth Profile per OVC End Point at a remote UNI is supported, it <b>MUST</b> be configured as color blind and <b>MUST</b> specify either CIR as ZERO or EIR as ZERO <sup>10</sup> . For more information on this Bandwidth Profile, please see [MEF 10.2]
Ingress Bandwidth Profile Per Class of Service Identifier at a UNI (remote UNI)	<b>MUST NOT</b> specify
Egress Bandwidth Profile Per OVC End Point at a UNI (remote UNI)	<b>MUST NOT</b> specify
Egress Bandwidth Profile Per Class of Service Identifier at a UNI (remote UNI)	<b>MUST NOT</b> specify

**Table 3: OVC End Point per UNI Service Attribute Constraints for UTA OVC End Point at the Remote UNI**

As indicated in Table 3, all frames transported by the UTA OVC are mapped to a single class of service. Therefore, if a service provider wants to support multiple EVCs with different performance objectives on a single UTA OVC, then the service provider should select UTA OVC performance objectives such that the UNI to UNI performance objectives of the most demanding EVCs can be achieved.

### 5.3 UTA OVC End Point at the ENNI in the Network Operator's MEN

The UTA OVC applies the OVC End Point per ENNI Service Attributes and Requirements as defined in Section 7.3 of [MEF 26]. However some specific service attributes have been further constrained and are described in the requirements below.<sup>11</sup> In addition, the color marking behavior for egress ENNI Frames at the UTA OVC End Point at the ENNI in the Network Operator's MEN is described in Section 5.3.1.

**[R3]** An OVC End Point supporting a UTA at an ENNI **MUST** assign service attributes and values according to Table 4.

<sup>9</sup> Class of Service Identifier should be based on the OVC End Point as described in Section 7.5.3.1 of [MEF 26]

<sup>10</sup> Note, this implies a single color in that either all frames will be declared yellow, or all will be declared green, respectively.

<sup>11</sup> Note, this applies to the OVC End Point on the Network Operator's side of the ENNI. The requirements for the End Point at the VUNI Provider's side of the ENNI are provided in Section 7.

OVC End Point per ENNI Service Attribute	Additional Constraints for the UTA OVC End Point at the ENNI
OVC End Point Identifier	<i>No additional constraints</i>
Class of Service Identifiers	<b>MUST</b> provide only a single Class of Service Identifier
Ingress Bandwidth Profile Per OVC End Point	<b>MUST</b> be configured as color aware and <b>MUST</b> specify either CIR as ZERO or EIR as ZERO
Ingress Bandwidth Profile Per ENNI Class of Service Identifier	<b>MUST NOT</b> specify
Egress Bandwidth Profile Per End Point	<i>No additional constraints</i>
Egress Bandwidth Profile Per ENNI Class of Service Identifier	<b>MUST NOT</b> specify

**Table 4: OVC End Point per ENNI Service Attribute constraints for an OVC supporting UTA**

### 5.3.1 Color Marking at the UTA OVC End Point at the ENNI in the Network Operator's MEN

Since the Ingress Bandwidth Profile at the UTA OVC End Point at a remote UNI is defined to declare Service Frames to be either Green/Red (since CIR>0, EIR=0) or Yellow/Red (since CIR=0, EIR>0) (i.e., all resulting egress ENNI Frames must be the same color), there is no need for the Network Operator to carry the ingress color marking result across the network to the ENNI. Proper ENNI Frame color marking may be achieved by examining the Bandwidth Profile information of the UTA OVC End Point at the remote UNI to identify the appropriate color marking of each egress ENNI Frame mapped to the UTA OVC End Point at the Network Operator ENNI. The Bandwidth Profile attribute of the UTA OVC End Point at the remote UNI describes the color marking of each egress ENNI Frame (i.e. toward the VUNI provider) that is mapped to the UTA OVC End Point at the ENNI by the ENNI End Point Map.

- [R4] When there is an ingress Bandwidth Profile of the UTA OVC End Point at the remote UNI with CIR > 0 and EIR = 0, each egress ENNI Frame mapped to the corresponding UTA OVC End Point at the ENNI by the ENNI End Point Map **MUST** be marked Green via the S-Tag as per [MEF 23].
- [R5] When there is an ingress Bandwidth Profile of the UTA OVC End Point at the remote UNI with CIR = 0 and EIR > 0, each egress ENNI Frame mapped to the corresponding UTA OVC End Point at the ENNI by the ENNI End Point Map **MUST** be marked Yellow via the S-Tag as per [MEF 23].
- [O1] In the case where no ingress Bandwidth Profile is defined for the UTA OVC End Point at the remote UNI, the Network Operator **MAY** set the color of the egress ENNI Frame based on bilateral agreement with the Service Provider.

## 5.4 ENNI Service Attributes Supporting the UTA OVC

From the point of view of the UTA, the ENNI is the point of demarcation between the VUNI Provider MEN and the Network Operator MEN. This section addresses the ENNI service attribute constraints associated with the Network Operator.

For the UTA Network Operator, the ENNI Attributes as defined in Section 7.1 of [MEF 26] are applied.

[R6] A Network Operator ENNI supporting the UTA related OVC End Point **MUST** assign service attributes and values according to Table 5.

Constraints for the UTA Network Operator ENNI Service Attributes are summarized in Table 5.

ENNI Service Attribute	Service Attribute Parameters and Constraints for the UTA Network Operator
Operator ENNI Identifier	<i>No additional constraints</i>
Physical Layer	<i>No additional constraints</i>
Frame Format	<i>No additional constraints</i>
Number of Links	<i>No additional constraints</i>
Protection Mechanism	<i>No additional constraints</i>
ENNI Maximum Transmission Unit Size	<i>No additional constraints</i>
End Point Map	The End Point Type within an End Point Map for a UTA OVC Component related OVC End Point at an ENNI <b>MUST</b> take the value of "OVC".
Maximum Number of OVCs	<i>No additional constraints</i>
Maximum Number of OVC End Points per OVC	<i>No additional constraints</i>

**Table 5: ENNI Service Attribute Constraints for the UTA Network Operator**

## 6 Requirements for the Remote UNI Component

This section describes how some of the service attributes associated with the remote UNI are constrained in support of the UTA. For the UTA, the remote UNI service attributes are constrained to have the OVC type being Point-to-Point across the Network Operator MEN. MEF Services like EPLAN can be offered by the Service Provider, because any changes to other end points in the Service Provider domain (e.g., adding or deleting UNI end points) do not require coordination with the Network Operator supporting the remote UNI.

The remote UNI reuses the UNI service attributes specified in Section 7.4 of [MEF 26].

As described by the OVC End Point Map attribute in Table 3, the remote UNI supporting the UTA OVC is configured to support a single OVC End Point to which all CE VLAN IDs are mapped at the remote UNI. A Bandwidth Profile is specified for the OVC End Point of the UTA OVC at the remote UNI. For UTA, other Bandwidth Profiles may be configured, for example a Bandwidth Profile for the VUNI as a whole (see Section 7.4). A separate Bandwidth Profile per remote UNI is redundant and may cause additional undesired behavior; hence it is not to be specified.

- [R7] The remote UNI supporting the UTA OVC **MUST NOT** specify an Ingress Bandwidth Profile per UNI.
- [R8] The remote UNI supporting the UTA OVC **MUST NOT** specify an Egress Bandwidth Profile per UNI.

## 7 Requirements for the VUNI Component

VUNI requirements detail the behavior that is associated with the UTA on the VUNI Provider's side of the ENNI. This is referred to as the VUNI component.

The VUNI component's responsibilities include: Mapping of the VUNI End Point to the ENNI; and Mapping of ENNI Frames between one or more VUNI Provider OVC End Points and the VUNI End Point for the UTA in support of Subscriber services.

The behavior at the VUNI is specified by the following sets of attributes:

- VUNI Service Attributes are presented in Section 7.1.
- ENNI Service Attributes for the ENNI supporting the VUNI are presented in Section 7.2.
- Service Attributes for OVC End Points associated by the VUNI are presented in Section 7.3.

### 7.1 Virtual UNI (VUNI) Service Attributes

The VUNI Service Attributes are similar to the UNI attributes specified in Section 7.4 of [MEF 26]. This section describes how these VUNI service attributes focus on support of the UTA.

In order to describe the VUNI attributes, the concept of an ENNI CE-VLAN ID is defined for an ENNI Frame that is mapped to a VUNI End Point as follows:

- If an ENNI Frame is mapped to a VUNI End Point and the ENNI Frame has a C-Tag whose VLAN ID value is not zero, then the ENNI CE-VLAN ID for the ENNI Frame is the value of VLAN ID in the C-Tag.
- If an ENNI Frame is mapped to a VUNI End Point and the ENNI Frame either has no C-Tag or has a C-Tag whose VLAN ID value is zero, then the ENNI CE-VLAN ID is a value in the range 1,2,...,4094 that is agreed upon by both the Service Provider and the Operator supporting the VUNI.<sup>12</sup>

**[R9]** A VUNI supporting the UTA **MUST** assign service attributes and values according to Table 6.

Note, in Table 6, the Ingress Bandwidth Profile is applied to traffic that flows from the Subscriber at the remote UNI to the VUNI Provider MEN, and the Egress Bandwidth Profile is applied to traffic that flows from the VUNI Provider MEN to the Subscriber at the remote UNI.

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<sup>12</sup> The value also needs to be agreed upon between the Service Provider and the Subscriber.



VUNI Service Attribute	Service Attribute Parameters and Constraints for UTA
VUNI Identifier	Arbitrary text string of no more than 45 bytes to identify the VUNI. The VUNI Identifier <b>MUST</b> be unique among all VUNI Identifiers within the scope of all ENNIs supported by the VUNI Provider MEN.
ENNI CE-VLAN ID value for ENNI Frames with no C-Tag or a C-Tag whose VLAN ID value is 0	<b>MUST</b> specify CE-VLAN ID value in the range of 1-4094.
Maximum number of related OVC End Points in the VUNI Provider MEN	<b>MUST</b> be an integer $\geq 1$ .
Ingress Bandwidth Profile Per VUNI	(See Section 7.4.1)
Egress Bandwidth Profile Per VUNI	(See Section 7.4.2)

**Table 6: VUNI Service Attribute Constraints for UTA**

## 7.2 ENNI Service Attributes Supporting the VUNI

From the point of view of the UTA, the ENNI is the point of demarcation between the VUNI Provider MEN and the Network Operator MEN<sup>13</sup>. This section addresses the ENNI attribute constraints associated with the VUNI Provider.

When VUNI attributes are enabled in support of the UTA, the ENNI Attributes as defined in Section 7.1 of [MEF 26] are applied to describe the behavior of the ENNI, however a specific attribute has been extended as described in the requirement below to allow for mapping of an S-VLAN ID at the ENNI to a specific VUNI End Point.

**[R10]** A VUNI Provider ENNI supporting the UTA **MUST** assign service attributes and values according to Table 7.

Constraints for the VUNI Provider ENNI Service Attributes are specified in Table 7.

<sup>13</sup> These service attributes would remain the same in the case where an intermediate operator provides connectivity to the network operator supporting the remote UNI as described in the Multi-MEN model provided in Appendix B.

ENNI Service Attribute	Service Attribute Parameters and Constraints for VUNI Provider
Operator ENNI Identifier	<i>No additional constraints</i>
Physical Layer	<i>No additional constraints</i>
Frame Format	<i>No additional constraints</i>
Number of Links	<i>No additional constraints</i>
Protection Mechanism	<i>No additional constraints</i>
ENNI Maximum Transmission Unit Size	<i>No additional constraints</i>
End Point Map	At an ENNI in the VUNI Provider MEN, the End Point Type within an End Point Map for ENNI frames mapped to a VUNI <b>MUST</b> take the value of "VUNI" <sup>14</sup>
Maximum Number of OVCs	<i>No additional constraints</i>
Maximum Number of OVC End Points per OVC	<i>No additional constraints</i>

**Table 7: ENNI Service Attribute Constraints for VUNI Provider**

The VUNI End Point at the VUNI Provider ENNI is associated with a UTA and is indicated with the End Point Type VUNI in the ENNI Service Attribute End Point Map, see Section 7.1.7.1 of [MEF 26]. Multiple VUNI End Points can reside at a single ENNI.

**[R11]** At an ENNI, an End Point Map entry with an End Point Type of *VUNI* **MUST** provide an association to a VUNI End Point by applying the End Point Map entry's End Point Identifier to map ENNI frames with the given S-VLAN ID Value to a VUNI End Point.

As per requirement [R16] of [MEF 26], the End Point Map at the ENNI uses the S-VLAN-ID of a given S-Tagged ENNI Frame to determine the VUNI End Point to which an ENNI Frame is mapped.

### 7.3 Service Attributes for an OVC End Point associated by the VUNI

There are attributes for each instance of an OVC End Point associated with a specific VUNI.<sup>15</sup> These service attributes are based on the OVC per UNI Attributes as described in Section 7.5 of [MEF 26].

**[R12]** A given OVC **MUST** associate at most one OVC End Point that is associated by a specific VUNI.

<sup>14</sup> This requirement extends the End Point Type as defined in [R18] of [MEF 26].

<sup>15</sup> Note that the OVC(s) discussed in this section are in the VUNI Provider MEN, as opposed to the UTA OVC Service Component that is in the Network Operator MEN.

[R13] In the VUNI Provider MEN, once an ENNI frame received from the Network Operator's MEN is mapped to a specific VUNI End Point that identifies the VUNI based on the S-VLAN ID Value in the ENNI End Point Map Service Attribute, the VUNI OVC End Point Map **MUST** be applied to determine the OVC End Point associated with the frame's C-VLAN ID Value.

[R14] An OVC End Point's service attributes for an OVC End Point that is associated by a VUNI **MUST** be configured with values according to Table 8.

Service Attributes for an OVC End Point associated by the VUNI	Service Attribute Parameters and Values
VUNI OVC Identifier	An arbitrary string of no more than 45 bytes formed by the concatenation of the VUNI Identifier and the OVC Identifier
OVC End Point Map	A list of one or more CE-VLAN ID values mapped to the OVC End Point
Class of Service Identifiers	The way that a Class of Service is determined for ingress ENNI Frames that are mapped to a VUNI (see Section 7.3.1)
Ingress Bandwidth Profile Per OVC End Point associated by a VUNI	(See Section 7.4.3)
Ingress Bandwidth Profile Per Class of Service Identifier associated by a VUNI	(See Section 7.4.4)
Egress Bandwidth Profile Per OVC End Point associated by a VUNI	(See Section 7.4.5)
Egress Bandwidth Profile Per Class of Service Identifier associated by a VUNI	(See Section 7.4.6)

**Table 8: Service Attributes for OVC End Points associated by the VUNI**

### 7.3.1 VUNI Class of Service Identifiers

[R15] There **MUST** be three mutually exclusive ways to determine the Class of Service Identifier from the content of a given ENNI Frame mapped to a VUNI as described in Sections 7.3.1.1, 7.3.1.2, and 7.3.1.3.

Note that Sections 7.3.1.1, 7.3.1.2, and 7.3.1.3 describe Class of Service Identifiers for ingress ENNI Frames mapped to a VUNI.

### 7.3.1.1 VUNI Class of Service Identifier Based on OVC End Point

- [R16] When the Class of Service Identifier is based on OVC End Point, all ingress ENNI Frames mapped to the same OVC End Point at the VUNI **MUST** have the same Class of Service Identifier.

As an example, consider OVC End Point 1 and OVC End Point 2 associated by a VUNI. ENNI Frames mapped to OVC End Point 1 have a first Class of Service Identifier that indicates gold service. ENNI Frames mapped to OVC End Point 2 have a second Class of Service Identifier that indicates silver service.

### 7.3.1.2 VUNI Class of Service Identifier Based on C-Tag Priority Code Point Field

- [R17] When the Class of Service Identifier is based on C-Tag Priority Code Point field, the Class of Service Identifier for an ingress ENNI Frame mapped to a VUNI **MUST** be determined by the combination of the OVC End Point and non-overlapping sets of values of the C-Tag Priority Code Point field.
- [R18] When the Class of Service Identifier is based on C-Tag Priority Code Point field, if the ingress ENNI frame does not contain a C-Tag, it **MUST** have the same Class of Service Identifier as an ingress frame with C-Tag Priority Code Point field = 0 in the C-Tag.
- [R19] When the Class of Service Identifier is based on C-Tag Priority Code Point field, the union of the sets of C-Tag PCP field values **MUST** contain all of the possible values.

As an example, consider OVC End Point 1 and OVC End Point 2 associated by a VUNI. The ENNI Frames mapped to OVC End Point 1 with C-Tag Priority Code Point values 4, 5, 6, and 7 have a first Class of Service Identifier that indicates gold service. The ENNI Frames mapped to OVC End Point 1 with C-Tag Priority Code Point values 0 and 3 have a second Class of Service Identifier that indicates silver service. The ENNI Frames mapped to OVC End Point 1 with C-Tag Priority Code Point values 1 and 2 have a third Class of Service Identifier that indicates Service Frame discard. VUNI-mapped ENNI Frames without a C-Tag that are mapped to OVC End Point 1 also have the second Class of Service Identifier that indicates silver service. The ENNI Frames mapped to OVC End Point 2 with C-Tag Priority Code Point value 7 have a fourth Class of Service Identifier that indicates platinum service. All other VUNI mapped frames mapped to OVC End Point 2 have a fifth Class of Service Identifier that indicates gold service.

### 7.3.1.3 VUNI Class of Service Identifier Based on DSCP

- [R20] When the Class of Service Identifier is based on DSCP, the Class of Service Identifier for an ingress ENNI Frame mapped to a VUNI containing an IP packet **MUST** be determined by the combination of the OVC End Point and non-overlapping sets of values of the DSCP.

- [R21] When the Class of Service Identifier is based on DSCP, the union of the sets of DSCP values **MUST** contain all of the possible DSCP values.
- [R22] When the Class of Service Identifier is based on DSCP, each ingress ENNI Frame mapped to a VUNI not containing an IP packet and mapped to a given OVC End Point **MUST** have the same Class of Service Identifier with a value agreed upon by the Subscriber and the Service Provider.

## 7.4 Bandwidth Profiles at the VUNI

VUNI Bandwidth Profiles in this Technical Specification use the parameters and algorithm described in Section 7.6.1 of [MEF 26].

### 7.4.1 Ingress Bandwidth Profile per VUNI End Point Service Attribute

- [R23] When an Ingress Bandwidth Profile per VUNI is in force, the algorithm and parameters described in Section 7.6.1 of [MEF 26] **MUST** be applied to all incoming ENNI Frames mapped to the VUNI End Point of the VUNI.
- [R24] When an Ingress Bandwidth Profile per VUNI is in force, ingress ENNI Frames mapped to the VUNI End Point of the VUNI **MUST NOT** be subjected to any other type of ingress bandwidth profile.

Per Section 7.6.1 of [MEF 26], each ingress ENNI Frame can be the subject of at most one ingress Bandwidth Profile. The Ingress Bandwidth Profile per VUNI manages bandwidth non-discriminately for all OVCs supported by the VUNI.

### 7.4.2 Egress Bandwidth Profile per VUNI End Point Service Attribute

- [R25] When an Egress Bandwidth Profile per VUNI is in force, suitable parameters <CIR, CBS, EIR, EBS, CF, CM> as defined in Section 7.6.1 of [MEF 26] **MUST** be specified and all egress ENNI Frames mapped to the given VUNI End Point **MUST** have the property defined in 7.6.3 of [MEF 26].
- [R26] When an Egress Bandwidth Profile per VUNI is in force, egress ENNI Frames mapped to the VUNI End Point of the VUNI **MUST NOT** be subjected to any other type of egress bandwidth profile.

The Egress Bandwidth Profile per VUNI, when present, manages bandwidth non-discriminately for all OVCs supported by the VUNI. Therefore, some OVCs may get more bandwidth while others may get less.

### 7.4.3 Ingress Bandwidth Profile per OVC End Point associated by a VUNI Service Attribute

The Ingress Bandwidth Profile per OVC End Point associated by a VUNI describes ingress policing by the VUNI Provider MEN on all ingress ENNI Frames mapped to a given OVC End Point associated by a VUNI.

[R27] When the Ingress Bandwidth Profile per OVC End Point associated by a VUNI is in force for a given OVC End Point, suitable parameters *<CIR, CBS, EIR, EBS, CF, CM>* as defined in Section 7.6.1 of [MEF 26] **MUST** be specified and the algorithm of Section 7.6.1 of [MEF 26] **MUST** be applied to all ingress ENNI Frames that are mapped to the given OVC End Point.

### 7.4.4 Ingress Bandwidth Profile per Class of Service Identifier per OVC End Point associated by a VUNI Service Attribute

The Ingress Bandwidth Profile per Class of Service Identifier per OVC End Point associated by a VUNI describes ingress policing by the VUNI Provider MEN on all ingress ENNI Frames with a given Class of Service Identifier mapped to the OVC End Point associated by a VUNI.

[R28] When the Ingress Bandwidth Profile per Class of Service Identifier per OVC End Point associated by a VUNI is in force, suitable parameters *<CIR, CBS, EIR, EBS, CF, CM>* as defined in Section 7.6.1 of [MEF 26] **MUST** be specified and the algorithm of Section 7.6.1 of [MEF 26] **MUST** be applied to all ingress ENNI Frames mapped to the OVC End Point that have the given Class of Service Identifier.

### 7.4.5 Egress Bandwidth Profile per OVC End Point associated by a VUNI Service Attribute

The Egress Bandwidth Profile per OVC End Point associated by a VUNI describes egress shaping by the VUNI Provider MEN on all egress ENNI Frames mapped to a given OVC End Point associated by a VUNI.

[R29] When the Egress Bandwidth Profile per OVC End Point associated by a VUNI is in force for a given OVC End Point, suitable parameters *<CIR, CBS, EIR, EBS, CF, CM>* as defined in Section 7.6.1 of [MEF 26] **MUST** be specified and all egress ENNI Frames mapped to the given OVC End Point **MUST** have the property defined in 7.6.3 of [MEF 26].

### 7.4.6 Egress Bandwidth Profile per Class of Service Identifier per OVC End Point associated by a VUNI Service Attribute

The Egress Bandwidth Profile per Class of Service Identifier per OVC End Point associated by a VUNI describes egress shaping by the VUNI Provider MEN on all egress ENNI Frames with a given Class of Service Identifier mapped to the OVC End Point associated by a VUNI.

[R30] When the Egress Bandwidth Profile per Class of Service Identifier per OVC End Point associated by a VUNI is in force, suitable parameters <*CIR, CBS, EIR, EBS, CF, CM*> as defined in Section 7.6.1 of [MEF 26] **MUST** be specified and all egress ENNI Frames mapped to the given OVC End Point that have the Class of Service Identifier **MUST** have the property defined in 7.6.3 of [MEF 26].

#### 7.4.7 Color Awareness at the VUNI

[R31] When CM = "Color-Aware", the color marking for the ENNI frame **MUST** be based on the C-Tag PCP or the DSCP as mandated in [MEF 23] for the M and L CoS labels.

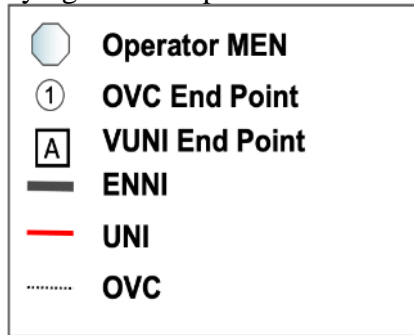
## 8 Appendix A: Example: Multiple EVCs

A number of abbreviations are used in the figures to avoid clutter. These are shown in Table 9.

Abbreviation	Object
C-VID	C-VLAN ID value
S-VID	S-VLAN ID value
O EP	OVC End Point Identifier value
V EP	VUNI End Point Identifier value

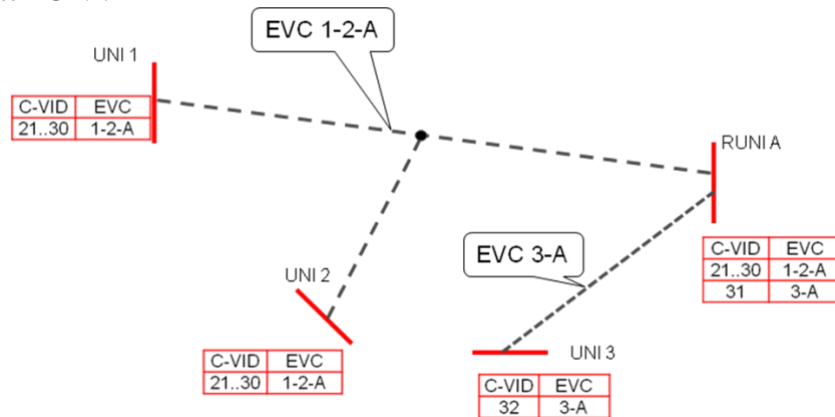
**Table 9: Abbreviations Used in the Examples**

In addition, the figures accompanying the examples use the icons as shown in Figure 4.



**Figure 4 – Key to the Icons Used in the Examples**

Figure 5 shows an example of both a point to point EVC and multipoint EVC in which remote UNI A participates as seen by the Subscriber. The associated CE VLAN ID mapping to the EVC is depicted at each UNI.



**Figure 5 – Example of the remote UNI in multiple EVCs**

Figure 6 shows how the UTA and a VUNI may be employed to instantiate the services in Figure 5. Note that the remote UNI A OVC End Point Map Service Attribute maps all CE-VLAN ID



values to the OVC End Point (see Table 3), and the end point mapping at the VUNI associates the C-VIDs with the OVCs supporting the Subscriber EVCs (see Table 8).

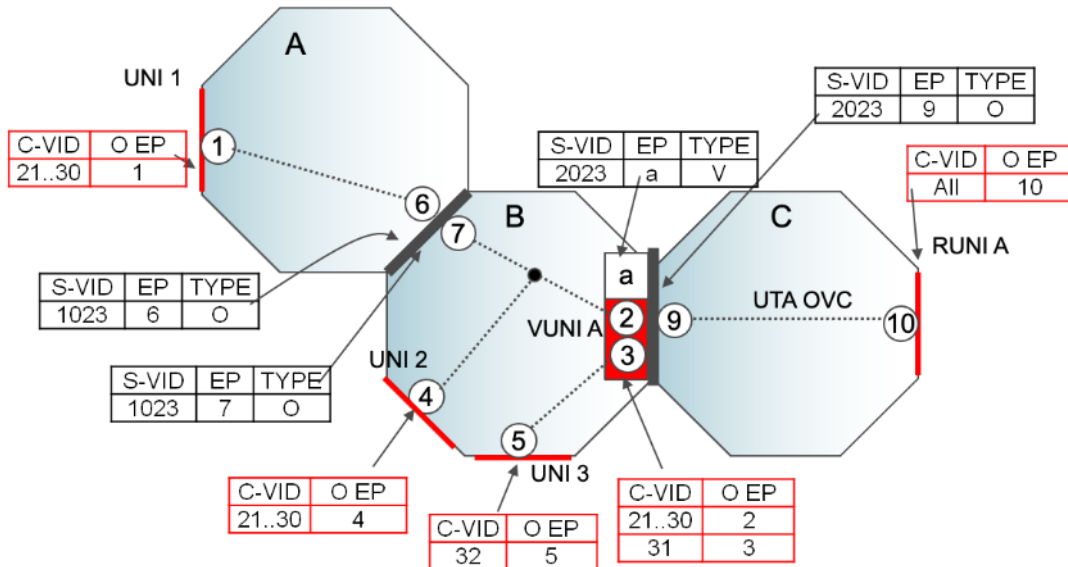
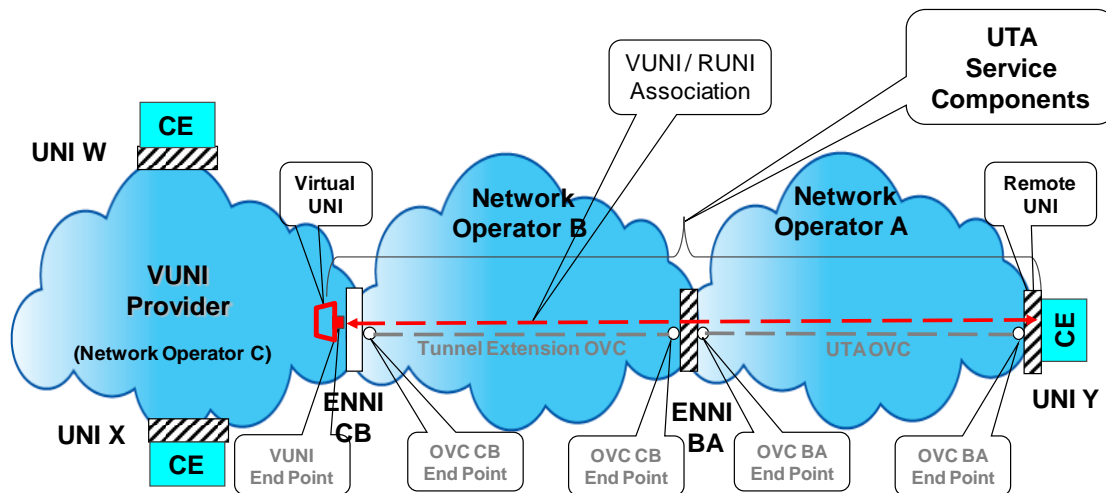


Figure 6 – Example multiple EVCs supported by UTA and VUNI

At the ENNI between MEN B and MEN C, Figure 6 shows the mapping of frames with an S-VID of 2023 to a VUNI End Point representing VUNI A.

## 9 Appendix B: Multi-MEN UTA

This technical specification presented the base concepts behind the UTA model as applicable to tunnels that traverse a single Network Operator. This appendix illustrates how the UNI tunnel access model may be generalized to multi-MEN scenarios. Figure 7 provides a model showing the context for the UTA among two Network Operators and the VUNI Provider. (See 802.1Qbc for more details.)



**Figure 7 - Multi-MEN UNI tunnel access model**

As in Figure 1, the VUNI in the VUNI Provider's MEN has service attributes similar to those of a UNI, and is paired with a remote UNI in the Network Operator A's MEN. In this scenario, however, the UTA is realized via two OVCs, one associating the remote UNI in Network Operator A (UNI Y) with the ENNI with Network Operator B (ENNI BA), and one OVC (Tunnel Extension OVC) associating ENNI BA with the ENNI for the VUNI Provider (ENNI CB).

The rules for configuration of the UTA OVC (OVC BA) and the associated OVC End Point Service Attributes follow the same rules as the UTA OVC specified in Sections 5.1 and 5.3. Service Attribute constraints related to the Tunnel Extension OVC are for further study.

Figure 8 illustrates the generalization of the multi-EVC scenario in Appendix A, Figure 6, to a multi-MEN UTA. The scenario in Figure 8 assumes the same EVC configurations as in Appendix A, Figure 5, however the UTA is now supported by two OVCs: a) one Tunnel Extension OVC traversing Network Operator C, and b) one UTA OVC between the remote UNI on Network Operator D and the ENNI between Network Operator D and Network Operator C. At this ENNI an S-VID of 3456 is used to map the ENNI frames between the two Network Operators to the OVCs supporting the UTA.

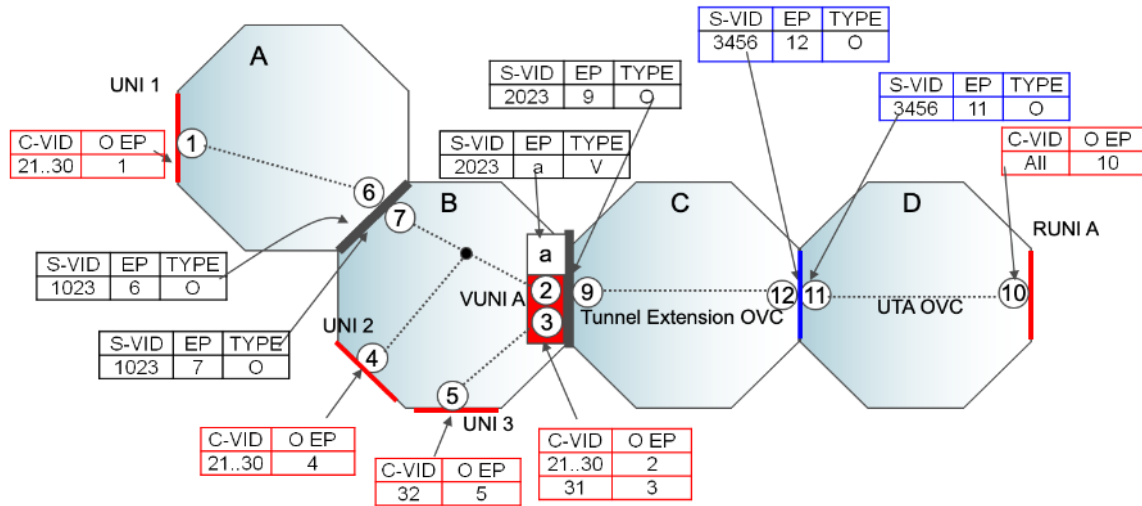


Figure 8 - Example multiple EVCs supported by a multi-MEN UTA

Note that this extension to the UTA model will work well in conjunction with future definitions of ENNI-to-ENNI OVC Services.

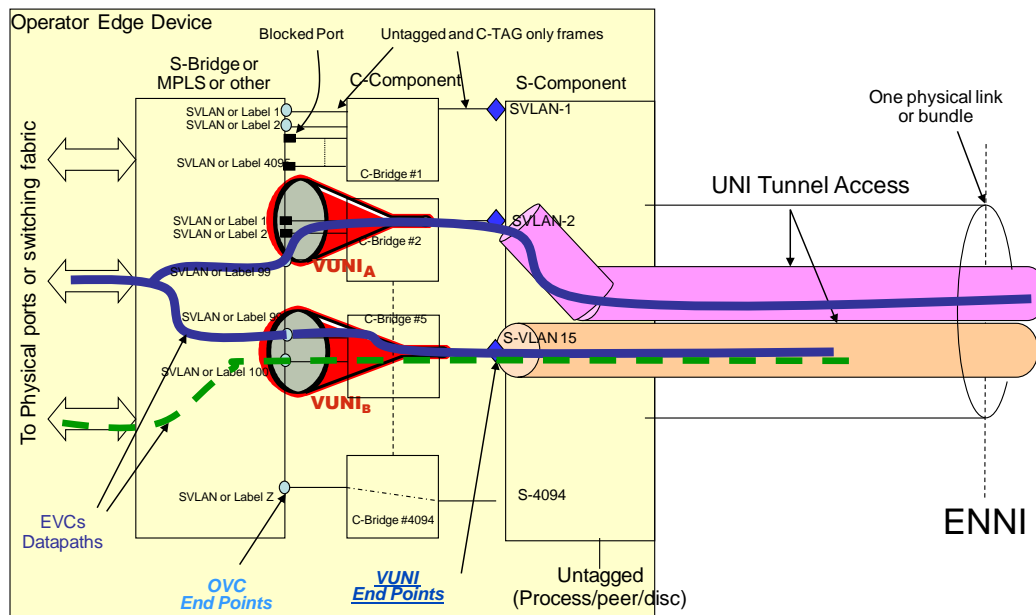
## 10 Appendix C: VUNI Implementation Example

This section describes how a VUNI could be implemented using the IEEE 802.1 Provider Bridge model as described in [IEEE 802.1ad]. The model uses C-VLAN components and S-VLAN components. (See 802.1Qbc for more details.)

**C-VLAN component:** A VLAN-aware bridge component that can recognize, insert, and remove Customer VLAN tags.

**S-VLAN component:** A VLAN-aware bridge component that can recognize, insert, and remove Service VLAN tags.

The example described in this section uses a C-VLAN component per Remote UNI. Figure 9 models the functions of an interface realizing the data path ENNI-N and VUNI functions.



**Figure 9 – VUNI Using IEEE 802.1 C and S Components Model**

The figure shows two VUNIs and 2 EVCs (dashed green and solid blue lines) supported by the tunnels. The dashed green EVC is a point-to-point EVC sharing a VUNI with the multipoint blue EVC. The multipoint blue EVC is associated with the two remote UNIs located on the other end of the two UTA OVCs. In this scenario, a frame in the blue EVC coming from a remote UNI, could be hairpin switched and sent to the other remote UNI.

### Life of a frame:

Ingress direction (going from the right to left in Figure 9):

An ENNI frame is received at the ENNI from the Network Operator that supports the UTA OVC. If it is untagged, it is not mapped to a VUNI End Point (or OVC End Point). If there is an S-TAG, the S-VLAN component maps the frame to the corresponding VUNI End Point based on the S-VLAN ID value and removes the S-TAG.

The frame is sent to a C-VLAN component associated with the VUNI End Point. The C-VLAN component will map the frame to one of its 4094 virtual ports based on the C-VLAN ID value.

The frame is received at the OVC End Point associated with the C-VLAN component virtual port by an entity which performs further encapsulation. The nature of this encapsulation is dependent on the VUNI Provider MEN and is out of the scope of this specification.

Egress direction (from left to right in Figure 9):

A frame associated with an OVC in the VUNI Provider MEN is received at an OVC End Point associated by a VUNI. The frame is stripped of the overhead used internally in the VUNI Provider MEN to identify the OVC End Point.<sup>16</sup>

The frame is received by C-VLAN Component which maps all the frames to the port connected to its VUNI End Point.

The frame is sent to the S-VLAN Component which adds the S-TAG and sends the now complete ENNI frame to the Network Operator MEN.

Note that a C-VLAN component is required to process L2CP PDUs according to the IEEE 802.1Q specifications.

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<sup>16</sup> It is assumed the VUNI Provider does not transport Service Frames natively in its MEN without encapsulating them further in order to segregate the traffic from various OVCs.

## 11 References

- [MEF 10.2] Metro Ethernet Forum, MEF 10.2, *Ethernet Services Attributes Phase 2*, October 2009.
- [MEF 23] Metro Ethernet Forum, MEF 23, Metro Ethernet Forum, *Implementation Agreement: Carrier Ethernet Class of Service – Phase 1*, June 2009.
- [MEF 26] Metro Ethernet Forum, MEF 26, *External Network Network Interface (ENNI) – Phase 1*, January 2010.
- [IEEE 802.1ad] IEEE Standard 802.1ad – *Provider Bridges*, May 2006.
- [IEEE P802.1Qbc] IEEE Draft Standard 802.1Qbc/D1.1 – *Virtual Bridged Local Area Network – Amendment: Provider Bridging – Remote Customer Service Interfaces*, Draft 1.1, February 2010.