



**MEF Standard**

**MEF 45.1**

# **Layer 2 Control Protocols in Ethernet Services**

**December 2018**

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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.

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

## **2 Abstract**

This document specifies the Service Attributes and requirements for handling Layer 2 Control Protocol (L2CP) Frames for Ethernet Services.

### 3 Terminology and Abbreviations

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

In addition, terms defined in MEF 6.2 [12], MEF 10.4 [13], MEF 26.2 [16], and MEF 51.1 [18] are included in this document by reference and are not repeated in table below. If Table 1 contains a definition for a term that is also defined in one of the documents listed above, the definition in Table 1 applies within the context of this document.

Term	Definition	Reference
<b>Carrier Ethernet Network</b>	A network from a Service Provider or network Operator supporting the MEF service and architecture models.	MEF 12.2 [14]
<b>CEN</b>	Carrier Ethernet Network	MEF 12.2 [14]
<b>Discard</b>	An action taken at an L2CP Decision Point where an L2CP Frame is neither delivered to a Protocol Entity, nor delivered to the External Interface where the L2CP Decision Point is located, nor propagated to L2CP Decision Points at other External Interfaces.	This document
<b>Filter</b>	An action that prevents a frame from being propagated within a bridge or within a network.	This document
<b>L2CP Decision Point</b>	Layer 2 Control Protocol Decision Point	This document
<b>Layer 2 Control Protocol Decision Point</b>	The fundamental element of the L2CP behavioral model that determines how an L2CP Frame is processed at an External Interface	This document
<b>Layer 2 Control Protocol Frame</b>	An L2CP Service Frame or L2CP ENNI Frame	This document
<b>Link Identifier</b>	A value that uniquely identifies a physical link at an EI. At a UNI this is equivalent to the <i>id</i> value in the 4-tuple in the Subscriber UNI List of Physical Links Service Attribute	This document
<b>Pass</b>	An action taken at an L2CP Decision Point where an L2CP Frame is either delivered to the External Interface where the L2CP Decision Point is located, or propagated to the L2CP Decision Points located at all other EVC End Points or OVC End Points associated by the EVC or OVC.	This document



<b>Term</b>	<b>Definition</b>	<b>Reference</b>
<b>Peer</b>	An action taken at an L2CP Decision Point where an L2CP Frame is delivered to a Protocol Entity determined by the Protocol Identifier in the L2CP Frame.	This document
<b>Protocol Entity</b>	A function that processes L2CP Frames according to the specification of the protocol identified within the L2CP Frame.	This document
<b>Protocol Identifier</b>	An LLC Address or EtherType, in some cases including a subtype, that follows the Source Address (or VLAN Tag or Tags if present) in a frame.	This document

**Table 1 – Terminology and Abbreviations**

## 4 Compliance Levels

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**NOT RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 (RFC 2119 [9], RFC 8174 [10]) when, and only when, they appear in all capitals, as shown here. All key words must be in bold text.

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

## 5 Introduction

This document specifies the processing of Layer 2 Control Protocol (L2CP) Frames for services spanning one or more Carrier Ethernet Networks (CEN). An L2CP Frame is defined as a frame that could be used in a recognized Layer 2 Control Protocol. This includes frames containing a Destination Address that is one of the 32 addresses reserved for control protocols by IEEE Std 802.1Q-2018 [4] (see Table 2 of this document). Processing of frames with a Destination Address that is not one of these 32 addresses is beyond the scope of this document.

This specification develops a behavior model of L2CP treatment for services delivered across single or multiple CENs. The model includes the attributes, behaviors, and requirements for passing, peering, or discarding L2CP Frames at a UNI [13], VUNI [16], and ENNI [16], as well as detailed peering requirements for selected protocols and/or services. The model is developed with a goal of promoting interoperability by minimizing configuration and providing testable requirements.

Requirements on Subscriber equipment are not within the scope of this document. Nonetheless, proper configuration of the Subscriber equipment with respect to L2CP is necessary to achieve proper operation of the protocols. Such configuration is typically protocol specific. One example is that if Link Aggregation is enabled at a UNI, both the Subscriber equipment and Operator equipment need to use the same Destination Address in Link Aggregation Control Protocol (LACP, [2]) Frames. Another example is that if an EP-LAN service passes Rapid Spanning Tree Protocol (RSTP, [4]) Frames at all UNIs, the service will look like shared media to the protocol, and therefore the Subscriber equipment should configure the RSTP port connected to the UNI as a port to shared media rather than a point-to-point link.

The remainder of this document is organized as follows:

- Section 6 provides an overview of the behaviors specified in IEEE Std 802.1Q [4] for frames using a Bridge Reserved Address or MRP Reserved Address as a Destination Address.
- Section 7 describes the behavioral model for the treatment of L2CP Frames in a CEN.
- Section 8 specifies the Service Attributes used to manage L2CP Frame processing.
- Section 9 specifies the detailed requirements for processing L2CP Frames in a CEN using the L2CP Service Attributes.
- Section 10 specifies the L2CP requirements for specific Ethernet Services defined by MEF.
- Section 11 provides the references used in this document.
- Appendix A contains use cases of Link Aggregation.
- Appendix B summarizes changes from MEF 45 to this document.

## 6 Background Information for L2CP

The L2CP processing specified in this document is based largely on the IEEE 802.1Q [4] specification for handling L2CP Frames. IEEE 802.1Q provides a mechanism for separating the Layer 2 control plane into multiple Subscriber Network and CEN control planes. It allows a protocol to operate solely within a CEN, or solely within a Subscriber Network, or to allow interaction between the Subscriber Network and the CEN. It additionally provides a mechanism for Subscriber L2CP Frames to pass transparently through a CEN while maintaining isolation from the control plane of other Subscriber Networks. It provides a set of forwarding rules, based on a set of Bridge Reserved Addresses and MRP Reserved Addresses, that allow an L2CP Frame using one of those addresses to be properly forwarded or filtered without requiring protocol-specific configuration. Most Layer 2 Control Protocols have been defined to use these addresses and to operate according to the IEEE 802.1Q rules. This document abstracts the IEEE 802.1Q rules for bridges to specifications for handling L2CP Frames at the External Interfaces of a CEN. This approach provides a high probability that IEEE 802 control protocols, and the Subscriber equipment using those protocols, will interoperate with the CEN.

The remainder of this section provides background on the IEEE 802.1Q mechanisms for handling L2CP Frames. The subsequent sections adapt this to a CEN model based on Service Attributes and requirements for the External Interfaces of the CEN.

### 6.1 L2CP Frames and L2CP Addresses

Within this document, an L2CP Frame includes any L2CP Service Frame (MEF 10.4 [13]) or L2CP ENNI Frame (MEF 26.2 [16]) with a Destination Address that is from one of two blocks of multicast addresses, shown in Table 2, that have been reserved by the IEEE 802.1 Working Group<sup>1</sup>. These addresses have special forwarding rules in IEEE 802.1 Bridges that facilitate the deployment and operation of Layer 2 Control Protocols. While a protocol that affects the configuration or operation of a Layer 2 network can use frames with ordinary unicast or multicast addresses, those protocols that are considered Layer 2 Control Protocols use these Bridge Reserved Addresses and MRP Reserved Addresses to take advantage of the special forwarding rules. Note that although the MEF does not specify what technology is used within a CEN, non-802.1 technologies can adopt these forwarding rules to assure correct operation of protocols using these addresses.

L2CP MAC Destination Addresses <sup>2</sup>	Description
01-80-C2-00-00-00 through 01-80-C2-00-00-0F	Bridge Reserved Addresses
01-80-C2-00-00-20 through 01-80-C2-00-00-2F	MRP Reserved Addresses

**Table 2 – List of Standardized L2CP Destination MAC Addresses**

<sup>1</sup> MEF 10.4 [13] and MEF 26.2 [16] allows a Service Provider to define additional addresses that result in frames containing those addresses to be considered L2CP Frames. Such frames are beyond the scope of this document.

<sup>2</sup>Hexadecimal canonical format

## 6.2 Bridge Reserved Addresses

The IEEE 802.1 Bridge Reserved Addresses<sup>3</sup> are shown in Table 3. The special forwarding rule for L2CP Frames with a Destination Address from this block is that a bridge, depending on the bridge type, will filter the frame. That is, the bridge will not propagate the frame from the ingress port to any other port of the bridge. The significance of this rule is that a Protocol Entity in one device can send a frame intended to reach a peer Protocol Entity in a neighboring device and be confident that the frame will not propagate beyond the neighboring device even if the neighbor does not actually recognize the protocol. This prevents the frame from propagating through the network to other devices where the information could be misinterpreted. Many protocols, including Link Aggregation Control Protocol (LACP, [2]), Link Layer Discovery Protocol (LLDP, [1]), Link Operation Administration and Management (Link OAM, [7]), and others rely on this forwarding behavior.

Different types of devices filter different subsets of the Bridge Reserved Addresses. End Stations, bridges that do not recognize VLAN tags (MAC Bridges) and bridges that recognize and respond to C-Tags (Customer Bridges and Provider Edge Bridges) apply the special forwarding rule to all of the addresses in the block. Bridges that recognize and respond only to S-Tags (Provider Bridges) apply the special forwarding rule to a subset of these addresses as shown in Table 3. Two Port MAC Relays (TPMRs) apply the special forwarding rule to a smaller subset of these addresses as shown in Table 3. The different subsets allow a sending device to select the type of device intended to receive the frame by the choice of Destination Address. For example, a frame with the Nearest Bridge Address (01-80-C2-00-00-0E) will only traverse a single link before it is filtered by the neighboring device. On the other hand a frame with the Nearest Customer Bridge Address (01-80-C2-00-00-00) will be forwarded through any TPMRs and Provider Bridges, including an entire Provider Network, and will not be peered or discarded until it reaches a Customer Bridge (or a device that does not forward Layer 2 frames such as a server or router).

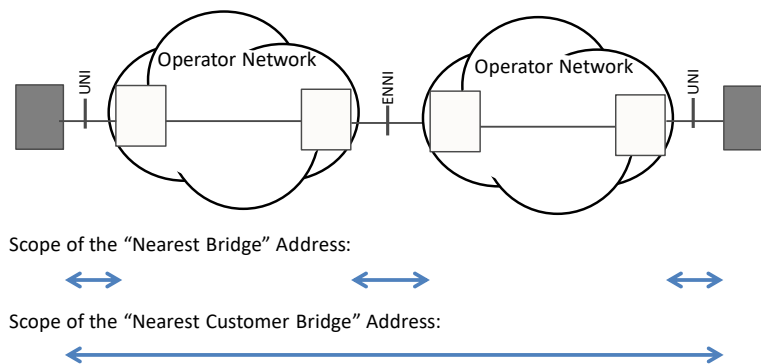
Address	Assignment	Filtered by:		
		End Station, MAC Bridge, Customer Bridge, Provider Edge Bridge	Provider Bridge	Two Port MAC Relay
01-80-C2-00-00-00	Nearest Customer Bridge	X		
01-80-C2-00-00-01	IEEE MAC Specific Control Protocols	X	X	X
01-80-C2-00-00-02	IEEE 802 Slow Protocols	X	X	X
01-80-C2-00-00-03	Nearest non-TPMR Bridge	X	X	
01-80-C2-00-00-04	IEEE MAC Specific Control Protocols	X	X	X
01-80-C2-00-00-05	Reserved for Future Standardization	X	X	
01-80-C2-00-00-06	Reserved for Future Standardization	X	X	

<sup>3</sup> All LANs Bridge Management Group Address (01-80-C2-00-00-10) was deprecated in IEEE Std 802.1Q-2005 (subclause 8.13.7) and there are no longer any special filtering requirements for this address.

Address	Assignment	Filtered by:		
		End Station, MAC Bridge, Customer Bridge, Provider Edge Bridge	Provider Bridge	Two Port MAC Relay
01-80-C2-00-00-07	Metro Ethernet Forum ELMF	X	X	
01-80-C2-00-00-08	Provider Bridge Group	X	X	
01-80-C2-00-00-09	Reserved for Future Standardization	X	X	
01-80-C2-00-00-0A	Reserved for Future Standardization	X	X	
01-80-C2-00-00-0B	Reserved for Future Standardization	X		
01-80-C2-00-00-0C	Reserved for Future Standardization	X		
01-80-C2-00-00-0D	Provider Bridge MVRP	X		
01-80-C2-00-00-0E	Nearest Bridge, Individual LAN Scope	X	X	X
01-80-C2-00-00-0F	Reserved for Future Standardization	X		

**Table 3 – Bridge Reserved Addresses**

In many cases, a single network device can run multiple instances of the same protocol, each transmitting and receiving frames with different Destination Addresses to communicate with devices in different parts of a network. For example, consider running LLDP between devices supporting the EPL service shown in Figure 1. The equipment in the Subscriber Network could run an instance of LLDP using the Nearest Bridge Address to communicate with equipment in the Service Provider Network across a UNI, and another instance of LLDP using the Nearest Customer Bridge Address to communicate with equipment in the Subscriber Network at a remote UNI.



**Figure 1 – Scope of Reserved MAC Addresses for an EPL**

In other cases, a single protocol running in different regions of a network will use a different address to maintain separation between protocol operation in the respective regions. For example, RSTP running in the Subscriber Network will use the Nearest Customer Bridge Address, and RSTP running in the CENs will use the Provider Bridge Group Address.

Note that each of the Bridge Reserved Addresses can be used by many different protocols. Initially, when the number of L2CPs was small, the IEEE specified different addresses for use by each protocol. Unfortunately this implied the address was specific to the protocol, and caused confusion as the number of L2CPs grew and the IEEE began to specify the same address for use by several different protocols. It is important to recognize that the Protocol Identifier in an L2CP Frame is what identifies the protocol. The Destination Address determines the intended recipient device for the frame. The protocol is determined by the Protocol Identifier, an LLC Address or EtherType, sometimes including a subtype, that follows the Source Address (or VLAN Tag or Tags if present) in the frame.

### 6.3 MRP Reserved Addresses

The IEEE 802.1 Multiple Registration Protocol (MRP) Addresses are a block of 16 addresses in the second row of Table 2. The special forwarding rule for any frame with one of these addresses as a destination is that a bridge will pass (section 7.1.3) the frame only if it does not peer (section 7.1.2) any protocol using this address. If the bridge peers any protocol using this address then it will either peer the frame (if the Protocol Identifier matches the peered protocol) or discard (section 7.1.1) the frame (if the Protocol Identifier does not match the peered protocol). This forwarding rule allows a Protocol Entity to send a frame to the nearest device that understands the protocol. Any intervening devices that do not understand the protocol will forward the frame. This is in contrast with the Bridge Reserved Address forwarding rule which calls for some types of intervening devices that do not understand the protocol to discard the frame. The MRP Reserved Address forwarding rule is useful for protocols such as Multiple MAC Registration Protocol (MMRP) that propagate information hop by hop between devices that run the protocol, but are tolerant of intervening devices that do not run the protocol.

## 7 The L2CP Behavioral Model

MEF specifications describe the characteristics of a service in terms of attributes and requirements of the interfaces (i.e. UNIs or ENNIs), virtual connections (i.e. EVCs or OVCs) and End Points (i.e. EVC End Points or OVC End Points) used to construct the service. The purpose of the L2CP behavioral model is to describe how a CEN handles L2CP Frames in these terms. Note that this model describes the behavior of the CEN per L2CP Frame, not per protocol.

The behavioral model describes the behavior of a CEN from two distinctly different viewpoints. One is the Subscriber viewpoint, from which the CEN is a monolithic network observable only at the UNIs. The other is the Operator viewpoint (including the Service Provider, Operators, and Super Operators), from which the overall network can be seen to consist (potentially) of multiple operator CENs and is observable at ENNIs as well as at UNIs. If the model were only concerned with the Subscriber viewpoint, it would be sufficient to describe the overall behavior of the network simply in terms of the end results observable at UNIs. It would not be important to know specifically where in the network the actions occurred that resulted in the observed behavior. In the case of a multiple CEN service, it is important to know the actions taken on L2CP Frames at External Interfaces and between External Interfaces.

In the multiple CEN case, the reasons for specifying behavior at and between External Interfaces include:

- In a multi-CEN network, it is necessary to know which Operator is responsible for peering or discarding an L2CP Frame when that is the expected behavior from the Subscriber viewpoint. In some cases, it might be the responsibility of the Operator with the ingress UNI, but in a scenario with a Feeder OVC [16], for example, it might make more sense for it to be the responsibility of the Operator with the VUNI [16].
- Clear identification of the actions expected from each Operator Network in a multi-CEN service, which promotes interoperability and facilitates CEN interconnect.
- A multi-CEN network has different types of interfaces (UNIs and ENNIs with or without VUNIs), and the L2CP actions can be different depending on the interfaces involved. For example, an ingress L2CP ENNI Frame might be delivered unchanged as an egress L2CP ENNI Frame at an ENNI associated by the OVC, but peered or discarded at an egress UNI.
- At an ENNI it is necessary to specify how L2CP Frames for protocols controlling the CEN are differentiated from L2CP Frames for protocols controlling the Subscriber Network.

The L2CP behavioral model resolves these issues by describing behavior as ingress actions or egress actions that take place at an External Interface. It is important to recognize that the model is a tool used to describe the expected behavior, not a specification of how a CEN is implemented. An action that the model describes as an ingress action at a UNI need not be implemented in the



actual device that provides the physical interface for the UNI. The only constraint on the Operator or Service Provider is that the externally observable behavior matches the behavior described by the model.

### 7.1 The L2CP Decision Point

The basic construct of the L2CP behavioral model is an L2CP Decision Point that determines how an L2CP Frame is processed at an External Interface. Figure 2 shows the representation of this L2CP Decision Point in L2CP behavioral model diagrams. L2CP Frames that enter the L2CP Decision Point from the External Interface will either be passed to the EVC (or OVC), or peered by redirecting the frame to a Protocol Entity, or discarded. The black dots in Figure 2 represent these three options. In the other direction, L2CP Frames that enter the L2CP Decision Point from the EVC (or OVC) will either be passed to the External Interface, or peered by redirecting the frame<sup>4</sup> to a Protocol Entity, or discarded. The white dots in Figure 2 represent these three options. In a CEN, there is one L2CP Decision Point for each UNI and ENNI, and a further L2CP Decision Point for each VUNI at an ENNI.

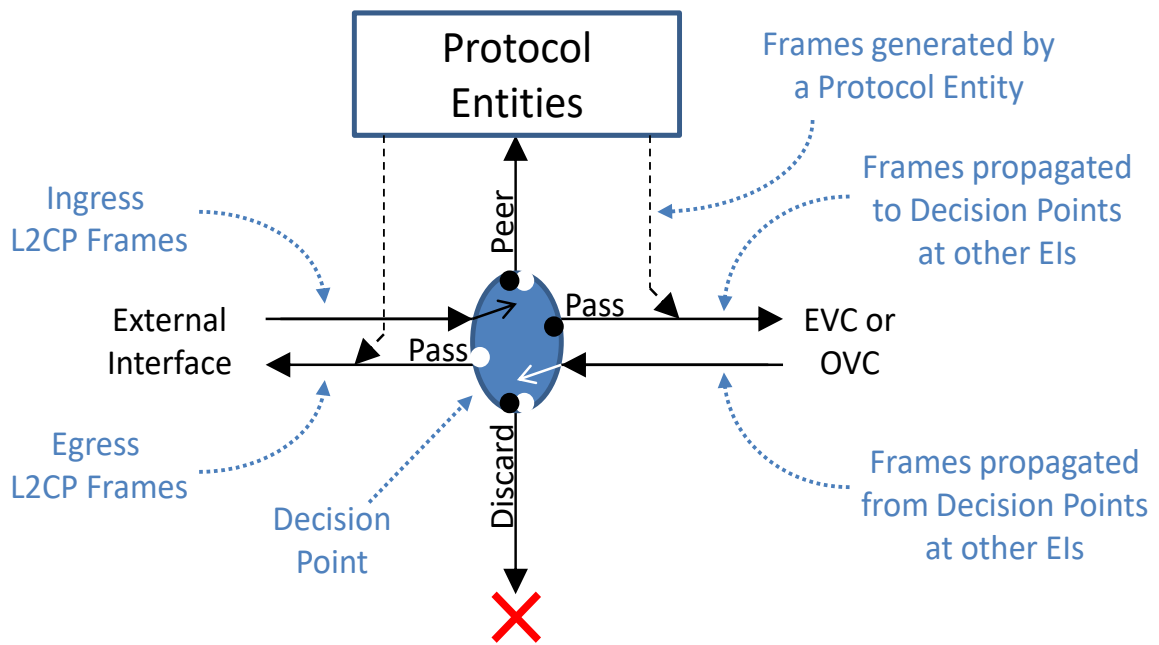


Figure 2 – L2CP Decision Point

The action taken for a given L2CP Frame at a given L2CP Decision Point depends upon the Destination Address and the Protocol Identifier within the frame, and upon the configured values of the L2CP Service Attributes.

The definitions and associated requirements of the L2CP Service Attributes are specified in section 8. The detailed description of how the L2CP Decision Point determines the action taken for a given L2CP Frame is specified in the flow charts and requirements in section 9. For the purposes of

<sup>4</sup> MEF does not mandate how the content of a frame is forwarded within a CEN. For simplicity of discourse, we say that the frame (or a copy of the frame) is propagated, but any method of forwarding the content of the frame is acceptable.

understanding the model, it is sufficient to know that the three possible actions at an L2CP Decision Point are Discard, Peer, or Pass.

### 7.1.1 Discard

Discard means the L2CP Frame is neither peered nor propagated toward any External Interface (EI). As an ingress action at an EI, this means the frame will not be propagated to any EI. As an egress action at an EI, this means the frame will not result in an egress L2CP Frame at that EI.

### 7.1.2 Peer

Peer means the L2CP Frame is delivered to a Protocol Entity that participates in the specific Layer 2 Control Protocol determined by the Protocol Identifier (EtherType or LLC Address) in the frame. The Protocol Entity qualifies and potentially processes the frame according to the specification of the particular protocol. (These protocol specifications are typically published by other standards organizations, and are beyond the scope of this document.) Qualifying the frame is protocol specific and can include validating the Destination Address, VLAN ID, Protocol Identifier, version number, length, TLV format, etc. Processing the frame is also protocol specific and can include:

- changing local state information,
- invoking actions based on the contents of the frame,
- generating an egress L2CP Frame at the External Interface,
- generating an L2CP Frame that is propagated on an EVC or OVC to all External Interfaces associated by that EVC or OVC or
- ignoring the frame (taking no action).

Note that the Protocol Entity typically does not process an L2CP Frame by generating an identical L2CP Frame, however that behavior is not explicitly prohibited.

### 7.1.3 Pass

Pass means the L2CP Frame is handled in the same manner as a Data Frame with a multicast Destination Address. As an egress action at an EI, this results in an egress L2CP Frame at that EI. As an ingress action at an EI, this results in the propagation of the frame to the L2CP Decision Point at all other EIs associated by the EVC or OVC to which the L2CP Frame is mapped. The mechanism of mapping of L2CP Frames to an EVC End Point or OVC End Point is the same as the mapping of Data Frames. The propagation of L2CP Frames within the CEN is subject to the same constraints as Data Frames<sup>5</sup>. For example:

- Frames at a UNI that do not map to any EVC End Point or OVC End Point, and frames at a ENNI that do not map to any OVC End Point, are not propagated.

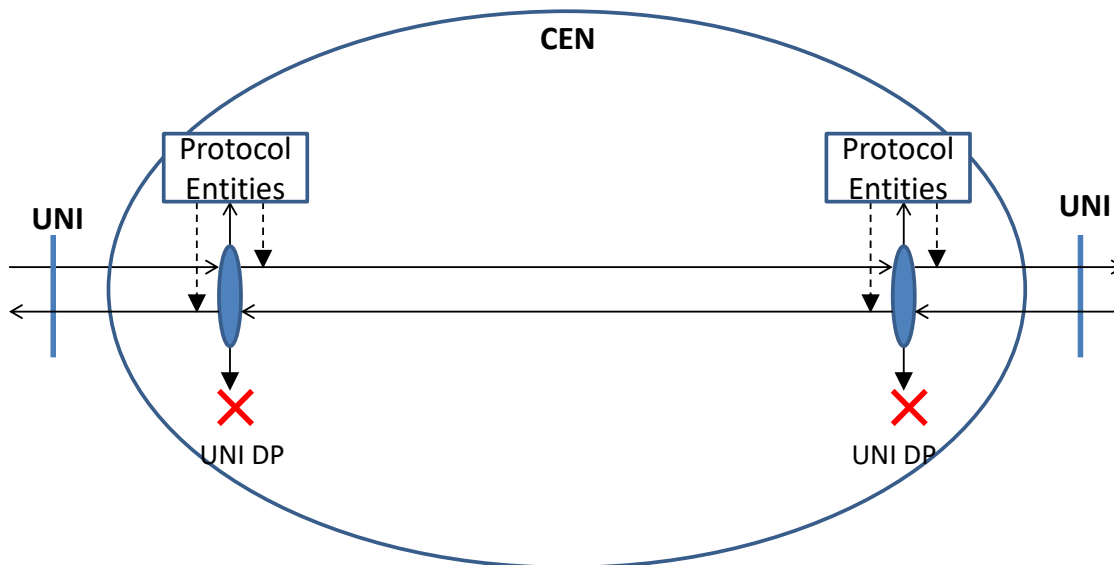
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<sup>5</sup> Note that the performance objectives for L2CP Frames may differ from Data Frames since L2CP Frames can map to a different Class of Service Name than Data Frames.

- For Rooted Multipoint EVCs [13] and OVCs [16], frames that ingress at a Leaf are not propagated to another Leaf.
- Frames that are declared Red by an Ingress Bandwidth Profile are not propagated.

### 7.2 Subscriber View of the L2CP Behavioral Model

Figure 3 shows the Subscriber view of the L2CP behavioral model. This figure represents a simple case where there are two UNIs associated by a single EVC, but more complex examples are easily constructed. There is an L2CP Decision Point for each UNI. How the model is used to specify L2CP behavior can be seen by following an L2CP Frame through the network.



**Figure 3 – Subscriber L2CP Behavioral Model**

When an ingress L2CP Service Frame enters the network at one of the UNIs, it is evaluated by a UNI L2CP Decision Point that determines whether the frame is to be discarded, peered, or passed. The L2CP Decision Point at the ingress UNI is referred to as the ingress L2CP Decision Point for the frame. If the determination of the ingress L2CP Decision Point is to pass the frame, it will be mapped to an EVC and the frame will be propagated to the L2CP Decision Point at all other UNIs associated by that EVC. These L2CP Decision Points are referred to as the egress L2CP Decision Points for the frame, and the frame at this point is referred to as a potential egress frame. The egress L2CP Decision Point evaluates the potential egress frame and determines whether it is to be discarded, peered, or passed. If the frame is passed then it results in an egress L2CP Service Frame at that UNI.

The behavior observed between any pair of UNIs is the combination of the determinations made by the ingress and egress L2CP Decision Points. If either L2CP Decision Point discards the frame then the ingress L2CP Service Frame does not result in an egress L2CP Service Frame. If either L2CP Decision Point peers the frame then the ingress L2CP Service Frame is not delivered to any

other EI, however there could be indirect protocol specific results of the peering that would be observable as described in section 7.1.2. If both L2CP Decision Points pass the frame then the ingress L2CP Service Frame at one UNI can result in an egress L2CP Service Frame at the other UNI.

The model can also be used to describe L2CP behavior not directly triggered by an ingress L2CP Service Frame at a UNI. For example, when there is a Protocol Entity for a particular protocol at a UNI L2CP Decision Point, that Protocol Entity can generate frames that are subsequently observed as egress L2CP Service Frames at that UNI. Some protocols propagate information within the network by generating frames that are propagated to the L2CP Decision Points at all other UNIs associated by the EVC. Unless these frames are passed at an egress UNI L2CP Decision Point they will never be observable as an egress L2CP Service Frame, but in a multi-CEN network they could be observable at an ENNI.

### 7.3 Service Provider and Super Operator View of the L2CP Behavioral Model

This section describes the Service Provider (SP) and Super Operator (SO) view of the L2CP behavioral model. In the SP/SO view of a CEN, the L2CP behavior is determined by L2CP Decision Points at each EI.

Figure 4 represents a simple case where there are two UNIs associated by a single EVC that spans two CENs via a single ENNI, but more complex examples are easily constructed, including examples with Super Operators. There are L2CP Decision Points for each UNI and each ENNI in each CEN. How the model is used to specify L2CP behavior can be seen by following an L2CP Frame through the network.

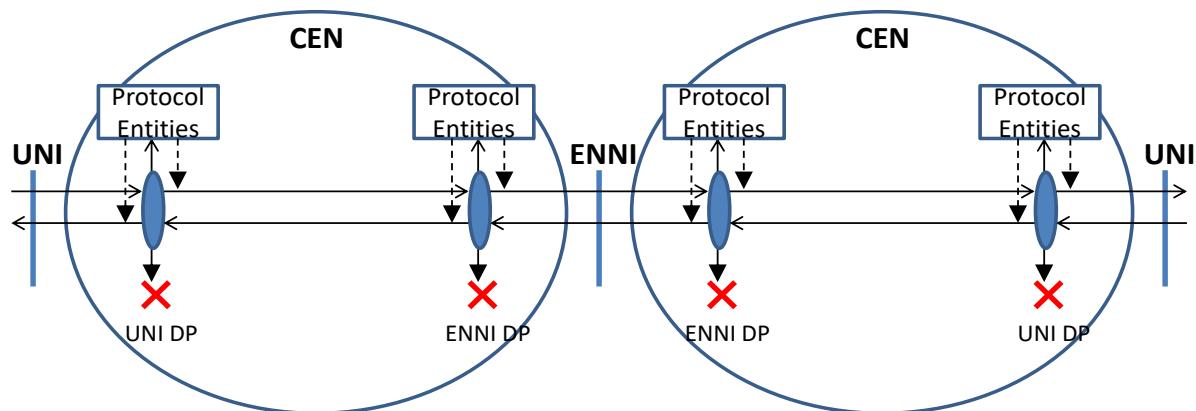


Figure 4 – Service Provider L2CP Behavioral Model

When an ingress L2CP Service Frame enters the network at one of the UNIs, it is evaluated by a UNI L2CP Decision Point that determines whether the frame is to be discarded, peered, or passed. If the determination of the ingress L2CP Decision Point is to pass the frame, it will be mapped to an OVC and propagated to the L2CP Decision Point at all other OVC End Points associated by that OVC. These L2CP Decision Points are referred to as the egress L2CP Decision Points, and a frame at an egress L2CP Decision Point is referred to as a potential egress frame. The egress Decision Point then evaluates the frame and determines whether it is to be discarded, peered, or

passed. If the frame is passed at an egress ENNI L2CP Decision Point, then it results in an egress L2CP ENNI Frame at that ENNI, which in turn results in an ingress L2CP ENNI Frame in the other Operator Network. The ingress L2CP ENNI Frame is evaluated at an ENNI L2CP Decision Point, and the process described for the first Operator Network repeats in the second Operator Network. The L2CP Frame can be peered or discarded at any of the L2CP Decision Points, but as long as it is passed it continues to propagate just as a Data Frame would through the interconnected Operator Networks.

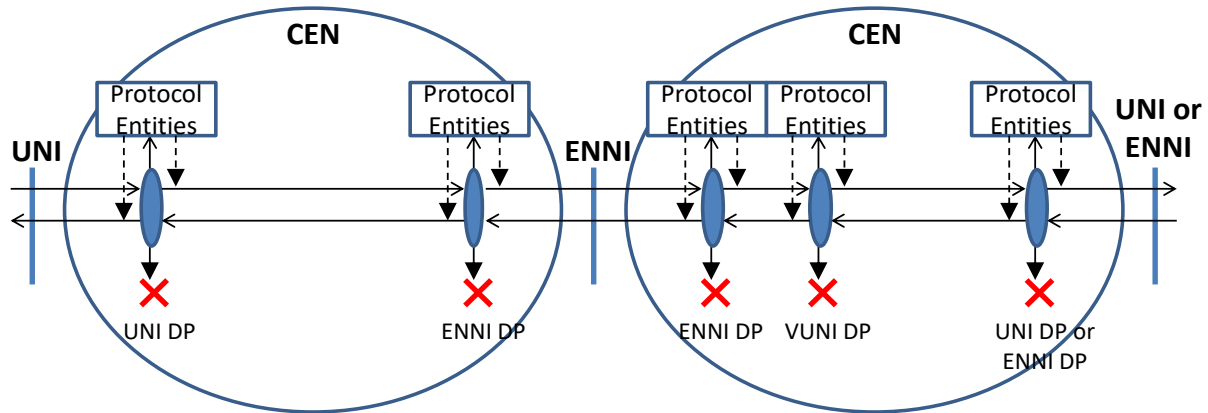
Focusing on a single Operator Network, the behavior observed between any pair of External Interfaces is the combination of the determinations made by the ingress and egress L2CP Decision Points within that Operator Network. If either L2CP Decision Point discards the frame, then the ingress L2CP Frame does not result in an egress L2CP Frame. If either L2CP Decision Point peers the frame, then the ingress L2CP Frame does not result in an egress L2CP Frame, however there could be indirect protocol specific results of the peering that would be observable. If both L2CP Decision Points pass the frame, then the ingress L2CP Frame at one EI can result in an egress L2CP Frame at the other EI.

The behavior observed between any pair of UNIs associated by an EVC that spans multiple Operator Networks is the combination of the determinations made by all of the L2CP Decision Points encountered in each of the Operator Networks between the UNIs. The L2CP Service Attributes in the Operator/SP agreements are specified such that the behavior observed between the UNIs is the same as the behavior determined by the specification of the L2CP Service Attributes in the Subscriber/SP agreement.

Note that an L2CP Frame observed at an ENNI could have resulted from an ingress L2CP Service Frame at one of the UNIs, or could have resulted from an L2CP Frame generated by a Protocol Entity in an Operator Network. The latter case includes frames associated with Operator Network Layer 2 Control Protocols, used to control some aspect of the CEN operation, that are not associated with any Subscriber Network Layer 2 Control Protocols carried on a service within the Operator Network. A typical example of a Operator Network protocol is LACP running at an ENNI to provide active and standby links for the ENNI. The L2CP behavioral model, together with the Service Attributes, flow charts and requirements of sections 8 and 9, determine the behavior related to both Subscriber Network and Operator Network L2CP Frames.

### 7.3.1 L2CP Behavioral Model with a VUNI

Figure 5 shows the L2CP behavioral model for a CEN with a VUNI. The figure shows a simple case with a single VUNI at the ENNI and a single OVC End Point in the VUNI, but more complex examples are easily constructed. At an ENNI with one or more VUNIs, there is a VUNI L2CP Decision Point for each VUNI in addition to the ENNI L2CP Decision Point.



**Figure 5 – L2CP Behavioral Model with a VUNI**

An ingress L2CP ENNI Frame with an S-VLAN ID that maps to a VUNI is first evaluated by the ENNI L2CP Decision Point and subsequently evaluated by the VUNI L2CP Decision Point. Either L2CP Decision Point can peer or discard the frame. If it is passed by both L2CP Decision Points then it is propagated, subject to the same propagation constraints as Data Frames, to all other OVC End Points associated by the OVC.

An L2CP Frame received at another External Interface and propagated to an OVC End Point in a VUNI is first evaluated by the VUNI L2CP Decision Point and subsequently evaluated by the ENNI L2CP Decision Point. Either L2CP Decision Point can peer or discard the frame. If it is passed by both L2CP Decision Points then it can result in an egress L2CP ENNI Frame.

## 8 L2CP Service Attributes

The behavior of an L2CP Decision Point is governed by a set of Service Attributes. The Subscriber UNI Service Attributes (Table 4) govern the way an L2CP Decision Point processes L2CP Service Frames at a UNI from the Subscriber viewpoint. The Operator Service and Multilateral Attributes (Table 5) govern the way an L2CP Decision Point processes L2CP Frames at a UNI, VUNI, or ENNI from the SP/SO viewpoint.

L2CP Decision Point Location	Subscriber Service Attributes Used by L2CP Decision Point
UNI	<ul style="list-style-type: none"> <li>• Subscriber UNI L2CP Peering Service Attribute</li> <li>• Subscriber UNI L2CP Address Set Service Attribute</li> </ul>

**Table 4 – Subscriber Service Attributes for L2CP Decision Points**

L2CP Decision Point Location	Operator Service Attributes Used by L2CP Decision Point
UNI	<ul style="list-style-type: none"> <li>• Operator UNI L2CP Peering Service Attribute</li> <li>• Operator UNI L2CP Address Set Service Attribute</li> </ul>
VUNI	<ul style="list-style-type: none"> <li>• VUNI L2CP Peering Service Attribute</li> <li>• VUNI L2CP Address Set Service Attribute</li> </ul>
ENNI	<ul style="list-style-type: none"> <li>• ENNI L2CP Peering Multilateral Attribute</li> <li>• ENNI Tagged L2CP Frame Processing Multilateral Attribute</li> <li>• OVC L2CP Address Set Service Attribute (for each OVC with an OVC End Point at the ENNI)</li> </ul>

**Table 5 – Operator Service Attributes for L2CP Decision Points**

### 8.1 L2CP Address Set Service Attribute

The term L2CP Address Set Service Attribute is a generic term that applies to the Subscriber UNI L2CP Address Set Service Attribute, Operator UNI L2CP Address Set Service Attribute, VUNI



L2CP Address Set Service Attribute, or OVC L2CP Address Set Service Attribute. An L2CP Address Set Service Attribute specifies the subset of the Bridge Reserved Addresses that are filtered (i.e., L2CP Frames with this Destination Address are peered or discarded but not passed) at an L2CP Decision Point. In the description of the Bridge Reserved Addresses in section 6.2, it is noted that different types of 802.1 Bridges filter different subsets of these addresses, depending on whether or not they recognize C-Tags. This distinction is incorporated into MEF Ethernet Services by the introduction of an L2CP Address Set Service Attribute.

The values for an L2CP Address Set Service Attribute are defined as follows:

- C-Tag Aware (*CTA*), for services where the presence of a C-Tag is considered when mapping a frame to the service.
- C-Tag Blind (*CTB*), for services where the presence of a C-Tag is not considered when mapping a frame to the service.
- C-Tag Blind Option 2 (*CTB-2*), for point-to-point services where the presence of a C-Tag is not considered when mapping a frame to the service, and that service supports the EPL Option 2 L2CP processing (described below).

The subsets of the Bridge Reserved Addresses filtered for each of these values is defined in Table 6. When the value is *CTA* or *CTB*, the subset of the Bridge Reserved Addresses is consistent with the Provider Edge Bridge or Provider Bridge columns, respectively, of Table 3. The processing of L2CP Frames at an L2CP Decision Point is also consistent with IEEE 802.1Q [4] and is specified in the flow diagrams in sections 9.1 and 9.2. The value *CTB-2* is provided specifically to support an EPL Service where transparency is emphasized over adherence to IEEE 802.1Q [4] by allowing some L2CP Frames to be passed that would normally be discarded or peered. This is referred to as “EPL Option 2 L2CP processing” and is specified in section 9.1.1. Note that EPL Option 2 L2CP processing can compromise proper operation of many protocols, including LACP, LLDP, Link OAM, E-LMI, PTP, and ESMC.



L2CP Destination Address	802.1Q [4] Assignment	Filtered by:		
		CTA	CTB	CTB-2
01-80-C2-00-00-00	Nearest Customer Bridge	X		
01-80-C2-00-00-01	IEEE MAC Specific Control Protocols	X	X	X
01-80-C2-00-00-02	IEEE 802 Slow Protocols	X	X	
01-80-C2-00-00-03	Nearest non-TPMR Bridge	X	X	
01-80-C2-00-00-04	IEEE MAC Specific Control Protocols	X	X	
01-80-C2-00-00-05	Reserved for Future Standardization	X	X	
01-80-C2-00-00-06	Reserved for Future Standardization	X	X	
01-80-C2-00-00-07	Metro Ethernet Forum ELMI	X	X	
01-80-C2-00-00-08	Provider Bridge Group	X	X	
01-80-C2-00-00-09	Reserved for Future Standardization	X	X	
01-80-C2-00-00-0A	Reserved for Future Standardization	X	X	
01-80-C2-00-00-0B	Reserved for Future Standardization	X		
01-80-C2-00-00-0C	Reserved for Future Standardization	X		
01-80-C2-00-00-0D	Provider Bridge MVRP	X		
01-80-C2-00-00-0E	Nearest Bridge, Individual LAN Scope	X	X	
01-80-C2-00-00-0F	Reserved for Future Standardization	X		

**Table 6 – L2CP Address Sets**

For a Subscriber Ethernet Service defined using the Service Attributes in MEF 10.4 [13], there is an L2CP Address Set Service Attribute for each UNI. For an Operator Ethernet Service defined using the Service Attributes in MEF 26.2 [16], there is an L2CP Address Set Service Attribute for each UNI, VUNI, and OVC. Note that the value of the L2CP Address Set Service Attribute agreed between a SP and a Subscriber at a UNI may be different to the value the SP agrees with an Operator. The OVC L2CP Address Set Service Attribute supplants the need for an ENNI L2CP Address Set Service Attribute. Were it not for the need to support EPL services with EPL Option 2 L2CP processing at an ENNI then an ENNI would always have behavior corresponding to an L2CP Address Set value of *CTB*. Having an L2CP Address Set per OVC allows an ENNI to support EPL services with EPL Option 2 L2CP processing for OVCs supporting such services.

The constraints on the Subscriber UNI L2CP Address Set Service Attribute are specified in [R1] through [R4]:

- [R1] When the EVC EP Map Service Attribute = *List* or *UT/PT* for the EVC EP(s) at a UNI, then the Subscriber UNI L2CP Address Set Service Attribute **MUST** have a value of *CTA*.
- [R2] When the EVC EP Map Service Attribute = *All* for the EVC EP at a UNI, and the EVC Type Service Attribute = *Multipoint-to-Multipoint* or *Rooted-Multipoint*, then the Subscriber UNI L2CP Address Set Service Attribute **MUST** have a value of *CTB*.

- [R3] When the EVC EP Map Service Attribute = *All* for the EVC EP at a UNI, and the EVC Type Service Attribute = *Point-to-Point*, then the Subscriber UNI L2CP Address Set Service Attribute **MUST** have a value of *CTB* or *CTB-2*.

A consequence of R1 through R3 is that if the Subscriber UNI L2CP Address Set Service Attribute has a value of *CTB-2*, there is a single EVC EP at the UNI in an EVC with EVC Type Service Attribute value of *Point-to-Point*.

- [R4] When the Subscriber UNI L2CP Service Attribute at a UNI is *CTB-2*, then the Subscriber UNI L2CP Address Set Service Attribute at the other UNI associated by that EVC **MUST** have a value of *CTB-2*.

Given the constraints on the EVC EP Map Service Attribute in MEF 10.4 [13], a consequence of [R1] through [R4] is that the value of the Subscriber UNI L2CP Address Set Service Attribute will be the same at all UNIs associated by a given EVC.

The constraints on the Operator UNI, VUNI, and OVC L2CP Address Set Service Attributes are specified in [R5] through [R9]:

- [R5] If an OVC has an OVC End Point at a UNI where not all CE-VLAN ID values map to that OVC End Point, or the OVC has an OVC End Point in a VUNI where not all ENNI CE-VLAN IDs map to that OVC End Point, then the value of the OVC L2CP Address Set Service Attribute **MUST** be *CTA*.
- [R6] If an OVC has an OVC Type Service Attribute = *Point-to-Point*, and both OVC End Points are at an ENNI and not in a VUNI or one OVC End Point is at an ENNI and not in a VUNI and the other is at a UNI where all CE-VLAN ID values map to that OVC End Point, then the value of the OVC L2CP Address Set Service Attribute **MUST** be *CTB* or *CTB-2*.
- [R7] If an OVC does not meet the conditions of [R5] or [R6], then the value of the OVC L2CP Address Set Service Attribute **MUST** be *CTB*.
- [R8] If an OVC has an OVC End Point at a UNI, then the value of the Operator UNI L2CP Address Set Service Attribute **MUST** be the same as the OVC L2CP Address Set Service Attribute.
- [R9] If an OVC has an OVC End Point in a VUNI, then the value of the VUNI L2CP Address Set Service Attribute **MUST** be the same as the OVC L2CP Address Set Service Attribute.

A consequence of [R5] through [R9] is that the value of all Operator UNI L2CP Address Set Service Attributes and VUNI L2CP Address Set Service Attributes will be the same at all OVC End Points at a UNI or in a VUNI that are associated by a given OVC. Also, at a given UNI or VUNI, the value of the Operator UNI L2CP Address Set Service Attributes or VUNI L2CP Address Set Service Attributes will be the same for all OVC End Points at that UNI or in that VUNI.

When a SP/SO implements an EVC or OVC using one or more constituent Operator Ethernet Services, it is the responsibility of the SP/SO to ensure that the L2CP behavior of these constituent Operator Ethernet Services is consistent with the EVC or OVC. This implies the following restrictions:

- When an EVC associates UNIs with the Subscriber UNI L2CP Address Set Service Attribute equal to *CTA*, at least one of the constituent OVCs needs to have the OVC L2CP Address Set Service Attribute equal to *CTA*, and there can be one or more constituent OVCs with the OVC L2CP Address Set Service Attribute equal to *CTB*.
- When an EVC associates UNIs with the Subscriber UNI L2CP Address Set Service Attribute equal to *CTB*, all constituent OVCs should have the OVC L2CP Address Set Service Attribute equal to *CTB*.
- When an EVC associates UNIs with the Subscriber UNI L2CP Address Set Service Attribute equal to *CTB-2*, all constituent OVCs need to have the OVC L2CP Address Set Service Attribute equal to *CTB-2*.

## 8.2 L2CP Peering Service Attribute

The term L2CP Peering Service Attribute is a generic term that applies to the Subscriber UNI L2CP Peering Service Attribute, Operator UNI L2CP Peering Service Attribute, VUNI L2CP Peering Service Attribute, or ENNI L2CP Peering Multilateral Attribute. The L2CP Peering Service Attribute is a list of Layer 2 Control Protocols that will be peered by a Protocol Entity at a UNI, VUNI, or ENNI. Each entry in the list specifies the Protocol Identifier and the Destination Address in use by the Protocol Entity. An example is shown in Table 7. Notice that the Protocol Identifier is either an LLC Address or an EtherType, and that it could have subtypes. The list specifies only the L2CP Frames that are to be peered. Any L2CP Frame that is not peered will either be discarded or passed as a result of the flow charts and requirements specified in section 9.

Protocol to be Peered (not part of L2CP Peering Service Attribute)	L2CP Peering Service Attribute	
	Protocol Identifier	L2CP Destination Address
Link Aggregation (LACP)	EtherType: 0x8809 Subtypes: 01,02	01-80-C2-00-00-02
Link OAM	EtherType: 0x8809 Subtype: 03	01-80-C2-00-00-02
E-LMI	EtherType: 0x88EE	01-80-C2-00-00-07
Spanning Tree (RSTP/MSTP)	LLC Address: 0x42	01-80-C2-00-00-00

**Table 7 – Example L2CP Peering Service Attribute**

In a Subscriber Ethernet Service (described using the Service Attributes from MEF 10.4 [13]), there is a Subscriber UNI L2CP Peering Service Attribute for each UNI. In an Operator Ethernet Service (described using the Service Attributes in MEF 26.2 [16]), there is an Operator UNI L2CP Peering Service Attribute for each UNI, an ENNI L2CP Peering Multilateral Attribute for each ENNI, and a VUNI L2CP Peering Service Attribute for each VUNI at an ENNI.

When Link Aggregation is used at an EI, its purpose is to make the multiple physical links appear to be a single logical link to the attached devices and thus a single EI to the CEN. Most Layer 2 Control Protocols operate over the EI as a single logical link and hence are agnostic to the individual physical link selected to carry the protocol frames, however some (e.g., LLDP, ESMC, PTP) can operate over the individual physical links. It is even possible that a protocol (e.g., ESMC, PTP) could operate on some, but not all, of the physical links. In this situation, the entry in the L2CP Peering Service Attribute can include a Link Identifier. When the Link Identifier is included in a list entry, Ingress L2CP Frames that match the entry will only be peered if the L2CP Frame was received on the identified link. If no Link Identifier is specified then the list entry will apply to all links. For L2CP Frames that are propagated to an L2CP Decision Point from an EVC or OVC, the Link Identifier in the list entry is disregarded.

- [R10]** The L2CP Peering Service Attribute value **MUST** be an empty list, or a list of entries identifying protocols to be peered where each entry consists of {Destination Address, Protocol Identifier} or {Destination Address, Protocol Identifier, Link Identifier}.

Table 8 contains a list of some Layer 2 Control Protocols and a reference to the standard that specifies the protocol. The Protocol Identifiers and L2CP Destination Addresses in the table are specified by the cited references. This document does not preclude the use of addresses other than those listed in this table. The protocols may generate VLAN-tagged, priority-tagged, or untagged frames as specified in the cited references.

Layer 2 Control Protocol	Protocol Identifier	L2CP Destination Addresses	Ref
Link Aggregation Control/Marker Protocol (LACP)	EtherType: 0x8809 Subtypes: 0x01, 0x02	01-80-C2-00-00-00 01-80-C2-00-00-02 01-80-C2-00-00-03	[2]
802.3 Operations, Administration, and Maintenance (Link OAM)	EtherType: 0x8809 Subtype: 0x03	01-80-C2-00-00-02	[7]
Ethernet Synchronization Messaging Channel (ESMC)	EtherType: 0x8809 Subtype: 0x0A	01-80-C2-00-00-02	[11]
Precision Time Protocol Peer-Delay (PTP)	EtherType: 0x88F7	01-80-C2-00-00-0E	[8]
Ethernet Local Management Interface (E-LMI)	EtherType: 0x88EE	01-80-C2-00-00-07	[15]
Link Layer Discovery Protocol (LLDP)	EtherType: 0x88CC	01-80-C2-00-00-00 01-80-C2-00-00-03 01-80-C2-00-00-0E	[1]
Virtual Station Interface Discovery and Configuration Protocol (VDP)	EtherType: 0x8940 Subtype: 0x0001	01-80-C2-00-00-00	[4]
Port Extender Control and Status Protocol (PE-CSP)	EtherType: 0x8940 Subtype: 0x0002	01-80-C2-00-00-03	[5]
Port-Based Network Access Control	EtherType: 0x888E	01-80-C2-00-00-00 01-80-C2-00-00-03 01-80-C2-00-00-0E	[6]
802.3 MAC Control: PAUSE	EtherType: 0x8808 Subtype: 0x0001	01-80-C2-00-00-01	[7]
802.3 MAC Control: Priority Flow Control (PFC)	EtherType: 0x8808 Subtype: 0x0101	01-80-C2-00-00-01	[4]
802.3 MAC Control: Multipoint MAC Control	EtherType: 0x8808 Subtype: 0x0002-0x0006	01-80-C2-00-00-01	[7]
802.3 MAC Control: Organization Specific Extensions	EtherType: 0x8808 Subtype: 0xFFFE	01-80-C2-00-00-01	[7]
Rapid/Multiple Spanning Tree Protocol (RSTP/MSTP)	LLC Address: 0x42	01-80-C2-00-00-00 01-80-C2-00-00-08	[4]
Shortest Path Bridging (SPB)	LLC Address: 0xFE	01-80-C2-00-00-2E 01-80-C2-00-00-2F	[4]
Multiple MAC Registration Protocol (MMRP)	EtherType: 0x88F6	01-80-C2-00-00-20	[4]
Multiple VLAN Registration Protocol (MVRP)	EtherType: 0x88F5	01-80-C2-00-00-21 01-80-C2-00-00-0D	[4]
Multiple Stream Registration Protocol (MSRP)	EtherType: 0x22EA	01-80-C2-00-00-0E	[4]
Multiple ISID Registration Protocol (MIRP)	EtherType: 0x8929	01-80-C2-00-00-00	[4]

**Table 8 – Selected Layer 2 Control Protocols**

All recommendations and requirements for EPL services with EPL Option 2 L2CP processing are to either discard or pass L2CP Frames at all UNIs (section 9.1.1). Therefore, the following constraint is recommended on the L2CP Peering Service Attribute:

- [D1] When the UNI L2CP Address Set Service Attribute is *CTB-2*, the UNI L2CP Peering Service Attribute **SHOULD** be an empty list.

For Ethernet Services where all frames map to a single service at a UNI or VUNI, any L2CP Frame with a Bridge Reserved Address in Table 6 but not in the *CTB* subset of Table 6 is to be passed at all L2CP Decision Points. Therefore, the following constraints are placed on the L2CP Peering Service Attribute:

- [R11] When the Subscriber UNI, Operator UNI, or VUNI L2CP Address Set Service Attribute is *CTB*, any entry in the Subscriber UNI, Operator UNI, or VUNI L2CP Peering Service Attribute **MUST NOT** have a Destination Address that is in Table 6 but not in the *CTB* subset of Table 6.
- [R12] Any entry in the ENNI L2CP Peering Multilateral Attribute **MUST NOT** have a Destination Address that is in Table 6 but not in the *CTB* subset of Table 6.

### 8.2.1 Requirements for Peering Specific Layer 2 Control Protocols

MEF 10.4 [13] and MEF 26.2 [16] define Service Attributes that determine whether peering LACP is required at a UNI and/or ENNI.

- [R13] When the value of the Subscriber UNI Link Aggregation Service Attribute is "*2-Link Active/Standby*" or "*All-Active*", the Subscriber UNI L2CP Peering Service Attribute at that UNI **MUST** list LACP with a "Slow Protocols" Destination Address (01-80-C2-00-00-02), and a Protocol Identifier consisting of the "Slow Protocols" EtherType value (0x8809) and the LACP and LAMP subtypes (01, 02).
- [R14] When the value of the Operator UNI Link Aggregation Service Attribute is "*2-Link Active/Standby*" or "*All-Active*", the Operator UNI L2CP Peering Service Attribute at that UNI **MUST** list LACP with a "Slow Protocols" Destination Address (01-80-C2-00-00-02), and a Protocol Identifier consisting of the "Slow Protocols" EtherType value (0x8809) and the LACP and LAMP subtypes (01, 02).
- [R15] When the value of the ENNI Link Aggregation Common Attribute is "*2-Link Active/Standby*" or "*All-Active*", the ENNI L2CP Peering Multilateral Attribute at that ENNI **MUST** list LACP with a "Slow Protocols" Destination Address (01-80-C2-00-00-02), and a Protocol Identifier consisting of the "Slow Protocols" EtherType value (0x8809) and the LACP and LAMP subtypes (01, 02).

MEF 10.4 [13] and MEF 26.2 [16] define Service Attributes that determine whether peering Link OAM is required at a UNI and/or ENNI.

- [R16] When the Subscriber UNI Link OAM Service Attribute is *Enabled*, the Subscriber UNI L2CP Peering Service Attribute at that UNI **MUST** list Link OAM with a "Slow Protocols" Destination Address (01-80-C2-00-00-02), and a Protocol Identifier consisting of the "Slow Protocols" EtherType value (0x8809) and the Link OAM subtype (03).



[R17] When the Operator UNI Link OAM Service Attribute is *Enabled*, the Operator UNI L2CP Peering Service Attribute at that UNI **MUST** list Link OAM with a “Slow Protocols” Destination Address (01-80-C2-00-00-02), and a Protocol Identifier consisting of the “Slow Protocols” EtherType value (0x8809) and the Link OAM subtype (03).

[R18] When the ENNI Link OAM Common Attribute is *Enabled*, the ENNI L2CP Peering Multilateral Attribute at that ENNI **MUST** list Link OAM with a “Slow Protocols” Destination Address (01-80-C2-00-00-02), and a Protocol Identifier consisting of the “Slow Protocols” EtherType value (0x8809) and the Link OAM subtype (03).

MEF 10.4 [13] defines a Service Attribute that determines whether peering Precision Time Protocol (PTP) is required at a UNI.

[R19] When the Subscriber UNI List of Physical Links Service Attribute includes one or more links with *pt* equal to *Enabled*, the Subscriber UNI L2CP Peering Service Attribute at that UNI **MUST** list PTP with a Individual LAN Scope Destination Address (01-80-C2-00-00-0E), a Protocol Identifier consisting of the PTP EtherType value (0x88F7) and the *id* for each link with *pt* equal to *Enabled*.

### 8.3 ENNI Tagged L2CP Frame Processing Multilateral Attribute

The ENNI Tagged L2CP Frame Processing Multilateral Attribute reflects the capability of the ENNI to process Tagged L2CP ENNI Frames in an IEEE 802.1 compliant manner. Although almost all Layer 2 Control Protocols generate Untagged L2CP Frames, some do generate Tagged L2CP Frames (e.g., MMRP). Tagged L2CP ENNI Frames also result from L2CP Service Frames that ingress at a UNI and are subsequently passed by L2CP Decision Points. The special forwarding rules for the Bridge and MRP Reserved Addresses specified in 802.1Q [4] and discussed in section 6 apply to both Tagged and Untagged L2CP Frames, however the EPL with EPL Option 2 L2CP processing requirements conflict with these rules. It can be difficult for some ENNI implementations to apply the special forwarding rules for some OVCs but not for others. Therefore, this specification recommends applying the special forwarding rules to Tagged L2CP ENNI Frames mapping to OVCs supporting a service other than EPL with EPL Option 2 L2CP processing, but allows implementations to simply pass any Tagged L2CP ENNI Frames (see section 9.2).

The allowed values for the ENNI Tagged L2CP Frame Processing Multilateral Attribute are “*802.1 compliant*” or “*802.1 non-compliant*”. A value of *802.1 compliant* means the ENNI will apply the special forwarding rules to Tagged L2CP ENNI Frames that map to a VUNI or an OVC End Point supporting a service other than EPL with EPL Option 2 L2CP processing. A value of *802.1 non-compliant* means the ENNI will pass any Tagged L2CP ENNI Frames. There is an ENNI Tagged L2CP Frame Processing Multilateral Attribute for each ENNI.

[D2] The value of the ENNI Tagged L2CP Frame Processing Multilateral Attribute **SHOULD** be *802.1 compliant*.

When the value of the ENNI Tagged L2CP Processing Multilateral Attribute is *802.1 non-compliant*, it is possible that some Tagged L2CP ENNI Frames will be passed that are mandated to be discarded by the IEEE 802.1 architecture. This could cause protocols that depend upon the discard action to fail.



## 9 L2CP Processing Requirements

L2CP Decision Points at each ENNI, UNI and VUNI determine whether to Peer, Pass, or Discard an L2CP Frame based upon the L2CP Service Attributes defined above and the requirements specified below. Within this section, the “UNI L2CP Address Set” means the Subscriber UNI L2CP Address Set when applied to an L2CP Decision Point at a UNI for a Subscriber Ethernet Service, or the Operator UNI L2CP Address Set Service Attribute when applied to an L2CP Decision Point at a UNI for an Operator Ethernet Service.

### 9.1 UNI and VUNI L2CP Frame Processing Requirements

The flow chart in Figure 6 specifies the action taken on an L2CP Frame at a UNI or VUNI L2CP Decision Point when the L2CP Address Set Service Attribute has a value of *CTA* or *CTB*. When the L2CP Address Set Service Attribute has a value of *CTB-2*, the actions taken at a UNI L2CP Decision Point are specified in section 9.1.1.

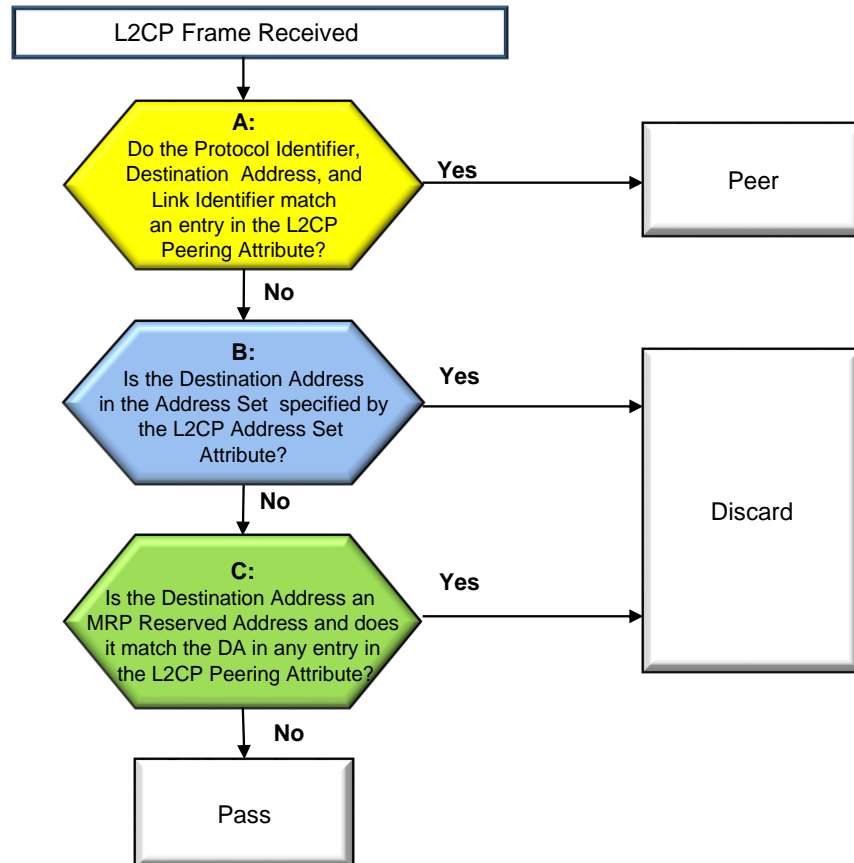
The flow chart is used to determine both ingress actions in response to an ingress L2CP Service Frame, and egress actions in response to a potential egress L2CP Frame propagated to this UNI from an L2CP Decision Point at another EI. L2CP Frames generated by a Protocol Entity at the UNI are not processed according to the flow chart.

At a UNI L2CP Decision Point, the inputs to the flow chart are the UNI L2CP Address Set and UNI L2CP Peering Service Attributes and the Destination Address and Protocol Identifier in the L2CP Frame. For ingress L2CP Frames, the Link Identifier of the link upon which the ingress L2CP Frame was received is also an input.

**[R20]** When the UNI L2CP Address Set is *CTA* or *CTB*, the flow chart in Figure 6 **MUST** be used to determine whether the action for an L2CP Frame at a UNI L2CP Decision Point is Peer, Pass, or Discard.

At a VUNI L2CP Decision Point, the inputs to the flow chart are the VUNI L2CP Address Set and VUNI L2CP Peering Service Attributes and the Destination Address and Protocol Identifier in the L2CP Frame. At a VUNI L2CP Decision Point, the S-tag in the L2CP ENNI Frame is ignored, and if the action taken is peer then the contents of the frame without the S-tag are acted upon by the appropriate Protocol Entity.

**[R21]** When the VUNI L2CP Address Set is *CTA* or *CTB*, the flow chart in Figure 6 **MUST** be used to determine whether the action for an L2CP Frame at a VUNI L2CP Decision Point is Peer, Pass, or Discard.



**Figure 6 – Flow Chart for UNI and VUNI L2CP Decision Points**

The first decision block in the flow chart (A) determines whether the L2CP Frame will be peered by comparing the Destination Address and Protocol Identifier in the L2CP Frame with the list entries configured in the UNI (or VUNI) L2CP Peering Service Attribute. For an ingress L2CP Frame, also compare the Link Identifier of the link upon which the L2CP Frame was received with the list entries. Note that if an entry has no Link Identifier then that entry applies to every link.

If the L2CP Frame is not peered, the second decision block (B) determines whether it will be discarded by comparing the Destination Address of the L2CP Frame with the specific set of Bridge Reserved Addresses checked in the column of Table 6 that corresponds to the configured value of the UNI L2CP Address Set.

As described in section 6.3, the special forwarding rule for MRP Reserved Addresses is that if any protocol using an MRP Reserved Address is peered, then no frames with that address will be passed. The first decision block (A) assures that frames with an MRP Reserved Address and Protocol Identifier that are listed in the L2CP Peering Service Attribute will be peered (and therefore not passed). The third decision block (C) assures that frames with that MRP Reserved Address but a different Protocol Identifier will be discarded (and therefore not passed).

If the L2CP Frame is not peered or discarded then it will be passed.

Recall from section 7.1.3 that an L2CP Frame that is passed is still subject to the same propagation constraints as a Data Frame, and in particular any L2CP Frame that does not map to any EVC or OVC End Point will not be propagated to L2CP Decision Points at other External Interfaces.

**9.1.1 UNI L2CP Frame Processing for EPL Option 2 L2CP Processing**

When the UNI L2CP Address Set value is *CTB-2*, Table 9 and Table 10 specify the action taken on an L2CP Frame at a UNI L2CP Decision Point. The behavior specified by Table 9 and Table 10 is known as EPL Option 2 L2CP Processing. The VUNI L2CP Address Set Service Attribute cannot be *CTB-2*, per the requirements in section 8.1. Note that the EPL Option 2 L2CP processing has L2CP processing requirements that are NOT in line with the current IEEE standards: 1588-2008 [8], 802.1Q-2018 [4], 802.1AB-2009 [1], and 802.1X-2010 [6].

The first column of Table 9 and Table 10 identifies the protocol requiring special action for EPL Option 2 L2CP processing. The second column is the Protocol Identifier. The third column is the Destination Address. The fourth column specifies the required UNI L2CP Decision Point action for a frame with matching Protocol Identifier and Destination Address.

**[R22]** If the value of the UNI L2CP Address Set Service Attribute is *CTB-2*, and an L2CP Frame at a UNI L2CP Decision Point has a Destination Address and Protocol Identifier matching an entry in Table 9, then the frame **MUST** be processed as specified in Table 9.

Protocol Type	Protocol Identifier	L2CP Destination Address	L2CP Action
STP[3]/RSTP[4]/MSTP[4]	LLC Address: 0x42	01-80-C2-00-00-00	Pass
E-LMI[15]	EtherType: 0x88EE	01-80-C2-00-00-07	Pass <sup>6</sup>
LLDP[1]	EtherType: 0x88CC	01-80-C2-00-00-0E	Pass
PTP Peer Delay[8]	EtherType: 0x88F7	01-80-C2-00-00-0E	Pass
GARP[4]/MRP[4] Reserved Address	any	01-80-C2-00-00-20 through 01-80-C2-00-00-2F	Pass

**Table 9 – EPL Option 2 L2CP Processing Requirements**

**[D3]** If the value of the UNI L2CP Address Set Service Attribute is *CTB-2*, and an L2CP Frame at a UNI L2CP Decision Point has a Destination Address and Protocol Identifier matching an entry in Table 10, then the frame **SHOULD** be processed as specified in Table 10.

<sup>6</sup> When using EPL Option 2, it is recommended for the Subscriber to turn off E-LMI in the equipment that is attached to the UNI. Trying to run E-LMI with EPL Option 2 in this equipment may lead to unpredictable results.

Protocol Type	Protocol Identifier	L2CP Destination Address	L2CP Action
PAUSE[7]	EtherType: 0x8808 Subtype: 0x0001	01-80-C2-00-00-01	Discard
LACP/LAMP[2]	EtherType: 0x8809 Subtypes: 0x01, 0x02	01-80-C2-00-00-02	Pass
Link OAM[7]	EtherType: 0x8809 Subtype: 0x03	01-80-C2-00-00-02	Pass
Port Authentication[6]	EtherType: 0x888E	01-80-C2-00-00-03	Pass
ESMC[11]	EtherType: 0x8809 Subtype: 0x0A	01-80-C2-00-00-02	Pass <sup>7</sup>

**Table 10 – EPL Option 2 L2CP Processing Recommendations**

Table 9 and Table 10 only specify actions for selected combinations of Protocol Identifier and Destination Address. It is recommended that the flow chart in Figure 6 be used to determine the UNI L2CP Decision Point action for L2CP Frames with other combinations of Protocol Identifier and Destination Address.

**[D4]** If the value of the UNI L2CP Address Set Service Attribute is *CTB-2*, and an L2CP Frame at a UNI L2CP Decision Point has a combination of Protocol Identifier and Destination Address not listed in Table 9 or Table 10, then the flow chart in Figure 6 **SHOULD** be used to determine whether the action for an L2CP Frame at a UNI L2CP Decision Point is Peer, Pass, or Discard.

**9.1.2 Example L2CP Frame Evaluation at a UNI or VUNI L2CP Decision Point**

For example, consider an ingress L2CP Service Frame that is an LLDP Frame with the Nearest Customer Bridge Destination Address (01-80-C2-00-00-00) being evaluated by the L2CP Decision Point at a UNI. Note that although this example is written in terms of an ingress L2CP Service Frame at a UNI, it is also applicable to an ingress L2CP ENNI Frame at a VUNI.

If the UNI L2CP Address Set is *CTB-2* then the LLDP Frame will be processed according to Table 9, however Table 9 does not have an entry for LLDP Frames with this Destination Address. Therefore [D4] recommends the frame be processed according to the flow chart in Figure 6. If the UNI L2CP Address set is *CTA* or *CTB* then the LLDP Frame will always be processed according to the flow chart in Figure 6.

If this protocol with this Destination Address is listed in the UNI L2CP Peering Subscriber UNI L2CP Address Set Service Attribute then the frame will be peered as a result of decision block A.

<sup>7</sup> When using EPL Option 2, it is recommended for the Subscriber to turn off ESMC in the equipment that is attached to the UNI. Trying to run ESMC with EPL Option 2 in this equipment may lead to unpredictable results. ESMC Frames that are passed by L2CP Decision Points may not accurately represent the state of the timing attributes of the physical interface to which the Subscriber interface is attached.

Note that [R11] forbids this Protocol Identifier and DA combination from being listed when the L2CP Address Set is *CTB*.

If the LLDP Frame was not peered as a result of decision block A, then the evaluation process continues with decision block B. If the UNI L2CP Address Set value is *CTA* then, since the Destination Address is in the *CTA* subset of Table 6, the LLDP Frame will be discarded. If the UNI L2CP Address Set value is *CTB* or *CTB-2* then, since the Destination Address is not in the *CTB* or *CTB-2* subset of Table 6, the evaluation will continue with decision block C.

The LLDP Frame will not be discarded at decision block C since the Destination Address is not an MRP Reserved Address. Therefore if it is not peered as a result of decision block A, or discarded as a result of decision block B, then the LLDP Frame will be passed.

## 9.2 ENNI L2CP Processing Requirements

The action taken on an L2CP Frame by an ENNI L2CP Decision Point is described by the flow chart in Figure 7. The flow chart uses the configuration of the ENNI L2CP Peering Multilateral Attribute, the OVC L2CP Address Set Service Attribute for OVCs that have an OVC End Point at the ENNI, the ENNI Tagged L2CP Frame Processing Multilateral Attribute, and the Destination Address, Protocol Identifier and S-VLAN ID in the L2CP Frame, to determine whether the action taken will be to Peer, Discard or Pass the L2CP Frame. For ingress L2CP Frames, the Link Identifier of the link upon which the ingress L2CP Frame was received may also affect the determination.

The flow chart is used to determine both ingress actions in response to an ingress L2CP ENNI Frame, and egress actions in response to a potential egress L2CP Frame propagated to this ENNI from another L2CP Decision Point. L2CP Frames generated by a Protocol Entity for the ENNI L2CP Decision Point are not processed according to the flow chart. For egress actions, the potential egress frame is assumed to be S-Tagged with an S-VLAN ID value determined by the OVC End Point Map for the OVC End Point at that ENNI.

**[R23]** The flow chart in Figure 7 **MUST** be used to determine whether the action for an L2CP Frame at a ENNI L2CP Decision Point is Peer, Pass, or Discard.

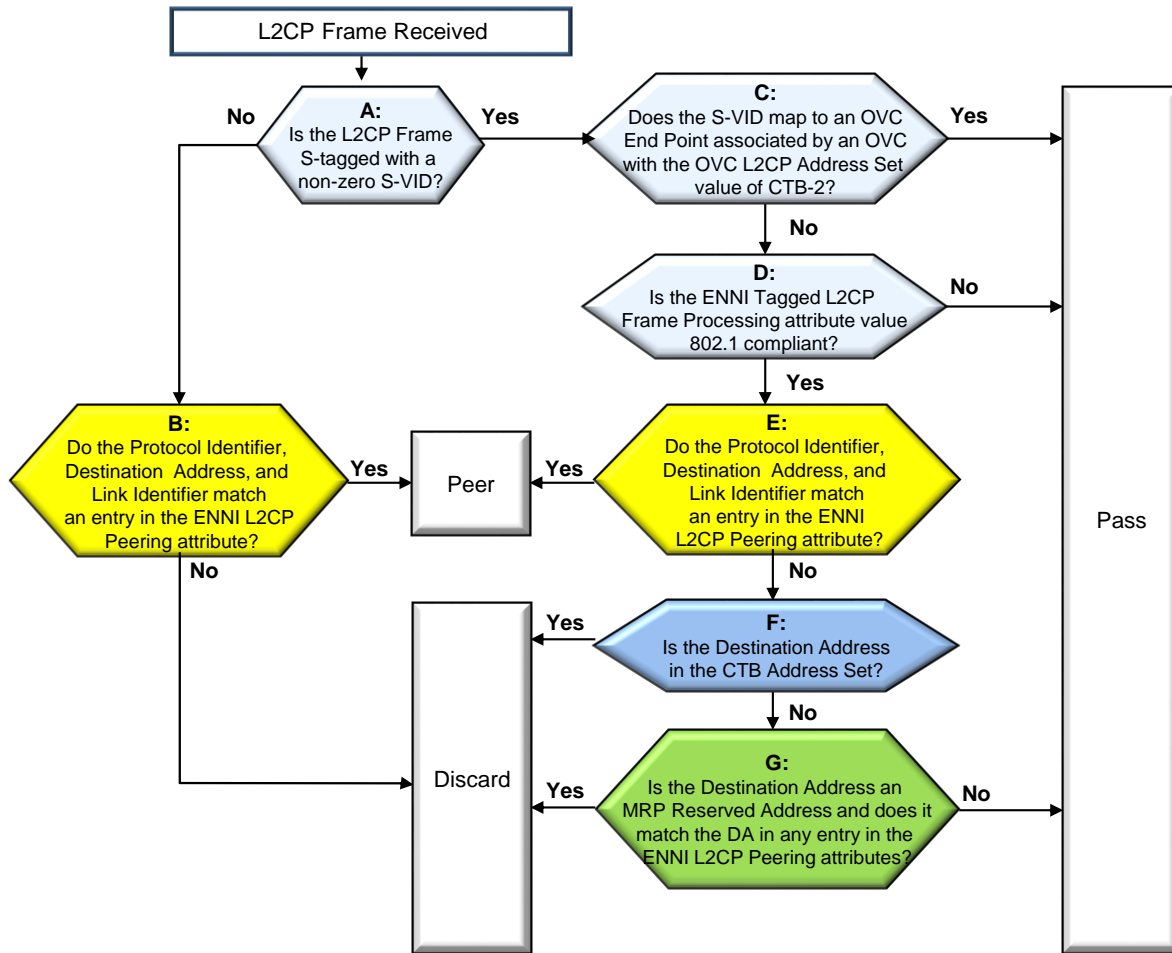


Figure 7 – Flow Chart for ENNI L2CP Decision Point

The first decision block in the flow chart (A) separates VLAN Tagged L2CP ENNI Frames, from Untagged and Priority Tagged L2CP ENNI Frames. The second decision block (B) determines whether an Untagged or Priority Tagged L2CP ENNI Frame will be peered by comparing the Destination Address and Protocol Identifier in the frame, and for ingress L2CP Frames, the Link Identifier of the link upon which the frame was received, with the list entries configured in the ENNI L2CP Peering Multilateral Attribute. Since an Untagged or Priority Tagged L2CP ENNI Frame cannot be mapped to any OVC End Point, it cannot be passed. Therefore, if it is not peered, it is discarded.

The third decision block (C) determines whether the VLAN Tagged L2CP ENNI Frame maps to an OVC End Point associated by an OVC supporting an EPL service with EPL Option 2 L2CP processing. If so then the frame is passed. Otherwise, including the case where the VLAN Tagged L2CP ENNI Frame maps to a VUNI, processing continues with decision block (D).

The fourth decision block (D) determines whether the L2CP processing implementation at the ENNI supports *802.1 compliant* processing of Tagged L2CP ENNI Frames (see section 8.3). If not then the frame is passed.



The fifth decision block (E) determines whether a VLAN Tagged L2CP ENNI Frame will be peered by comparing the Destination Address and Protocol Identifier in the L2CP Frame, and for ingress L2CP Frames, the Link Identifier of the link upon which the frame was received, with the list entries configured in the ENNI L2CP Peering Multilateral Attribute.

If the L2CP Frame is not peered, the sixth decision block (F) determines whether it will be discarded by comparing the Destination Address of the L2CP Frame with the specific set of Bridge Reserved Addresses checked in the *CTB* column of Table 6.

As described in section 6.3, the special forwarding rule for MRP Reserved Addresses is that if any protocol using an MRP Reserved Address is peered, then no frames with that address will be passed. The fifth decision block (E) assures that frames with an MRP Reserved Address and Protocol Identifier that are listed in the ENNI L2CP Peering Multilateral Attribute will be peered (and therefore not passed). The seventh decision block (G) assures that frames with that MRP Reserved Address but a different Protocol Identifier will be discarded (and therefore not passed).

Otherwise the frame is passed.

Recall from section 7.1.3 that an L2CP Frame that is passed is still subject to the same propagation constraints as a Data Frame, and in particular any L2CP Frame with an S-VLAN ID value that does not map to any OVC End Point will not be propagated.

### 9.2.1 Example L2CP Frame Evaluation at a ENNI L2CP Decision Point

For a first example, consider the LLDP Frame from the example in 9.1.2. Specifically consider the case where the LLDP Frame was passed by the ingress UNI L2CP Decision Point and propagated to an OVC End Point at an ENNI for evaluation by an ENNI L2CP Decision Point. Since all potential egress L2CP Frames at an ENNI are associated with an OVC End Point that maps to a non-zero S-VLAN ID, the result of decision block A will be to proceed to decision block C.

If the OVC Address Set Service Attribute is *CTB-2* then decision block C will cause the frame to be passed. Otherwise, if the ENNI implementation does not support processing of Tagged L2CP ENNI Frames, then decision block D will cause the frame to be passed. Otherwise the processing continues with decision block E.

The address of the LLDP Frame from the example in section 9.1.2 is the Nearest Customer Bridge Address. Since this address is not in the *CTB* subset of Table 6, there cannot be an entry in the ENNI L2CP Peering Multilateral Attribute that matches this frame (per [R11]). Therefore the frame will not be peered. Since the address is not in the *CTB* subset of Table 6, nor is it an MRP Reserved Address, the frame will not be discarded as a result of decision blocks F or G. The final decision will be to pass the frame.

For a second example, consider an ingress LLDP Frame that is an Untagged L2CP ENNI Frame. At an ENNI L2CP Decision Point, decision block B will result in this frame being peered if there is a matching entry for the LLDP protocol in the ENNI L2CP Peering Multilateral Attribute, and discarded otherwise.

## 10 Service Requirements for L2CP

The requirements from previous sections impose some constraints on the allowable values of the L2CP Service Attributes for Ethernet Services defined in MEF 6.2 [12] and MEF 51.1 [18]. These constraints are summarized in the following tables.

### 10.1 EVPL, EVP-LAN, and EVP-Tree Service Requirements

The Service Attribute and parameter requirements pertaining to L2CP for EVPL, EVP-LAN and EVP-Tree service types defined in MEF 6.2 [12] are shown in Table 11.

Subscriber UNI Service Attributes	EVPL, EVP-LAN, EVP-Tree Service Type Requirement
L2CP Address Set	[R1] applies, so value is <i>CTA</i> .
L2CP Peering	No additional constraints from section 8.1

**Table 11 – Subscriber UNI L2CP Service Attributes for EVPL, EVP-LAN, and EVP-Tree service types**

### 10.2 EPL, EP-LAN, and EP-Tree Service Requirements

The Service Attribute and parameter requirements pertaining to L2CP for EPL, EP-LAN and EP-Tree service types defined in MEF 6.2 [12] are shown in Table 12.

Subscriber UNI Service Attributes	EPL, EP-LAN, EP-Tree Service Type Requirement
L2CP Address Set	EPL: [R3] applies, so value is <i>CTB</i> or <i>CTB-2</i> . EP-LAN: [R2] applies, so value is <i>CTB</i> . EP-TREE: [R2] applies, so value is <i>CTB</i> .
L2CP Peering	No additional constraints from section 8.1

**Table 12 – Subscriber UNI L2CP Service Attributes for EPL, EP-LAN, and EP-Tree service types**



### 10.3 E-Access and E-Transit Service Requirements

The L2CP requirements in this section apply to the E-Access and E-Transit Services defined in MEF 51.1 Operator Ethernet Service Definitions [18].

Note that it is the responsibility of the Service Provider or Super Operator (MEF 26.2 [16]) to order an OVC appropriate for the requirements of the EVC. MEF 26.2 [16] Appendix H Tables 52, 54, and 55 describe the relationship of the L2CP Service Attributes when a Service Provider provides an EVC to a Subscriber, and implements the EVC using a number of OVCs obtained from underlying Operators.

#### 10.3.1 Access E-Line and Access E-LAN Service Requirements

The Service Attribute and parameter requirements pertaining to L2CP for Access E-Line and Access E-LAN services are shown in Table 13, Table 14, and Table 15. The Access E-Line requirements also apply to MEF 62 Managed Access E-Line Services [19] and MEF 43 Virtual NID (vNID) Functionality for E-Access Services [17]<sup>8</sup>.

Operator UNI Service Attributes	Access E-Line, Access E-LAN Service Type Requirement
L2CP Address Set	<p>When not all CE-VLAN IDs map to the same OVC End Point, [R5] and [R8] apply so the value is <i>CTA</i>.</p> <p>When all CE-VLAN IDs map to the same OVC End Point for an Access E-Line Service, [R6] and [R8] apply so the value is <i>CTB</i> or <i>CTB-2</i>.</p> <p>When all CE-VLAN IDs map to the same OVC End Point for an Access E-LAN Service, [R7] and [R8] apply so the value is <i>CTB</i>.</p>
L2CP Peering	No additional constraints from section 8.1

**Table 13 – Operator UNI L2CP Service Attribute for Access E-Line, Access E-LAN**

<sup>8</sup> MEF 43 is based upon an E-Access Service that was specified in MEF 33, which has been superseded by MEF 51.1. The L2CP requirements for an E-Access Service are the same as for an Access E-Line Service as specified in MEF 51.1.

OVC Service Attributes	Access E-Line, Access E-LAN Service Type Requirement
L2CP Address Set	<p>When not all CE-VLAN IDs map to the same OVC End Point at the UNI(s), [R5] applies so the value is <i>CTA</i>.</p> <p>When all CE-VLAN IDs map to the same OVC End Point at the UNI for an Access E-Line Service, [R6] applies so the value is <i>CTB</i> or <i>CTB-2</i>.</p> <p>When all CE-VLAN IDs map to the same OVC End Point at the UNI(s) for an Access E-LAN Service, [R7] applies so the value is <i>CTB</i>.</p>

**Table 14 – OVC L2CP Service Attribute for Access E-Line, Access E-LAN**

ENNI Multilateral Attributes	Access E-Line, Access E-LAN Service Type Requirement
L2CP Peering	No additional constraints from section 8.1
ENNI Tagged L2CP Frame Processing	No additional constraints from section 8.3

**Table 15 – ENNI L2CP Multilateral Attributes for Access E-Line, Access E-LAN**

**10.3.2 Transit E-Line and Transit E-LAN Service Requirements**

The Service Attribute and parameter requirements pertaining to L2CP for Transit E-Line and Transit E-LAN services are shown in Table 16 and Table 17.

OVC Service Attributes	Transit E-Line, Transit E-LAN Service Type Requirement
L2CP Address Set	<p>Transit E-Line Service: [R6] applies so the value is <i>CTB</i> or <i>CTB-2</i>.</p> <p>Transit E-LAN Service: [R7] applies so the value is <i>CTB</i>.</p>

**Table 16 – OVC L2CP Service Attribute for Transit E-Line, Transit E-LAN**

<b>ENNI Multilateral Attributes</b>	<b>Transit E-Line, Transit E-LAN Service Type Requirement</b>
L2CP Peering	No additional constraints from section 8.1
ENNI Tagged L2CP Frame Processing	No additional constraints from section 8.3

**Table 17 – ENNI L2CP Multilateral Attributes for Transit E-Line, Transit E-LAN**

## 11 References

- [1] IEEE Std 802.1AB – 2009, *IEEE Standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*, 17 September 2009.
- [2] IEEE Std 802.1AX – 2014, *IEEE Standard for Local and metropolitan area networks – Link Aggregation*, 10 December 2014.
- [3] IEEE Std 802.1D – 2004, *IEEE Standards for Local and metropolitan area networks—Media Access Control (MAC) Bridges*, 9 June 2004.
- [4] IEEE Std 802.1Q – 2014, *IEEE Standards for Local and metropolitan area networks—Bridges and Bridged Networks*, 3 November 2014.
- [5] IEEE Std 802.1BR-2012, *IEEE Standards for Local and metropolitan area networks – Virtual Bridged Local Area Networks – Bridge Port Extension*, 16 July 2012.
- [6] IEEE Std 802.1X – 2010, *IEEE Standards for Local and metropolitan area networks—Port Based Network Access Control*, 6 February 2010.
- [7] IEEE Std 802.3 – 2018, *IEEE Standard for Ethernet*, 7 May 2018.
- [8] IEEE Std 1588TM-2008, *IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems - 27 March 2008, Annex F*.
- [9] IETF RFC 2119, *Key words for use in RFCs to Indicate Requirement Levels*, March 1997.
- [10] IETF RFC 8174, *Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words*, May 2017.
- [11] ITU-T G.8264-2017, *Distribution of Timing Information Through Packet Networks – August 2017*.
- [12] MEF 6.2, *Ethernet Services Definitions - Phase 3*, August 2014.
- [13] MEF 10.4, *Subscriber Ethernet Service Attributes*, December 2018.
- [14] MEF 12.2, *Carrier Ethernet Network Architecture Framework Part 2: Ethernet Services Layer*, May 2014.
- [15] MEF 16, *Ethernet Local Management Interface (E-LMI)*, January 2006.
- [16] MEF 26.2, *External Network Network Interface (ENNI) and Operator Service Attributes*, August 2016.

- [17] MEF 43, *Virtual NID (vNID) Functionality for E-Access Services*, April 2014.
- [18] MEF 51.1, *Operator Ethernet Service Definitions*, December 2018.
- [19] MEF 62, *Managed Access E-Line Service Definition*, May 2018.

## Appendix A Link Aggregation Use Cases (Informative)

This appendix provides a brief description of the Link Aggregation Control Protocol, and what it means to have a Service Provider or Operator peer the protocol at a UNI or ENNI.

Link Aggregation is a mechanism for making multiple point-to-point links between a pair of devices appear to be a single logical link between those devices. Link Aggregation is specified in IEEE Std 802.1AX<sup>9</sup> [2]. Link Aggregation Control Protocol (LACP)<sup>10</sup> operates between exactly two peer devices for the purpose of creating, verifying, and monitoring the logical link created by aggregating individual links. Specific L2CP Frames, known as Link Aggregation Control Protocol Data Units (LACPDU), are exchanged between the peer devices on each individual link in the aggregation. The Protocol Identifier used by LACP is an EtherType with a value of 0x8809 (the “Slow Protocols” EtherType) and subtype values 01 and 02.

The operation of LACP affects the entire interface (UNI or ENNI) regardless of the number of services supported across that interface. LACP can be supported at each interface independent of whether it is supported at any other interface.

The 802.1AX standard supports aggregation of physical links, chains of physical links concatenated by Two Port MAC Relays (TPMRs), and virtual connections such as an EPL service in a CEN. A port can support one, two, or all three of these types of aggregation by running an instance of LACP for each type of aggregation. Each LACP instance uses a different Destination Address in LACPDUs so that the LACPDUs are addressed to the appropriate peer LACP instance. The Destination Addresses specified for use by LACP are shown in Table 18. The 00-80-C2-00-00-02 “Slow Protocols” is the default address for a single LACP instance, and was the only address specified in the original Link Aggregation standard. LACPDUs are untagged when generated by an LACP instance.

L2CP Reserved Destination MAC Address	Assignment	Used to aggregate:
01-80-C2-00-00-00	Nearest Customer Bridge	virtual connections
01-80-C2-00-00-02	Slow Protocols	physical links
01-80-C2-00-00-03	Nearest Non-TPMR Bridge	chains of physical links

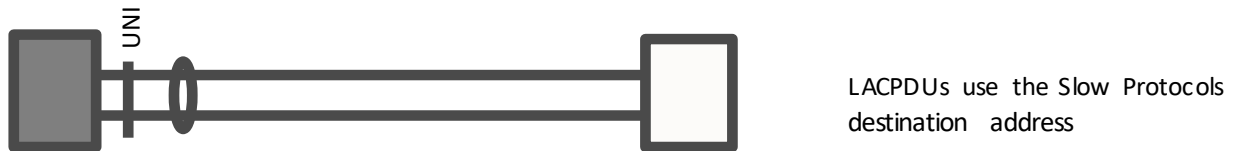
**Table 18 – LACP Destination Addresses**

<sup>9</sup> Link Aggregation was originally specified as clause 43 of IEEE Std 802.3 (originally as IEEE Std 802.3ad-2000 and subsequently incorporated into base 802.3 document). In 2008 the responsibility for maintaining the standard was moved from the 802.3 working group to the 802.1 working group, so it was removed from IEEE Std 802.3-2008 and published as IEEE Std 802.1AX-2008. It was amended by 802.1AXbk-2012, and a full revision published as IEEE Std 802.1AX-2014.

<sup>10</sup> The Link Aggregation standard specifies three protocols: Link Aggregation Control Protocol (LACP), Link Aggregation Marker Protocol (LAMP), and Distributed Relay Control Protocol (DRCP). For the purposes of this document the label “LACP” includes both LACP and LAMP, the label “LACPDU” includes both LACPDUs (protocol subtype 01) and LAMPDUs (protocol subtype 02), and peering of LAMP is implied when an L2CP Peering Service Attribute lists LACP as being peered.

### A.1 Peering LACP at a UNI

When there are two or more physical links at the UNI using Link Aggregation as the protection mechanism, peering LACP is required. In this case LACP is listed as being peered in the UNI L2CP Peering Service Attribute. When LACP is peered at a UNI, the Slow Protocols Destination Address is used ([R13]). This provides the basic aggregation of two physical links shown in Figure 8.

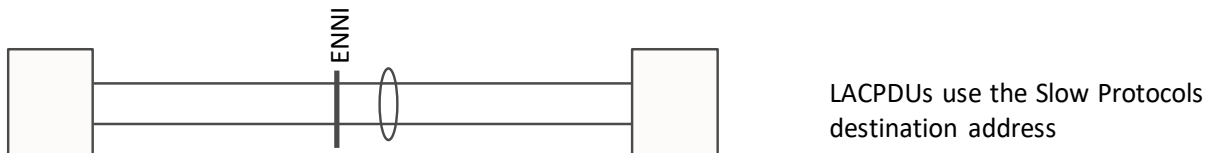


**Figure 8 – Basic Link Aggregation at a UNI**

LACPDUs generated by an LACP instance at a UNI are untagged. A tagged LACPDU with the Slow Protocols Destination Address is discarded by the Protocol Entity.

### A.2 Peering LACP at a ENNI

When there are two or more physical links at the ENNI using Link Aggregation as the protection mechanism, peering LACP is required. In this case LACP is listed as being peered in the ENNI L2CP Peering Multilateral Attribute. When LACP is peered at an ENNI, the Slow Protocols Destination Address is used (01-80-C2-00-00-02). This provides the basic aggregation of two physical links shown in Figure 9.



**Figure 9 – Basic Link Aggregation at an ENNI**

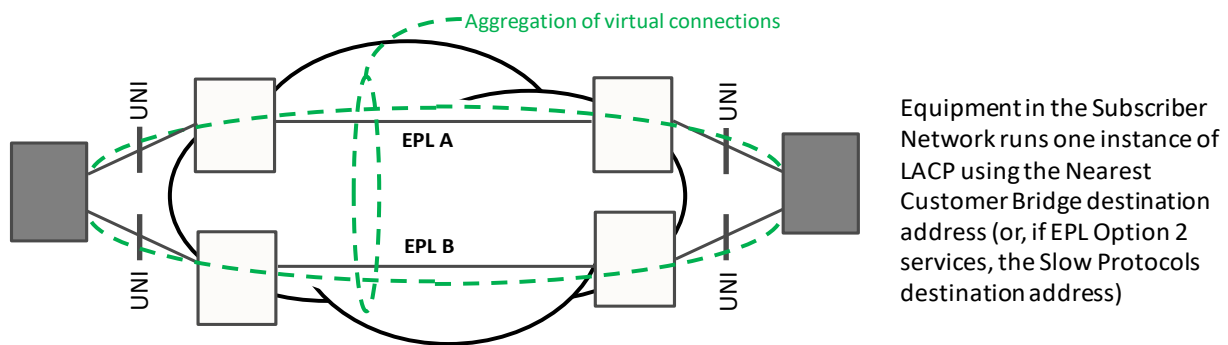
LACPDUs generated by an LACP instance at an ENNI are untagged. Ingress LACPDUs at an ENNI that have an S-Tag will not be delivered to an LACP Protocol Entity by the processes and requirements specified in section 9. Any such frames that were not generated in error will have resulted from ingress LACPDUs at a UNI. In the absence of errors these frames either have the Nearest Customer Bridge Destination Address or are on an EPL service with EPL Option 2 L2CP processing. In these cases the frames are passed by the processes and requirements specified in section 9. In all other cases S-VLAN tagged LACPDUs are either passed or discarded by the processes and requirements specified in section 9.

### A.3 LACP and EPL Option 2 L2CP processing

EPL Option 2 L2CP processing recommends that LACPDUs with the Slow Protocols Destination Address are passed at all UNIs. This conflicts with the requirement to use Link Aggregation with LACP on a UNI with two links. Therefore, if LACPDUs with the Slow Protocols Destination Address are passed at the UNI, the UNI cannot have UNI Link Aggregation Service Attribute equal to *2-Link Active/Standby* or *All Active* and LACP is not listed as being peered in the UNI L2CP Peering Service Attribute. Conversely, if the UNI has UNI Link Aggregation Service Attribute equal to *2-Link Active/Standby* or *All Active* then LACP is listed as being peered in the UNI L2CP Peering Service Attribute and LACPDUs with the Slow Protocols Destination Address are not passed.

### A.4 Aggregation of EPL services

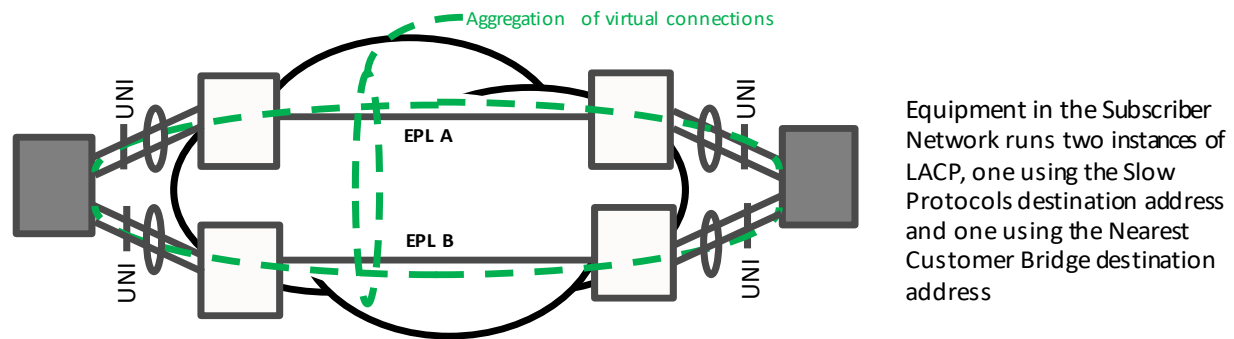
Figure 10 shows an example of a Subscriber using Link Aggregation to aggregate EVCs. Because Link Aggregation is only intended to operate on point-to-point links between the same systems, these EVCs are instances of an EPL service. In this case only the equipment in the Subscriber Network needs to be running LACP and the equipment in the Service Provider Network does not participate. Therefore, LACP is not listed as being peered in the Subscriber UNI L2CP Peering Service Attribute. The LACP instances in the equipment in the Subscriber Network use the Nearest Customer Bridge Destination Address so that the LACPDUs will pass through the CEN. If the EVCs are EPL services with EPL Option 2 L2CP processing that pass LACPDUs with the Slow Protocols Destination Address, then the equipment in the Subscriber Network can use the Slow Protocols Destination Address instead.



**Figure 10 – Link Aggregation of EPL Services**

It is possible to aggregate EVCs where one or more of the UNIs are protected by Link Aggregation on the physical links as shown in Figure 11. In this case the equipment in the Subscriber Network runs two instances of LACP, one using the Slow Protocols Destination Address and one using the Nearest Customer Bridge Destination Address. LACP is listed as being peered in the Subscriber UNI L2CP Peering Service Attribute, and the equipment in the Service Provider Network runs one instance of LACP using the Slow Protocols Address. From the Service Provider point of view this is no different than the basic Link Aggregation at a UNI shown in Figure 8.





**Figure 11 – Link Aggregation of EPL services with protected UNIs**

### A.5 Configuring Link Aggregation for Active/Standby operation

When there are two physical links at a UNI or ENNI using Link Aggregation in active/standby mode, IEEE Std 802.1AX will designate links in an aggregation as active or standby when device limitations prevent all links from being active simultaneously. However, there is no standard management object that allows an Operator to explicitly configure active/standby operation. Some devices have private management objects that either specify active/standby operation directly, or allow setting the maximum number of active links in an aggregation to one. In either of these cases the primary link can be designated by the setting of the port priority value. It is sufficient to configure active/standby operation in just one of the devices in the aggregation, so at a UNI it is typically configured in equipment in the Service Provider Network.

An alternative way to achieve active/standby operation is to use a distribution algorithm that transmits all frames on one link in the aggregation. Whether this distribution algorithm is supported, and how it is configured, is device specific.

## Appendix B Changes from MEF 45 (Informative)

This revision updates MEF 45 to incorporate the MEF 45.0.1 amendment and to align with MEF 10.4 and MEF 51.1.

The following changes from MEF 45.0.1 are incorporated:

- Adds a new subsection to section 10 to identify L2CP attributes necessary to support E-Access and E-Transit Services as defined in MEF 51.
- Replaces the UNI Tunnel Access (UTA) Service requirements in section 10 with Feeder OVC requirements. This is consistent with MEF 26.2 which supersedes MEF 28 and replaces the UNI Tunnel Access Service with the Feeder OVC.
- Corrects miscellaneous errata and cross-references.

The following changes are made to align with MEF 51.1:

- Updates references from MEF 51 to MEF 51.1.
- Removes the Access EPL and Access EVPL Service Requirements for L2CP, and removes references to MEF 33, as MEF 51.1 supersedes MEF 33.

The following changes are made to align with MEF 10.4:

- Updates references from MEF 10.3 to MEF 10.4.
- Reworks requirements to replace the All to One Bundling Service Attribute with the EVC EP Map Service Attribute.
- Defines *CTA*, *CTB*, and *CTB-2* without the term “CE-VLAN ID”.

The following additional changes are made:

- Separates the UNI L2CP Service Attributes into Subscriber UNI Service Attributes and Operator UNI Service Attributes.
- Incorporates the concept of a Super Operator into the behavioral model.
- Restructures the requirements for L2CP Address Set Service Attributes for Operator Services to avoid making assumptions about how an OVC will be used by a SP/SO, and to clarify the relationship between the OVC L2CP Address Set and the Operator UNI L2CP Address Set values.
- Requires that multipoint OVCs have an OVC Address Set value of *CTA* or *CTB*, consistent with the intent that *CTB-2* OVCs are used only in support of EPL Services with Option 2 L2CP Processing.