



Technical Specification

MEF 30

Service OAM Fault Management Implementation Agreement

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Table of Contents

1. Abstract..... 1

2. Terminology..... 1

3. Scope..... 4

4. Compliance Levels 4

5. Introduction..... 5

 5.1 OAM Domains 5

 5.2 OAM Architecture..... 6

 5.3 Default Behaviors 7

6. Related Activity on OAM Fault Management Requirements 8

 6.1 MEF 6.1 8

 6.2 MEF 7.1 8

 6.3 MEF 10.2 8

 6.4 MEF 12.1 8

 6.5 MEF 16 8

 6.6 MEF 17 9

 6.7 MEF 20 9

 6.8 MEF 26 9

7. Maintenance Entities 10

 7.1 Generic MEG Requirements 10

 7.2 MEG Security Considerations 11

 7.3 SOAM PDU Processing Capacity 12

 7.4 Subscriber MEG 12

 7.5 Test MEG 12

 7.6 EVC MEG 14

 7.7 Service Provider MEG 14

 7.8 Operator MEG 15

 7.9 UNI MEG 16

 7.9.1 UNI-C MEP Requirements 16

 7.9.2 UNI-N MEP Requirements 16

 7.10 ENNI MEG 17

8. Fault Management Protocols 18

 8.1 MEG ID / MAID 18

 8.2 Continuity Check 19

 8.2.1 Remote Defect Indication Signal 22

 8.3 Loopback 22

 8.4 Linktrace 25

 8.5 Alarm Indication Signal 25

 8.6 Locked Signal 26

 8.7 Test Signal 26

9.	References	28
10.	Appendix A – FM Scenarios [Informative]	29
10.1.1	UNI Failure	29
10.1.1.1	<i>UNI Without Intervening Bridges</i>	29
10.1.1.2	<i>UNI With Intervening Bridges</i>	30
10.1.2	ENNI Failure.....	31
10.1.3	Operator NE Failure.....	32
11.	Appendix B – VLAN Tagging Implications on SOAM Treatment [Informative]	33
12.	Appendix C – Mapping Between 802.1ag and Y.1731 Terms [Informative]	36

List of Figures

Figure 1 – Example SOAM Maintenance Entities	6
Figure 2 – OAM Domain.....	7
Figure 3 – Example Point To Point Test MEG.....	13
Figure 4 – Example SP MEG With UTA	15
Figure 5 – MAID Field Format.....	18
Figure 6 – UNI Failure Without Intervening Bridges.....	29
Figure 7 – UNI Failure With Intervening Bridges.....	30
Figure 8 – ENNI Failure	31
Figure 9 – Operator NE Failure	32
Figure 10 – Reference Diagram.....	33
Figure 11 –VLAN Tagging Cases	34
Figure 12 – SOAM PDU Formats	35

List of Tables

Table 1 – Definitions	4
Table 2 – Suggested MEGs and Usages	5
Table 3 – Default MEG Levels.....	10
Table 4 – Minimum Number of EVCs	16
Table 5 – Terminology Mappings.....	36

1. Abstract

This document specifies an Implementation Agreement (IA) for Service Operations, Administration, and Maintenance (OAM) that builds upon the Fault Management (FM) framework and requirements specified by [MEF 17].

FM functions are defined in [IEEE 802.1ag] and [ITU-T Y.1731]. This IA details how to leverage these functions to achieve the requirements of Service OAM FM.

2. Terminology

Term	Definition	Reference
AIS	Alarm Indication Signal	[ITU-T G.8021]
BBF	Broadband Forum	
CCM	Continuity Check Message	[IEEE 802.1ag] [ITU-T Y.1731]
CFM	Connectivity Fault Management	[IEEE 802.1ag]
Class of Service	A set of Service Frames that have a commitment from the Service Provider to receive a particular level of performance.	[MEF 10.2]
CoS	Class of Service	[MEF 10.2]
CoS Identifier	The Class of Service identifier (CoS ID) is defined for Service Frames (defined in [MEF 10.2]) and for ENNI Frames (defined in [MEF 26]), and further discussed in the CoS IA ([MEF 23]). For example, for Service Frames of EVCs at a UNI, this is derivable from: a) the EVC to which the Service Frame is mapped, b) the combination of the EVC to which the Service Frame is mapped and a set of one or more than one CE-VLAN PCP values, c) the combination of the EVC to which the Service Frame is mapped and a set of one or more than one DSCP values, or d) the combination of the EVC to which the Service Frame is mapped and a set of one or more than one tunneled Layer 2 Control Protocols. Other cases (e.g., for an OVC End Point at a UNI and at an ENNI) have also been defined.	[MEF 23] for CoS ID [MEF 10.2] for CoS ID in Service Frames [MEF 26] for CoS ID in ENNI Frames
Down MEP	A MEP residing in a Bridge that receives SOAM PDUs from, and transmits them towards, the direction of the LAN ¹ . See also Up MEP.	[IEEE 802.1ag]
E-LAN	An Ethernet service type that is based on a Multipoint-to-Multipoint EVC.	[MEF 6.1]
E-Line	An Ethernet service type that is based on a Point-to-Point EVC.	[MEF 6.1]
E-LMI	Ethernet Local Management Interface	[MEF 16]
EMS	Element Management System	
ENNI	External Network-to-Network Interface	[MEF 4]
ENNI-N	The functional element comprising one half of an ENNI, administered by the Operator whose Operator MEN terminates at the functional element.	[MEF 26]
ENNI MEG	External Network-to-Network Interface Maintenance Entity Group	
ETH-AIS	Ethernet Alarm Indication Signal	[ITU-T Y.1731]
ETH-CC	Ethernet Continuity Check (see also CCM)	[ITU-T Y.1731]
ETH-LB	Ethernet Loopback (see also LBM)	[ITU-T Y.1731]
ETH-LT	Ethernet Linktrace (see also LTM)	[ITU-T Y.1731]
E-Tree	An Ethernet service type that is based on a Rooted-Multipoint EVC.	[MEF 6.1]
EVC	Ethernet Virtual Connection. An association of two or more UNIs that	[MEF 10.2]

¹In this context, the LAN is a transmission facility for egress, rather than towards the Bridge Relay Entity.

Term	Definition	Reference
	limits the exchange of Service Frames to UNIs in the Ethernet Virtual Connection.	
EVC MEG	Ethernet Virtual Connection Maintenance Entity Group	
FD	Frame Delay	[ITU-T Y.1731]
FDV	Frame Delay Variation	[ITU-T Y.1731]
FLR	Frame Loss Ratio	[ITU-T Y.1731]
FM	Fault Management	
IA	Implementation Agreement	
IEEE	Institute of Electrical and Electronics Engineers	
IETF	Internet Engineering Task Force	
ITU-T	International Telecommunication Union – Standardization sector	
LAN	Local Area Network	
LBM	Loopback Message	[IEEE 802.1ag] [ITU-T Y.1731]
LBR	Loopback Reply	[IEEE 802.1ag] [ITU-T Y.1731]
LTM	Linktrace Message	[IEEE 802.1ag] [ITU-T Y.1731]
LTR	Linktrace Reply	[IEEE 802.1ag] [ITU-T Y.1731]
MAC	Media Access Control	
MA	Maintenance Association. A set of MEPs, each configured with the same MAID and MD Level, established to verify the integrity of a single service instance. An MA can also be thought of as a full mesh of Maintenance Entities among a set of MEPs so configured. An MA is equivalent to a MEG, which is the term defined by ITU and used in this IA.	[IEEE 802.1ag]
MAID	Maintenance Association Identifier. An identifier for a Maintenance Association, unique over the OAM domain. The MAID has two parts: the MD Name and the Short MA Name. A MAID is equivalent to the ITUs term MEG ID.	[IEEE 802.1ag]
MD	Maintenance Domain. The part of a network for which faults in connectivity can be managed.	[IEEE 802.1ag]
ME	Maintenance Entity. A point-to-point relationship between two MEPs within a single MEG.	[IEEE 802.1ag] [ITU-T Y.1731] [MEF 17]
MEF	Metro Ethernet Forum	
MEG	Maintenance Entity Group. Equivalent to a Maintenance Association (MA). A set of MEs that exist in the same administrative boundary, with the same MEG Level and MEG ID.	[ITU-T Y.1731]
MEG ID	Maintenance Entity Group Identifier. Equivalent to the IEEE term Maintenance Association Identifier (MAID). An identifier for a MEG, unique over the domain that SOAM is to protect against the accidental concatenation of service instances.	[ITU-T Y.1731]
MEG Level	Maintenance Entity Group Level. A small integer in a field in a SOAM PDU that is used, along with the VID in the VLAN tag, to identify to which Maintenance Association among those associated with the SOAM frame's VID, and thus to which ME, a SOAM PDU belongs. The MEG Level determines the MPs a) that are interested in the contents of a SOAM PDU, and b) through which the frame carrying that SOAM PDU is allowed to pass. This term is equivalent to MD Level, which is used in [IEEE 802.1ag].	[ITU-T Y.1731]
MEN	Metro Ethernet Network	[MEF 4]
MEP	Maintenance association End Point [IEEE 802.1ag], or equivalently MEG	[IEEE 802.1ag]

Term	Definition	Reference
	End Point [ITU-T Y.1731]. An actively managed SOAM entity associated with a specific service instance that can generate and receive SOAM PDUs and track any responses. It is an end point of a single MEG, and is an endpoint of a separate Maintenance Entity for each of the other MEPs in the same MEG.	[ITU-T Y.1731]
MHF	MIP Half Function. A SOAM entity, associated with a single MD, and thus with a single MD Level and a set of VIDs, that can generate SOAM PDUs, but only in response to received SOAM PDUs.	[IEEE 802.1ag]
MIP	Maintenance domain Intermediate Point [IEEE 802.1ag] or equivalently MEG Intermediate Point [ITU-T Y.1731]. A SOAM entity consisting of two MHFs.	[IEEE 802.1ag] [ITU-T Y.1731]
MP	Maintenance Point. One of either a MEP or a MIP.	[IEEE 802.1ag]
MTU	Maximum Transmission Unit	[MEF 10.2] [MEF 26]
NE	Network Element	
NNI	Network-to-Network Interface	[MEF 4]
NMS	Network Management System	
OAM	Operations, Administration, and Maintenance	
OAM Domain	Equivalent to Maintenance Domain (MD).	[MEF 17]
OAM Flow Space	The portions of an end-to-end flow where SOAM frames are seen as SOAM frames (as opposed to being seen as data frames when double tagged).	
Operator MEG	Operator Maintenance Entity Group	
OVC	Operator Virtual Connection. An association between specific External Interfaces, e.g., a UNI and an ENNI.	[MEF 26]
P2P	Point-to-Point	
PDU	Protocol Data Unit	
PCP	Priority Code Point. This is the 3-bit field of the Tag that specifies the priority. When OAM frames are monitoring a particular EVC, they are assigned a PCP that is valid for that EVC. Note that multiple PCPs can be mapped to a single CoS.	[IEEE 802.1Q]
RDI	Remote Defect Indication	
RFC	Request For Comment	
RUNI	Remote UNI	
SP	Service Provider. The organization providing Ethernet service(s) to the subscriber.	[MEF 10.2]
SOAM	Service Operations, Administration, and Maintenance	[MEF 17]
SOAM PDU	Service OAM Protocol Data Unit. Specifically, those PDUs defined in [IEEE 802.1ag], [ITU-T Y.1731], or MEF specifications.	
Subscriber MEG	Subscriber Maintenance Entity Group	
Test MEG	Test Maintenance Entity Group	[MEF 20]
UNI	User-to-Network Interface. The physical demarcation point between the responsibility of the Service Provider and the responsibility of the Subscriber.	[MEF 10.2]
UNI-C	Subscriber side UNI functions	[MEF 4]
UNI MEG	User-to-Network Interface Maintenance Entity Group	[MEF 4]
UNI-N	Network side UNI functions	[MEF 4]
Up MEP	A MEP residing in a Bridge that transmits SOAM PDUs towards, and receives them from, the direction of the Bridge Relay Entity. See also Down MEP.	[IEEE 802.1ag]
VID	VLAN Identifier	[IEEE 802.1Q]
VLAN	Virtual LAN	[IEEE 802.1Q]
VUNI	Virtual UNI	

Table 1 – Definitions

Note: [IEEE 802.1ag] and [ITU-T Y.1731] define some of the same OAM concepts with different terminology. This document uses the [ITU-T Y.1731] terminology, except for MAID (and MA in the context of discussing the MAID), which is used in addition to MEG ID to clarify the formatting of the MEG ID. See Appendix C for a mapping between the two sets of terms.

3. Scope

The scope of this document is an Implementation Agreement (IA) that specifies functional requirements for Fault Management (FM) for Metro Ethernet Forum (MEF) services. These requirements are primarily driven by [MEF 17] and leverage the OAM functions defined by [IEEE 802.1ag] and [ITU-T Y.1731]. When and if necessary, this IA may define enhancements to existing functions to satisfy Service OAM (SOAM) requirements. These functions are defined as generically as possible, but in particular this IA is targeted at the following Maintenance Entity Groups (MEGs) defined and in use by the MEF:

- Subscriber MEG
- Test MEG
- EVC MEG
- Service Provider MEG
- Operator MEG
- UNI MEG
- ENNI MEG

This IA attempts to maintain consistent functionality and requirements across the various MEGs.

Only Fault Management elements such as Connectivity Status are covered in this IA. SOAM Performance Management capabilities will be covered in a future MEF document dealing with SOAM Performance Management.

4. Compliance Levels

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in [IETF RFC 2119]. All key words must be in upper case, bold text.

A paragraph preceded by [**R_n**], where *n* indicates a sequentially increasing number throughout the document, specifies a requirement that **MUST** be followed. A paragraph preceded by [**D_m**], where *m* indicates a sequentially increasing number throughout the document, specifies a desired requirement that **SHOULD** be followed.

5. Introduction

SOAM FM describes the use of standard protocols, mechanisms, and procedures for monitoring and investigating the status of Ethernet Virtual Connections (EVCs), Operator Virtual Connections (OVCs), and External Interfaces across a defined OAM Domain, where that domain can be a large network (or subnetwork), or a simple link. SOAM FM uses the protocols of [IEEE 802.1ag] and [ITU-T Y.1731] in order to determine the status of and troubleshoot connectivity across a particular domain. See Appendix C for a discussion of the use of [IEEE 802.1ag] and [ITU-T Y.1731] terminology.

The requirements in this IA are primarily from the perspective of the NE rather than the administrator of the NE. However, some requirements represent requirements on how NEs are implemented and used. These requirements are specified to make NE OAM functionality simpler and more likely to interoperate.

5.1 OAM Domains

As discussed in [MEF 17], SOAM allows a network to be partitioned into a set of hierarchical domains, where a domain is a contiguous (sub)-network, and each domain can be further partitioned into additional (sub)-domains. OAM domains are intended to represent administrative boundaries. The OAM domains relevant to this IA are listed in Table 2:

MEG	Suggested Usage
Subscriber MEG	Subscriber monitoring of an Ethernet service
Test MEG	Service Provider isolation of subscriber reported problems
EVC MEG	Service Provider monitoring of provided service
Service Provider MEG	Service Provider Monitoring of Service Provider network
Operator MEG	Network Operator monitoring of the portion of a network
UNI MEG	Service Provider monitoring of a UNI
ENNI MEG	Network Operators' monitoring of an ENNI

Table 2 – Suggested MEGs and Usages

Fault Management will be discussed for each OAM domain. For a further discussion of these Maintenance/OAM Domains, refer to [MEF 17]. The Test MEG was introduced in [MEF 20], and is described in Appendix A of that IA. The Service Provider MEG is introduced in this document in section 7.7.

5.2 OAM Architecture

Figure 1 (which is derived from Figure 1 from MEF 20, which in turn is based on Figure 5 from MEF 17) illustrates pairs of MEPs (thus MEGs) and MIPs that may be communicating across the various OAM domains discussed in this IA, and also illustrates the hierarchical relationship between these domains. Note that the orientations of the MEPs in the diagram are exemplary, and are not requirements. Requirements and recommendations for the orientation of MEPs are provided in later sections of this IA.

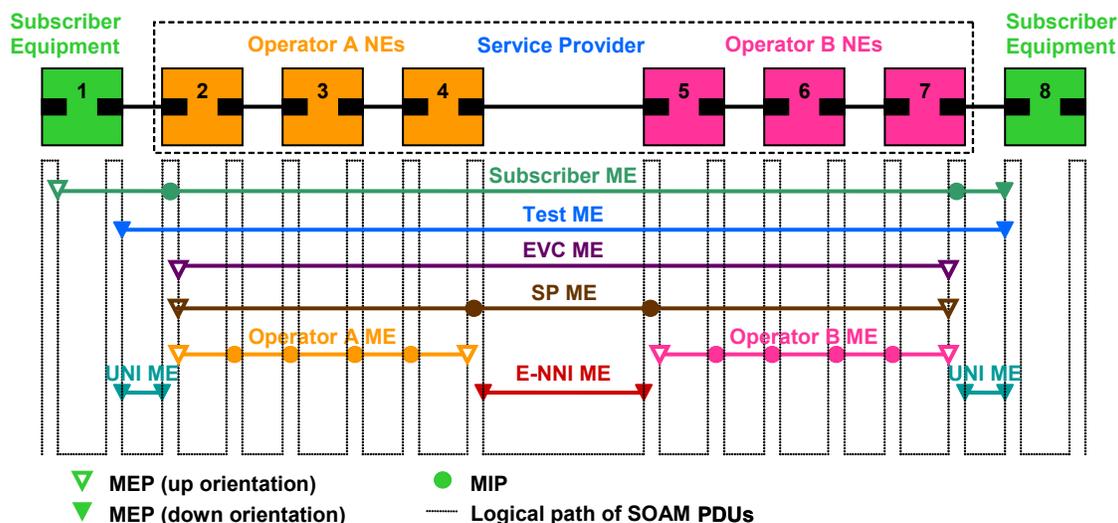


Figure 1 – Example SOAM Maintenance Entities

Note 1: The given MEP and MIP locations, and MEP orientations, are for example purposes only. There are cases where the locations and orientations may differ, and cases where orientation is not applicable. As shown with the example of the Subscriber MEG, the ends of a MEG are not required to be the same (i.e., both Up MEPs or both Down MEPs).

Note 2: The use of MIPs, as shown in Figure 1, by a Service Provider or an Operator at the Subscriber MEG level would allow a Subscriber to determine that traffic has traversed the intended EIs through the network(s). Additionally, MIPs configured by an Operator at the EVC MEG level could allow a Service Provider to determine if a connectivity problem exists in a particular Operator network (via the EVC MEG MIPs).

When flowing from subscriber equipment at one location to subscriber equipment at another location, a frame can have tags added or removed. Appendix B explains the impact of VLAN ID (VID) manipulation on Service OAM PDUs and the implications for OAM domain delineation. Sometimes this requires Subscribers, Providers, and Operators to share the MEG Levels and mutually agree on the use of each MEG Level.

Figure 2 looks more closely at one particular OAM domain and the MEs of a particular multipoint EVC. The OAM domain consists of the Maintenance Entity Group {MEP₁, MEP₂, MEP₃, MEP₄} where each unique MEP pair (i.e., {{MEP₁, MEP₂}, {MEP₁, MEP₃}, {MEP₁, MEP₄}, {MEP₂, MEP₃}, {MEP₂, MEP₄}, {MEP₃, MEP₄}}) constitutes a separate ME.

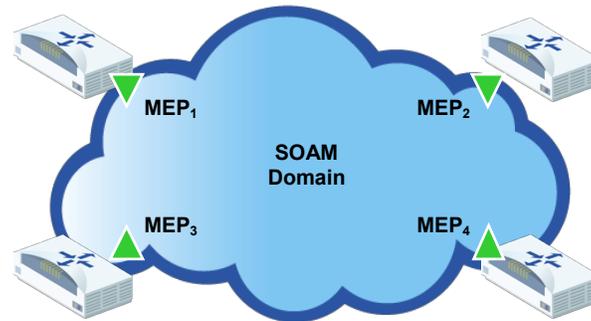


Figure 2 – OAM Domain

5.3 Default Behaviors

One of the important goals of this IA is to simplify the provisioning of OAM across a Metro Ethernet Network (MEN). To this end, a *default value* for an attribute of a maintenance object is defined as the value to be used for that attribute when no other value has been specified during the creation of that object. In this IA, we define default values for many attributes of maintenance objects so that users know what behavior to expect from an object when minimal attributes are specified during its creation.

6. Related Activity on OAM Fault Management Requirements

This section provides a brief overview of related OAM requirements in other MEF documents. This discussion is not intended to be complete or exhaustive. For additional information, refer to the referenced MEF specifications.

The primary MEF specifications that place requirements or assume behavior related to SOAM are [MEF 6.1], [MEF 7.1], [MEF 10.2], [MEF 12.1], [MEF 16], [MEF 17], [MEF 20], and [MEF 26]. Each of these is briefly discussed in the sections below.

6.1 MEF 6.1

[MEF 6.1] defines the Ethernet Service Types: E-Line, E-LAN, and E-Tree. It also provides some basic SOAM requirements.

6.2 MEF 7.1

[MEF 7.1] defines the MEF's element management object model. In particular, it provides the Service OAM information model.

6.3 MEF 10.2

[MEF 10.2] describes the attributes of an Ethernet service from the perspective of the Customer Equipment (CE) at the UNI reference point. These attributes are related to the type and quality of the forwarding service provided by that EVC, with the goal to provide a "black box" view of an EVC as seen by the customer. The customer perspective includes a number of fault/availability attributes including EVC availability.

6.4 MEF 12.1

[MEF 12.1] describes the network architecture in support of Ethernet service. Included in the architecture are the concepts of the Service Provider Ethernet Connection (SP EC), the Operator Ethernet Connection (O-EC), and the Subscriber Ethernet Connection (S-EC), and their relationships to EVCs and OVCs.

6.5 MEF 16

[MEF 16] specifies the ELMI, which defines the capability to communicate properties of the EVC, including status, from a UNI-N to a UNI-C. EVC status can either be active, inactive, or partially active depending if it is able to transfer data between all, none, or some of the UNIs comprising the EVC. It also defines some configuration capabilities.

6.6 MEF 17

[MEF 17] provides a high level overview of SOAM architecture and capabilities, and discusses some of the requirements for MEF Service OAM. According to these requirements, SOAM provides the ability to determine Connectivity Status, one-way FLR, two-way FD, and one-way FDV for point-to-point EVCs.

6.7 MEF 20

[MEF 20] provides requirements for UNI Type II devices. Included in the [MEF 20] specification are some Fault Management requirements for the Subscriber MEG, Test MEG, and UNI MEG. This document provides a superset of those requirements.

Note: Where requirements in this document are equivalent to or encompass requirements in [MEF 20], a footnote is provided indicating the equivalent or encompassed requirement number. Where a single original requirement number contains multiple requirements statements, the [MEF 20] requirement number is appended with the sub-requirement's ordinal value. For example, the second sub-requirement of R39 is referred to as R39.2.

6.8 MEF 26

[MEF 26] provides details about the External Network Network Interface (ENNI). [MEF 26] defines ENNI elements related to the ENNI, including the ENNI MEG, for which this document defines SOAM requirements.

7. Maintenance Entities

This section describes requirements that are specific to Maintenance Entities, both generically and per specific Maintenance Entity.

7.1 Generic MEG Requirements

This section details the MEGs that must be supported by NEs in a Metro Ethernet Network. Figure 1 illustrates the MEGs relevant to OAM.

- [R1] The MEG Level for each MEG **MUST** be configurable with any valid MEG Level value (0...7).²
- [R2] The default value for the MEG Level for each MEG **MUST** be in conformance with Table 3³:

MEG	Default MEG Level
Subscriber MEG	6
Test MEG	5
EVC MEG	4
Service Provider MEG	3
Operator MEG	2
UNI MEG	1
ENNI MEG	1

Table 3 – Default MEG Levels

Note 1: Table 3 is more specific than that given in [MEF 17], but is consistent with [MEF 17].

Note 2: Assignment of numerical MEG Levels to 'subscriber' (or customer) role, Service Provider role, and Operator role is somewhat arbitrary since those terms imply business relationships that cannot be standardized. For example, a 'subscriber' (or customer) may also be an Operator seeking a service from another Operator. The MEG Level default values are consistent with a shared MEG Level model across Subscriber, Operators, and Service Providers.

Note 3: The MEF and Broadband Forum (BBF) are not aligned on the use of MEG Level 5. If interworking between an MEF compliant implementation and a BBF compliant implementation is required, an agreement on the use of MEG Level 5 is required between the two parties.

- [R3] When a MEG uses tagged SOAM PDUs, the VLAN ID (VID) of the MEG **MUST** be configurable with any valid VID value (1-4094).

² Equivalent to sub-requirement 1 of Requirement 39 (R39.1) of [MEF 20].

³ Equivalent to R39.2 of [MEF 20].

7.2 MEG Security Considerations

The OAM architecture is designed such that a MEP at a particular MEG Level transparently passes SOAM traffic at a higher MEG Level, terminates traffic at its own MEG Level, and discards SOAM traffic at a lower MEG Level. This results in a nesting requirement where a MEG with a lower MEG Level cannot exceed the boundary of a MEG with a higher MEG Level. [IEEE 802.1ag] discusses this nesting in Clause 18.3.

The domain hierarchy provides a mechanism for protecting a Maintenance Point (MP) — either a MEP or a MIP — from other MPs with which the MP has not been designed to communicate. However, this protection does not guard against Denial of Service attacks at a MEG level where communications are allowed. It is possible for an MP (through error or deliberately) to flood one or more of its peer (or apparently peer) MPs with SOAM PDUs. This can result in a denial of service by forcing the receiving MPs to use computing resources for processing the SOAM PDUs from the flooding MP.

The following requirement is designed to ensure that Network Elements (NEs) are not susceptible to a denial of service attack via SOAM PDUs.

[R4] An NE supporting MPs **MUST** support a mechanism to limit the number of SOAM PDUs per second that are processed. This limit may be per network element, or a limit per sub-object on a network element (e.g., per interface, per card, per MP, etc.).

The intent is that the performance of an NE supporting MPs is to not be compromised by SOAM PDUs transmitted in excess of the limit mentioned above.

To meet this requirement, the NE is allowed to discard SOAM PDUs when the rate of SOAM PDUs exceeds capabilities of the NE. The performance of the NE, in this context, is the externally seen (or black-box) behavior of the NE. The mechanism is to be designed so that the discard of excess SOAM PDUs is not noticeable by any user of the system except in specifically designed alarms/statistics.

[R5] An NE **MUST** indicate that SOAM PDUs have been discarded due to exceeding the NE's capabilities.

[D1] An NE **SHOULD** indicate the number of SOAM PDUs that have been discarded due to exceeding the NE's capabilities, using the `inOamFramesDiscarded` attribute described in [MEF 7.1].

Note that this mechanism is most vital in applications where either the MEPs within an MEG are under different administrative authority (e.g., at the ENNI MEG), or when a MIP is made available for LinkTrace functions to MEPs under different administrative authorities (e.g., making a MIP at the ENNI visible to the subscriber MEG). However, the requirement is NE-specific and independent of the deployment location so that the function is applicable no matter where the NE is deployed.

7.3 SOAM PDU Processing Capacity

It is important to users of network elements to understand the capacity of the network element to initiate and respond to SOAM PDUs. The requirements of this section demonstrate a minimal OAM capacity to be supported by all network elements.

- [R6] An MP capacity (minimum number of MPs that can be instantiated on the NE) **MUST** be specified for a network element.
- [R7] An NE **MUST** be able to receive at least 1 SOAM PDU per second per remote MEP.
- [R8] An NE **MUST** be able to transmit at least 1 SOAM PDU per second per instantiated MP.
- [D2] An MP **SHOULD** support receiving at least 10 SOAM PDUs per second per remote MEP.

Note: The requirement for receiving 1 SOAM PDU per second provides for very minimal CCM processing. The desired amount of at least 10 SOAM PDUs per second provides for additional messages, especially LBM/LBR and LTM/LTR PDUs.

These requirements allow NEs of varying MP capacities. The NE then need only support a minimal number of SOAM PDUs based on its stated MP capacity. E.g., if a NE claims to support 1000 MPs, it must be able to receive and transmit at least 1000 SOAM PDUs per second.

7.4 Subscriber MEG

As can be seen from Figure 1, the Subscriber ME terminates at the UNI-C.

- [R9] A UNI-C **MUST** be able to support a MEP instance on the Subscriber-MEG for each configured EVC.⁴
- [D3] A UNI-N **SHOULD** be capable of enabling a MIP instance for each supported Subscriber MEG.
- [D4] The SOAM PDUs on the Subscriber-MEG **SHOULD** be C-Tagged and use the CE-VLAN ID with the lowest VID value that is mapped into that EVC.⁵

No preference is expressed for whether a MEP corresponding to the Subscriber MEG at the UNI-C is an Up MEP or a Down MEP.⁶

7.5 Test MEG

The Test MEG is assigned to the Service Provider for isolation of subscriber reported problems. The Test MEG uses MEPs placed in the subscriber's equipment, at the UNI-C, and at least one

⁴ Equivalent to R32.1 of [MEF 20].

⁵ Equivalent to R32.2 of [MEF 20].

⁶ Equivalent to R36 of [MEF 20].

MEP within the Service Provider’s network. The Test MEG is not active at all times, but is used on an on-demand basis.

Note: For additional information about the Test MEG, see Appendix A of [MEF 20].

- [R10] A UNI-C **MUST** be able to support a MEP instance on the Test MEG.
- [D5] A UNI-C **SHOULD** be able to support a MEP instance on the Test MEG for each configured EVC.⁷
- [D6] When the CE implementing the UNI-C is an [IEEE 802.1Q] Bridge, the MEP corresponding to the Test-MEG on a UNI-C **SHOULD** be a Down MEP.⁸
- [D7] The SOAM PDUs on the Test MEG **SHOULD** be C-Tagged and use the CE-VLAN ID with the lowest VID value that is mapped into that EVC.⁹

There are two ways that the Test MEG can be implemented: as a point to point configuration or as a multipoint configuration. If implemented in a point to point method, either one or two MEPs are placed in the Service Provider’s network, at a point that is CE-VLAN aware. If a single MEP is implemented, verification of continuity to one end of the EVC can be done. If two MEPs are implemented, verification of continuity to both ends of the EVC (via a Test MEP at a UNI-C) can be done. When implemented in this manner, MEs running at lower MEG levels that cross the span of the Test MEPs may not operate, as shown in Figure 3.

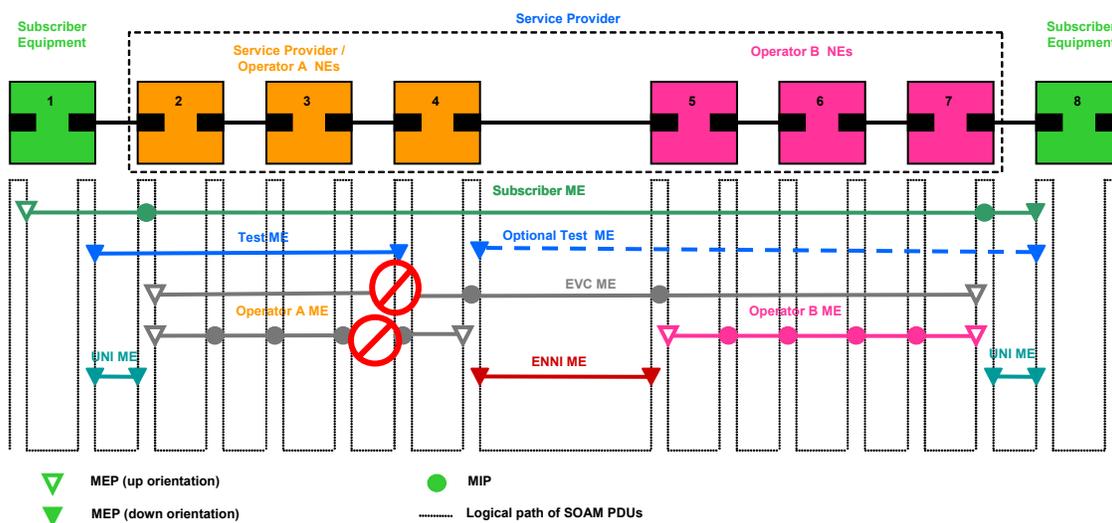


Figure 3 – Example Point To Point Test MEG

In Figure 3, the Test MEG is activated between device 4 and device 1. The activation of the Test MEG causes the EVC ME and Operator A ME to stop functioning. This is because the lower level MEGs can not extend beyond the Test MEG MEP located in device 4. The solid blue line

⁷ Equivalent to R33.1 of [MEF 20].

⁸ Equivalent to part of R35 of [MEF 20].

⁹ Equivalent to R33.2 of [MEF 20].

in the figure indicates the point-to-point Test MEG, and the dotted blue line shows an optional Test MEG.

[R11] The Service Provider **MUST** be able to add a MEP to the Test MEG in a point to point configuration. This method may impact lower-level MEGs that extend past the Test MEG location, as shown in Figure 3.

7.6 EVC MEG

An EVC MEG is intended to provide the most complete view of the EVC. The MEPs in the EVC MEG are to be placed as close to the UNI reference point as possible.

[R12] A UNI-N or VUNI **MUST** be capable of enabling a MEP instance for the EVC MEG associated with each EVC.

[D8] By default, an EVC MEG **SHOULD** be an Up MEP placed in the UNI-N or VUNI.

[R13] An EVC MEG SOAM PDU **MUST** have a C-tag when a C-VID is necessary to determine the EVC to which the frame belongs.¹⁰

[D9] When a C-VID is not necessary, an EVC MEG SOAM PDU **SHOULD** not have a C-tag.

[D10] An ENNI-N **SHOULD** be capable of enabling a MIP instance on any EVC MEG transiting the ENNI.

7.7 Service Provider MEG

A Service Provider (SP) MEG is used to monitor an SP-EC (as defined in [MEF12.1]). Usually an SP MEG would monitor the same portion of a network as an EVC MEG (as shown in Figure 1), an Operator MEG, or both. However, there are circumstances where there is not a direct correspondence, such as when a UNI Tunnel Access (UTA) configuration is being used, as shown in Figure 4. When an SP MEG would not monitor the same portion of a network as an EVC MEG or an Operator MEG, an SP MEG is an appropriate monitoring tool.

Note: A Service Provider has access to the end points of a UTA SP-EC.

¹⁰ See also the MIB attribute dot1agCfmDefaultMdPrimaryVid in [IEEE 802.1ag] for which C-tag to use when multiple C-tags are possible.

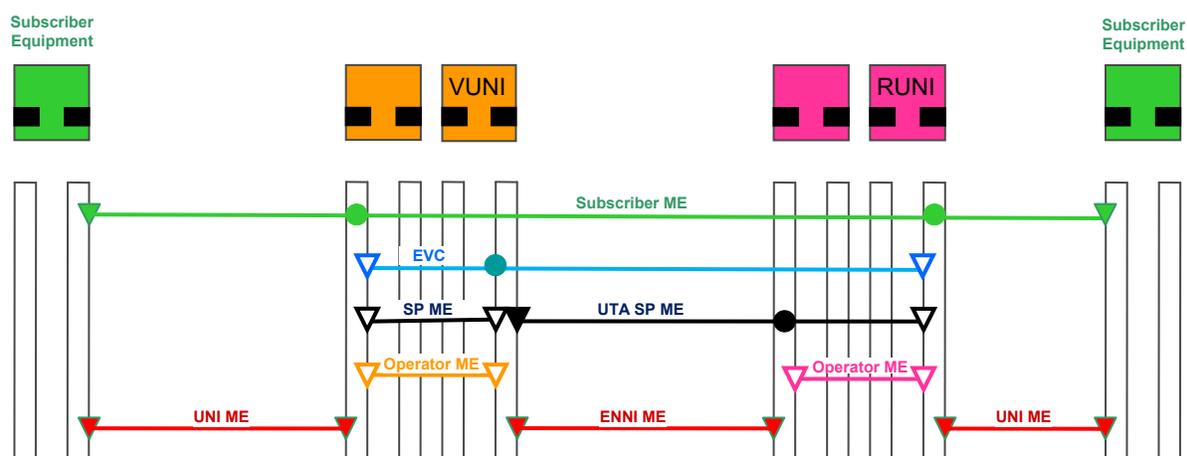


Figure 4 – Example SP MEG With UTA

[D11] An ENNI-N **SHOULD** be capable of enabling a MIP instance on any SP MEG transiting the ENNI.

Note: The previous two desired requirements can not both be met at the same time.

[R14] A UNI-N, VUNI, or RUNI **MUST** be capable of enabling a MEP instance on the SP MEG.

[D12] A MEP corresponding to the Service Provider MEG on a UNI-N, VUNI, or RUNI **SHOULD** be an Up MEP.

7.8 Operator MEG

If an Operator wishes to monitor an OVC or its portion of an EVC, then the Operator MEG would be the appropriate MEG to use.

[R15] An ENNI-N **MUST** be capable of enabling a MEP instance on each Operator MEG terminating at the ENNI-N.

[D13] A MEP corresponding to the Operator MEG on an ENNI-N **SHOULD** be an Up MEP.

[R16] A UNI-N or VUNI **MUST** be capable of enabling a MEP instance on the Operator MEG associated with each EVC or OVC.

[D14] A MEP corresponding to the Operator MEG on a UNI-N or VUNI **SHOULD** be an Up MEP.

7.9 UNI MEG

The desire is to support untagged SOAM PDUs for a port-based UNI MEG. In the event that this is not supported, using tagged SOAM PDUs for a port-based UNI MEG is acceptable, if agreed to by both parties in the UNI MEG.

- [R17] A port-based UNI MEG **MUST** support untagged SOAM PDUs.¹¹
- [D15] A port-based UNI MEG **SHOULD** support C-Tagged SOAM PDUs.
- [D16] The UNI MEG **SHOULD** default to using untagged SOAM PDUs.
- [D17] If tagged SOAM PDUs are used for the UNI MEG, then a default VLAN-ID of 4091 **SHOULD** be used.

7.9.1 UNI-C MEP Requirements

As can be seen from Figure 1, the UNI MEG terminates at the UNI-C.

- [R18] A UNI-C **MUST** be able to support a single MEP instance on the UNI MEG, regardless of whether any EVC is configured for that UNI or not.¹²
- [D18] When the CE implementing the UNI-C is an [IEEE 802.1Q] Bridge, the MEP corresponding to the UNI MEG on a UNI-C **SHOULD** be a Down MEP.¹³

7.9.2 UNI-N MEP Requirements

- [D19] A UNI-N **SHOULD** be able to support a UNI MEG MEP and a minimum number of EVC MEPs, as prescribed in Table 4¹⁴:

Link Speed	10/100 M bits/s	1 G bit/s	10 G bit/s
Minimum number of EVCs	8	64	512

Table 4 – Minimum Number of EVCs

Note: Being capable of enabling one or more MEPs does not imply that they are to be enabled. For example, this and similar requirements do not require that all MEPs that could be enabled would necessarily need to be enabled at the same time.

- [R19] A UNI-N **MUST** be able to support at least a single MEP instance on the UNI MEG, regardless of whether any EVC is configured for that UNI or not.¹⁵

¹¹ Encompasses R34.2 and R37.2 of [MEF 20].

¹² Equivalent to R34.1 of [MEF 20].

¹³ Equivalent to part of R35 of [MEF 20].

¹⁴ Equivalent to R24 of MEF 13.

[D20] When the NE implementing the UNI-N is an [IEEE 802.1Q] Bridge, the MEP corresponding to the UNI MEG on a UNI-N **SHOULD** be a Down MEP.¹⁶

7.10 ENNI MEG

The ENNI MEG allows monitoring the connectivity between adjacent ENNI-Ns. The desire is to support untagged SOAM PDUs for a port-based ENNI MEG. In the event that this is not supported, using tagged SOAM PDUs for a port-based ENNI MEG is acceptable, if agreed to by both parties in the ENNI MEG.

[R20] A port-based ENNI MEG **MUST** support untagged SOAM PDUs.

[D21] If tagged SOAM PDUs are used for the ENNI MEG, then a default VLAN-ID of 4091 **SHOULD** be used in the S-tag of the frames.

[D22] If ETH-AIS is supported, then AIS **SHOULD** be generated by MPs at higher MEG Levels (than the ENNI MEG Level of 1) for an ENNI failure impacting OVCs that terminate at this ENNI.

As can be seen from Figure 1, the Operator and ENNI MEs terminate at the ENNI-N.

[R21] An ENNI-N **MUST** be capable of enabling a MEP instance on the ENNI MEG, regardless of whether any EVC is supported across that ENNI or not. This ENNI MEG, referred to as the “default ENNI MEG”, is for use for the physical attachment, and is not associated with any EVCs.

[D23] A MEP corresponding to the ENNI MEG on an ENNI-N **SHOULD** be a Down MEP.

¹⁵ Equivalent to R37.1 of [MEF 20].

¹⁶ Equivalent to R38 of [MEF 20].

8. Fault Management Protocols

This section lists the Service OAM Fault Management requirements that are protocol specific.

8.1 MEG ID / MAID

The MEG ID is required to be unique within a MEN, operators network, where an operator and customer connect, or where two operators interconnect. When a MEG has MEPs or MIPs in more than one network (which is true for all MEGs other than the Operator MEG, and other than a Subscriber MEG with no MIPs configured), then all involved parties must agree to the naming format. This section proposes desired default formats, although any format can be used that is agreed upon by involved parties.

Although this IA generally uses the terminology of [ITU-T Y.1731], this section of the IA uses the Maintenance Association (MA) and Maintenance Association Identifier (MAID) terminology of [IEEE 802.1ag] to clarify the formatting of the MEG ID / MAID.

As specified per [IEEE 802.1ag], a MAID has two components consisting of the MD Name and the Short MA Name.

[D24] The Maintenance Domain Name Format field of the MAID **SHOULD** have a value of 1, as defined in Table 21-19 of [IEEE 802.1ag], which indicates that the MD Name field is not present.¹⁷

When the MD Name is not present, the format is as shown below (from [IEEE 802.1ag]):

	Octet
Maintenance Domain Name Format (1)	1
Short MA Name Format	2
Short MA Name Length	3
Short MA Name	$4 - (\text{smnl}^a + 3)$
0 pad, if necessary	$(\text{smnl} + 4) - 48$

^a Short MA Name Length

Figure 5 – MAID Field Format

[D25] The Short MA Name Format Field of the MAID **SHOULD** support values of {1, 2, 3, 4, or 32}, as defined in Table 21-20 of [IEEE 802.1ag].¹⁸

[D26] The Short MA Name Format Field of the MAID **SHOULD** default to 2, which indicates a format of Character String.

¹⁷ Encompasses R48.1 of [MEF 20].

¹⁸ Encompasses R48.2 of [MEF 20].

- [D27] The Short MA Name Field of the MAID **SHOULD** be uniquely related (but not necessarily equal) to the UNI ID, EVC ID, or ENNI ID as follows¹⁹:
- Representative value of the UNI ID, shared by the Subscriber and Service Provider, for the default (untagged) UNI MEG.
 - Representative value of the EVC ID, shared as needed by the Service Provider and Operator, for the EVC MEG.
 - Representative value of the EVC ID, shared as needed by the Subscriber and the Service Provider, for the Test MEG.
 - Representative value of the EVC ID, shared as needed by the Subscriber and any Service Provider or Operator that optionally decides to support a MIP on that EVC for the Subscriber MEG.
 - Representative value of the ENNI ID, shared by both Operators, for the default (untagged) ENNI MEG.

Note: Using UNI ID or EVC ID values as the value for the Short MA Name may lead to truncation problems. [MEF 10.2] specifies that UNI ID and EVC ID attributes must be unique across the MEN, but does not specify a maximum length. [MEF 16] truncates the UNI ID and EVC ID to 100 and 64 octets, respectively, when mapping these attributes into information elements. As such, these MEF identifiers can be larger than can possibly fit into a Short MA Name²⁰, which has a maximum possible length of 48 octets, and truncation does not necessarily produce unique identifiers. However, there is no issue if the ID is at most 45 octets.

[D28] The UNI ID and EVC ID **SHOULD** be no longer than 45 octets.

Note: [MEF 26] specifies a maximum length of 45 bytes for the OVC ID.

For an ENNI MEG, the MEG ID / MAID needs to have a format and a value that are jointly agreed upon by the providers of both ends of the ENNI.

8.2 Continuity Check

The following requirements apply to the implementation of the Continuity Check Message (CCM) function as an operation that runs on a MEP for service monitoring. These requirements define default protocol values and the protocol options that are required for MEF Service OAM.

- [R22] MEPs **MUST** support the CCM messages and processes as defined in [IEEE 802.1ag].²¹
- [R23] MEPs **MUST** have the capability to be administratively configured to enable and disable CCM transmissions.²²
- [D29] CCM transmissions **SHOULD** be disabled by default on the Subscriber MEG, the Test MEG, the EVC MEG, the SP MEG, and the Operator MEG.²³

¹⁹ Encompasses R48.3 of [MEF 20].

²⁰ See Table 21-18 of [IEEE 802.1ag].

²¹ Encompasses R40 and R42 of [MEF 20].

²² Equivalent to R44 of [MEF 20].

²³ Encompasses R46.1 of [MEF 20].

[D30] CCM transmissions **SHOULD** be enabled by default on the UNI MEG and the ENNI MEG.²⁴

The following requirements define the parameters that control CCM behavior.

[R24] Tagged CCM frames **MUST** support a configurable priority (as conveyed by the CoS ID²⁵) for transmitted CCM frames.²⁶

[R25] The default value of the CoS of a tagged CCM frame **MUST** be the value that yields the lowest frame loss for the EVC or OVC.²⁷

[D31] Untagged CCM frames, which therefore have no CoS ID field, **SHOULD** be transmitted with the highest priority supported by the NE.²⁸

[R26] A MEP **MUST** support the CCM frame transmission periods of $\{1\text{ s}, 10\text{ s}\}$.²⁹

[D32] The default CCM transmission period for a MEP in a UNI MEG or ENNI MEG **SHOULD** be 1 second.³⁰

[D33] The default CCM transmission period for a MEP in a MEG other than a UNI MEG or ENNI MEG **SHOULD** be 10 seconds.

[D34] A MEP **SHOULD** support the CCM frame transmission periods of $\{3.33\text{ ms}, 10\text{ ms}, 100\text{ ms}\}$.³¹

Note that there may be a direct correlation between the CCM frame transmission periods supported and the level of resiliency a network element can offer a specific EVC. Three consecutive CCM messages must be lost before a failure is detected across a specific MEG. For protection switching mechanisms that use CCM messages to detect connectivity failures across an ME (e.g., ITU-T G.8031, G.8032) a failure must be detected before any protection switching mechanisms can enable a new path through the network. E.g., to enact a protection switching mechanism that claims a maximum switching time of 50 ms and which uses CCMs to detect the failure, the CCM frame transmission period must be 10 ms or less. Otherwise, just detecting the failure would take more than 50 ms.

[D35] A MEP **SHOULD** provide a count of the number of CCM frames transmitted.³²

[D36] A MEP **SHOULD** support the CC defect and fault alarm hierarchy specified in clause 20.1.2 of [IEEE 802.1ag].³³

²⁴ Encompasses R46.2 of [MEF 20].

²⁵ See [MEF 23].

²⁶ Encompasses R47.1 of [MEF 20].

²⁷ Encompasses R47.2 of [MEF 20].

²⁸ Encompasses R47.3 of [MEF 20].

²⁹ Encompasses R45.1 of [MEF 20].

³⁰ Encompasses R45.3 of [MEF 20].

³¹ Encompasses R45.2 of [MEF 20].

³² Encompasses R49 of [MEF 20].

³³ Encompasses R50.1 of [MEF 20].

- [R27] If a MEP supports the CC defect and fault alarm hierarchy, the highest priority alarm **MUST** be made available to management.³⁴
- [D37] If a MEP supports the CC defect and fault alarm hierarchy, the highest priority alarm **SHOULD** mask lower priority alarms.³⁵
- [R28] A MEP located at a UNI-N or at a UNI-C Type 2 **MUST** support the minimum CC fault priority level specified in [IEEE 802.1ag] for which a CC alarm will be generated. An alarm will be generated only if the fault has equal or greater priority than this minimum fault level.³⁶
- [D38] If a MEP supports the CC defect and fault alarm hierarchy, the default minimum priority level **SHOULD** be set to RDI.³⁷
- [R29] A MEP **MUST** support a CC fault alarm time and a CC fault reset time.³⁸
- [D39] The default CC fault alarm time **SHOULD** be set to 2.5 seconds, as specified in 20.33.3 of [IEEE 802.1ag].³⁹
- [D40] The default CC fault reset time **SHOULD** be set to 10 seconds, as specified in 20.33.4 of [IEEE 802.1ag].⁴⁰

This IA does not require any specific TLV in the CCM frames; however their use is recommended, including Sender ID ([IEEE 802.1ag] 21.5.3), Port Status ([IEEE 802.1ag] 21.5.4), and Interface Status ([IEEE 802.1ag] 21.5.5).

A Sender ID TLV, if included, indicates the Chassis ID, the Management Domain, and the Management Address of the source of the CCM frame. Although including the management address of a remote device rather than just its MAC address can make the identification of the device possible in a large network where MAC addresses are not well-known, it is not recommended and is considered a security risk.

- [D41] A MEP **SHOULD** include the Sender ID TLV in CCM frames by default.
- [D42] The Management Domain field **SHOULD** be empty in the Sender ID TLV by default.
- [D43] The Management Address field **SHOULD** be empty in the Sender ID TLV by default.

The Port Status and Interface Status TLVs indicate the bridging and interface statuses of the sender of the CCM. These can be used to indicate to the far end that the local UNI or ENNI interface is down. An example usage is to indicate customer-customer connectivity is failed even though the MEPs on the EVC MEG continue to receive CCMs.

³⁴ Encompasses R50.2 of [MEF 20].

³⁵ Encompasses R50.3 of [MEF 20].

³⁶ Encompasses R51.1 of [MEF 20].

³⁷ Encompasses R51.2 of [MEF 20].

³⁸ Encompasses R52.1 of [MEF 20].

³⁹ Encompasses R52.2 of [MEF 20].

⁴⁰ Encompasses R52.3 of [MEF 20].

[D44] A MEP **SHOULD** include the Port Status TLV in CCM frames by default.

[D45] A MEP **SHOULD** include the Interface Status TLV in CCM frames by default.

8.2.1 Remote Defect Indication Signal

The following requirements apply to the implementation of the Ethernet Remote Defect Indication Signal (ETH-RDI) function as a communicative means for a MEP to indicate the presence of a defect condition to peer MEPs. These requirements define default protocol values and the protocol options that are required for a compliant MEF Service OAM. Note that this function requires the ETH-CC function to be enabled since RDI is an information element within the CCM PDU.

[R30] A MEP **MUST** support the ETH-RDI operations, information elements, and processes as defined in [IEEE 802.1ag].

8.3 Loopback

The following requirements apply to the implementation of the Ethernet Loopback (ETH-LB) function as an operation that runs on-demand on a MEP for service troubleshooting. These requirements define default protocol values and the protocol options that are required for a compliant MEF Service OAM implementation.

For the purposes of this section, an LB Session is defined as a sequence that begins with management initiating the transmission of n periodic LBM frames from a MEP to a peer MIP or MEP. An LB Session ends normally when the last LBR frame is received or incurs a timeout.

[R31] A MEP **MUST** support the LBM/LBR messages and processes as defined in [IEEE 802.1ag].⁴¹

[R32] A MEP **MUST** support the ability to be administratively configured to initiate and stop LB Sessions.⁴²

[R33] A MIP **MUST** support the LBM/LBR messages and processes as defined in [IEEE 802.1ag].

[R34] An UNI-N MIP **MUST** support the ETH-LB mechanism's sink functionality.

[R35] An ENNI-N MIP **MUST** support the ETH-LB mechanism's sink functionality.

The following requirements define the parameters that must be provided when initiating an LB Session.

[R36] A MEP **MUST** be configurable to use any Unicast MAC DA as the destination address of an LBM.⁴³

⁴¹ Encompasses R41 and R43.1 of [MEF 20].

⁴² Equivalent to R53 of [MEF 20].

- [D46] A MEP **SHOULD** also support multicast class 1 MAC destination addresses (see section 10.1 of [ITU-T Y.1731]) corresponding to the reserved multicast addresses for CCM.⁴⁴
- [R37] A MEP **MUST** be able to process and respond to both Unicast and Multicast LBM frames.⁴⁵
- [D47] A MEP that supports transmitting LBM frames with multicast MAC addresses **SHOULD** be able to report the originating MAC in at least one LBR sent in response to the LBM.
- [R38] For each LB session, the priority of LBM/LBR frames **MUST** be configurable.⁴⁶
- [D48] The default value of the CoS of an LBM/LBR frame **SHOULD** be the value that yields the lowest frame loss for the EVC or OVC.⁴⁷
- [D49] For each LB session, the timeout for an expected LBR result after a LBM transmission **SHOULD** be configurable.⁴⁸
- [D50] The default value of the LBR timeout **SHOULD** be 5 seconds.⁴⁹

Note that the primary intended use of multicast loopback is to discover the MAC addresses of the remote MEP(s) on a MEG. This discovery capability can have important applicability when the local and remote MEP(s) are under different administrative domains (e.g., on the UNI).

- [R39] The number of LBM transmissions to perform in an LB session **MUST** be configurable in the range of 1 through 1024.⁵⁰
- [D51] The default value for the number of LBM transmissions in an LB session **SHOULD** be 3.⁵¹
- [R40] For an LB Session, the time interval between LBM transmissions **MUST** be configurable in the range of 0 seconds through 60 seconds.⁵²
- [R41] For an LB Session, the time interval between LBM transmissions **MUST** be configurable with a granularity of at least 100 milliseconds.

Note that a value of 0 seconds indicates that the LBMs are to be sent with no enforced delay between them.

- [D52] The default value for the time interval between LBM transmissions in a LB Session **SHOULD** be 1 second.⁵³

⁴³ Encompasses R43.1 and R54.1 of [MEF 20].

⁴⁴ Encompasses R43.2 and R54.2 of [MEF 20].

⁴⁵ Equivalent to R41 of [MEF 20].

⁴⁶ Equivalent to R55.1 of [MEF 20].

⁴⁷ Equivalent to R55.2 of [MEF 20].

⁴⁸ Equivalent to R58.1 of [MEF 20].

⁴⁹ Equivalent to R58.2 of [MEF 20].

⁵⁰ Equivalent to R56.1 of [MEF 20].

⁵¹ Equivalent to R56.2 of [MEF 20].

⁵² Encompasses R57.1 of [MEF 20].

⁵³ Equivalent to R57.2 of [MEF 20].

- [R42] For an LB Session, the size of the LBM frame **MUST** be configurable to any Ethernet frame size between 64 bytes and the maximum transmission unit of the EVC.⁵⁴
- [R43] The Data TLV **MUST** be supported in LBMs/LBRs. The inclusion of the Data TLV in a specific LBM is dependent on the frame size requested.⁵⁵
- [D53] The default value of the LBM frame size **SHOULD** be 64 bytes.⁵⁶

Note that as with CCMs, a Sender ID TLV, if included, indicates the Chassis ID, the Management Domain, and the Management Address of the source of the CCM frame. Although including the management address of a remote device rather than just its MAC address can make the identification of the device possible in a large network where MAC addresses are not well-known, it is not recommended. Including the management address, which gets sent in the clear, is considered a security risk.

- [D54] A MEP **SHOULD** support the Sender ID TLV in the LBM/LBR, and **SHOULD** include it in LBM frames by default.
- [D55] The Management Domain field **SHOULD** be empty in the Sender ID TLV by default.
- [D56] The Management Address field **SHOULD** be empty in the Sender ID TLV by default.

The following requirements define the Loopback information that is to be maintained for each LB session that is sent to a unicast address.

- [R44] For an LB Session, the initiating MEP **MUST** be able to report the number of LBMs transmitted and the number of LBRs received.⁵⁷
- [D57] For an LB Session, the initiating MEP **SHOULD** be able to report the percentage of responses lost (timed out).⁵⁸
- [R45] For an LB session, the round trip time (RTT) min/max/average statistics **SHOULD** be supported by the initiating MEP.⁵⁹
- [D58] A responding MP **SHOULD** be able to report the aggregate number of LBMs received and the aggregate number of LBRs transmitted during a time period.

Note: The statistics that can be gleaned from LB RTT measurements can be useful for fault detection. For performance management, more precise measurements need to be used, as will be described in a future MEF document dealing with SOAM Performance Management.

⁵⁴ Equivalent to R59.1 of [MEF 20].

⁵⁵ Equivalent to R59.2 of [MEF 20].

⁵⁶ Equivalent to R59.3 of [MEF 20].

⁵⁷ Partially addresses R60 of [MEF 20].

⁵⁸ Partially addresses R60 of [MEF 20].

⁵⁹ Partially addresses R60 of [MEF 20].

8.4 Linktrace

The following requirements apply to the implementation of the Ethernet Linktrace (ETH-LT) function as an operation that runs on-demand on a MEP for service troubleshooting. These requirements define default protocol values and the protocol options that are required for a MEF-compliant Service OAM implementation.

- [R46] An MP **MUST** support the LTM/LTR messages and processes as defined in [IEEE 802.1ag].
- [R47] An UNI-N MIP **MUST** support the ETH-LT mechanism's sink and forward functionalities.
- [R48] An ENNI-N MIP **MUST** support the ETH-LT mechanism's sink and forward functionalities.

Note that as with CCMs, a Sender ID TLV, if included, indicates the Chassis ID, the Management Domain, and the Management Address of the source of the CCM frame. Although including the management address of a remote device rather than just its MAC address can make the identification of the device possible in a large network where MAC addresses are not well-known, it is not recommended. Including the management address, which gets sent in the clear, is considered a security risk.

- [D59] A MEP **SHOULD** support the Sender ID TLV in the LTM/LTR, and **SHOULD** include it in LTM frames by default.
- [D60] The Management Domain field **SHOULD** be empty in the Sender ID TLV by default.
- [D61] The Management Address field **SHOULD** be empty in the Sender ID TLV by default.

The following requirements define the Linktrace information that is to be maintained for each LT session that is sent to a unicast address.

- [R49] An initiating MEP **MUST** be able to report the number of LTMs transmitted and the number of LTRs received.
- [D62] A responding MP **SHOULD** be able to report the number of LTMs received and the number of LTRs transmitted.

Note: The information that can be gleaned from a string of LTRs can be useful for fault diagnosis. For performance management, more precise measurements need to be used, as will be described in a future MEF document dealing with SOAM Performance Management.

8.5 Alarm Indication Signal

The following requirements apply to the implementation of the Ethernet Alarm Indication Signal (ETH-AIS) function as an operation that runs following the detection of a fault. These require-

ments define default protocol values and the protocol options that are required for a MEF-compliant Service OAM implementation.

[D63] An MP **SHOULD** support the ETH-AIS operations, information elements, and processes as defined in [ITU-T Y.1731] and [ITU-T G.8021].

[D64] If ETH-AIS is supported, the default value for the AIS frame transmission period **SHOULD** be 1 second.

[R50] If ETH-AIS is supported, the default value for the CoS for an AIS frame **MUST** be the value that yields the lowest frame loss for the EVC or OVC.

Note 1: In some cases it can be useful to send the first three AIS messages using a short transmission period (3.33 ms or 10 ms) in order to enable fast service protection on higher MEG Levels. AIS messages could be affected by changes in network topology that result from the same fault which is causing the AIS to be generated. By sending multiple messages during the initial second, the probability of the AIS message being received at the destination increases.

Note 2: AIS is not intended to be used in multi-point services. Use of AIS in multi-point services is not recommended by this IA.

8.6 Locked Signal

The following requirements apply to the implementation of the Ethernet Locked Signal (ETH-LCK) function as a communicative means for a MEP receiving a Locked signal from a peer MEP to differentiate between an administratively locked MEP and a defect condition. These requirements define default protocol values and the protocol options that are required for a compliant MEF Service OAM implementation.

[D65] An MP **SHOULD** support the ETH-LCK operations, information elements, and processes as defined in [ITU-T Y.1731] and [ITU-T G.8021].

[D66] If ETH-LCK is supported, the default value for the LCK frame transmission period **SHOULD** be 1 second.

[R51] If ETH-LCK is supported, the default value for the CoS for a LCK frame **MUST** be the value that yields the lowest frame loss for the EVC or OVC.

8.7 Test Signal

The following requirements apply to the implementation of the Ethernet Test Signal (ETH-Test) function as a means for performing one-way in-service or out-of-service diagnostic testing between a pair of MEPs. These requirements define default protocol values and the protocol options that are required for a compliant MEF Service OAM implementation. Note that when performing out-of-service diagnostic testing, the ETH-LCK is used in conjunction with ETH-Test.

[D67] A MEP **SHOULD** support the ETH-Test operations, information elements, and processes as defined in [ITU-T Y.1731] and [ITU-T G.8021].

[R52] If ETH-Test is supported for in-service diagnostic testing, the default value for the CoS for a TST frame **MUST** be the value which yields the lowest frame loss for the EVC or OVC.

9. References

- [IEEE 802.1Q] *Virtual Bridged Local Area Networks, 2005*
[IEEE 802.1ag] *Virtual Bridged Local Area Networks – Amendment 5: Connectivity Fault Management, 2007*
- [IETF RFC 2119] *Key Words for use in RFCs to Indicate Requirement Levels*
[ITU-T Y.1731] *OAM Functions and Mechanisms for Ethernet-based Networks, 2008*
[ITU-T G.8021] *Characteristics of Ethernet Transport Network Equipment Functional Blocks, 2007*
- [MEF 4] *Metro Ethernet Network Architecture Framework – Part 1: Generic Framework*
- [MEF 6.1] *Ethernet Services Definition – Phase 2*
[MEF 7.1] *EMS-NMS Information Model – Phase 2*
[MEF 10.2] *Ethernet Service Attributes – Phase 2*
[MEF 12.1] *Carrier Ethernet Network Architecture Framework Part 2: Ethernet Services Layer – Phase 2*
- [MEF 16] *Ethernet Local Management Interface*
[MEF 17] *Service OAM Requirements and Framework – Phase 1*
[MEF 20] *UNI Type II Implementation Agreement*
[MEF 23] *Carrier Ethernet Class of Service – Phase 1*
[MEF 26] *External Network Network Interface (ENNI) – Phase 1*

10. Appendix A – FM Scenarios [Informative]

This appendix describes a few of the possible failure scenarios that could occur, and how they would be dealt with.

10.1.1 UNI Failure

A UNI failure is any failure in the function of the UNI, including the equipment providing the UNI-C or UNI-N and the equipment providing communication between the UNI-C and UNI-N. There are two cases to consider, the single-hop UNI and the multi-hop UNI.

10.1.1.1 UNI Without Intervening Bridges

If the UNI is a single-hop, MEPs will detect the UNI failure if their MEGs include the UNI, or if they are positioned on the Ethernet interface of the UNI-C and UNI-N which realize the UNI. This is illustrated by Figure 6:

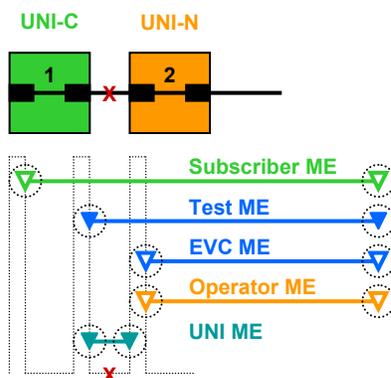


Figure 6 – UNI Failure Without Intervening Bridges

The Subscriber Up MEP on the UNI-C will not immediately detect the UNI failure since it is not positioned on the Ethernet interface which realizes the UNI. However, the MEP will be isolated and CCM, if running, will detect a loss of connectivity. The MEP and its peer MEP(s) will raise Remote MEP alarms. If CCM is running, the peer MEPs will also raise RDI (by setting the RDI bit in their CCM frames).

Note: Remote MEP alarms can be raised through the dot1agCfmFaultAlarm MIB attribute described in section 12.14.7.7, Table 17-1, and section 17.5 of [IEEE 802.1ag].

The Test Down MEP on the UNI-C would detect the UNI failure. However, CCM is not expected to be running in the Test MEG and no further behavior is triggered.

The EVC Up MEP on the UNI-N will detect the UNI failure and report the fault to peer MEP(s) via CCM and the Interface Status TLV, if CCM is running. These peer MEP(s) will set MAC Status defects.

Note: [IEEE 802.1ag] 20.33.6 defines the variable `someMACstatusDefect`. This can be useful to set because with an Up MEP, one can still send CCMs even with a defect in the equipment outside of the ME which the MEP the covers.

The Operator Up MEP on the UNI-N will detect the UNI failure and report the fault to peer MEP(s) via CCM and the Interface Status TLV. These peer MEP(s) will set MAC Status defects.

The UNI Down MEP on the UNI-C and UNI-N will detect the UNI failure. Furthermore, both MEPs will be isolated and CCM will detect a loss of connectivity. Both MEPs will raise Remote MEP alarms.

10.1.1.2 UNI With Intervening Bridges

If there are intervening bridges between the UNI-C and the UNI-N, and a failure occurs at an intermediate point (where SOAM protocols are not running), only those MEPs whose MEG spans the UNI will detect the UNI failure. This is illustrated by Figure 7.

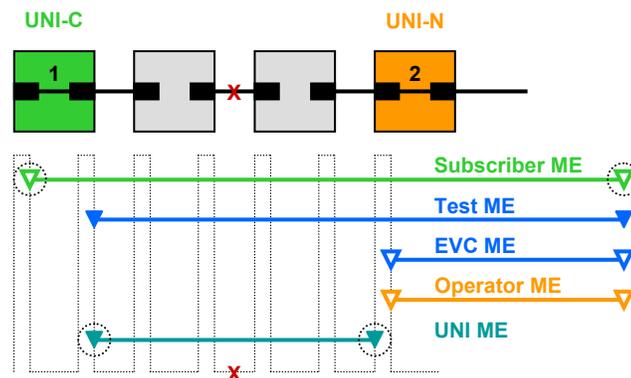


Figure 7 – UNI Failure With Intervening Bridges

The Subscriber Up MEP on the UNI-C will not immediately detect the UNI failure. However, the MEP will be isolated and CCM, if running, will detect a loss of connectivity. The MEP and its peer MEP(s) will raise Remote MEP alarms. The MEP and its peer MEP(s) will also raise RDI (by setting the RDI bit in their CCM SOAM PDUs).

The Test Down MEP, when present and operating on the UNI-C, will detect the UNI failure. However, the Test MEP is not expected to always be present and operating, being often used for failure verification and not necessarily for failure detection (as per [MEF 20]).

The EVC Up MEP on the UNI-N will not detect the UNI failure.

The Operator Up MEP on the UNI-N will not detect the UNI failure.

The UNI Down MEP on the UNI-C and UNI-N will not immediately detect the UNI failure. However, both MEPs will be isolated and CCM will detect a loss of connectivity. Both MEPs will raise Remote MEP alarms.

10.1.2 ENNI Failure

Upon an ENNI failure, a MEP on one side of the ENNI will be isolated from all peer MEP(s) on the other side of the ENNI, but not from peer MEP(s) on the same side of the ENNI.

MEPs will detect the ENNI failure if their MEG spans the ENNI, or if they are positioned on the Ethernet interface of the ENNI-N which realizes the ENNI. This is illustrated by Figure 8.

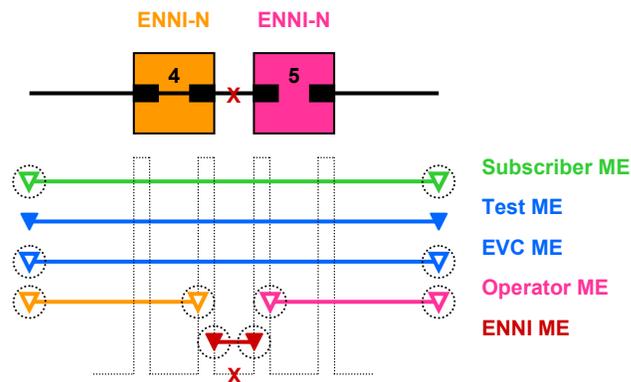


Figure 8 – ENNI Failure

The Subscriber Up MEP on the UNI-C will not immediately detect the ENNI failure since it is not positioned on the Ethernet interface which realizes the ENNI. However, the MEP will be isolated and CCM, if running, will detect a loss of connectivity. The MEP and its peer MEP(s) will raise Remote MEP alarms. The MEP and its peer MEP(s) will also raise RDI (by setting the RDI bit in their CCM frames).

The Test Down MEP on the UNI-C will not detect the ENNI failure.

The EVC Up MEP on the UNI-N will not immediately detect the ENNI failure. However, the MEP will be isolated and CCM will detect a loss of connectivity, if CCM is running. The MEP and its peer MEP(s) will raise Remote MEP alarms. The MEP and its peer MEP(s) will also raise RDI (by setting the RDI bit in their CCM frames).

The Operator Up MEP on the ENNI-N will detect the ENNI failure and report the fault to peer MEP(s) via CCM and the Interface Status TLV, if CCM is running. These peer MEP(s) will raise MAC Status defects.

The ENNI Down MEP on each ENNI-N will detect the ENNI failure. Furthermore, both MEPs will be isolated and CCM will detect a loss of connectivity. Both MEPs will raise Remote MEP alarms.

10.1.3 Operator NE Failure

Upon the failure of an Operator Network Element or a Link, a MEP will be isolated from those peer MEP(s) that are only accessible via forwarding paths that traverse the failed Operator NE or Link.

Only those MEPs whose MEG spans the Operator NE will detect the NE failure. This is illustrated by Figure 9.

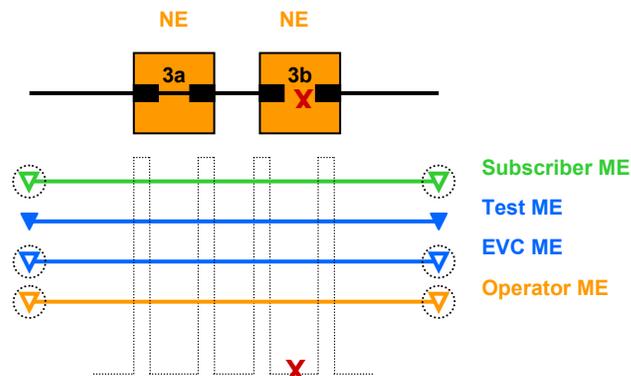


Figure 9 – Operator NE Failure

The Subscriber Up MEP on the UNI-C will not immediately detect the NE failure. However, the MEP will be isolated and CCM, if running, will detect a loss of connectivity. The MEP and its peer MEP(s) will raise Remote MEP alarms. The MEP and its peer MEP(s) will also raise RDI (by setting the RDI bit in their CCM frames).

The Test Down MEP on the UNI-C will not detect the NE failure.

The EVC Up MEP on the UNI-N will not immediately detect the NE failure. However, the MEP will be isolated and CCM will detect a loss of connectivity, if CCM is running. The MEP and its peer MEP(s) will raise Remote MEP alarms. The MEP and its peer MEP(s) will also raise RDI (by setting the RDI bit in their CCM frames).

The Operator Up MEP on the ENNI-N will not immediately detect the NE failure. However, the MEP will be isolated and CCM will detect a loss of connectivity, if CCM is running. The MEP and its peer MEP(s) will raise Remote MEP alarms. The MEP and its peer MEP(s) will also raise RDI (by setting the RDI bit in their CCM frames).

11. Appendix B – VLAN Tagging Implications on SOAM Treatment [Informative]

This appendix reviews some different ways in which VLAN tagging may occur for Subscriber Service Frames, and discusses the implications on Service OAM flows in an 802.1ad network.

Figure 10 provides the reference diagram for this discussion. Here, NE 1 and NE 6 are owned by the Subscriber, while NE 2, NE 3, NE 4, and NE 5 are owned by a Service Provider and/or one or more Operators.

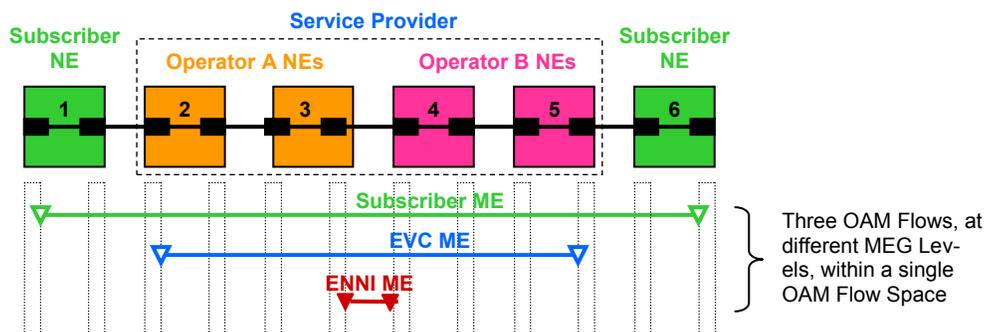


Figure 10 – Reference Diagram

At a UNI, the Subscriber can send into the Service Provider network:

- Untagged frames, or
- C-tagged frames.

If the network receives untagged frames, the Service Provider can transform the frame in many ways, including:

- Add a C-tag, or
- Add an S-tag, or
- Add both a C-tag and an S-tag.

If the network receives C-tagged frames, the Service Provider can transform the frame in many ways, including:

- Continue the C-tag and not add another tag, or
- Remove the C-tag and add an S-tag, or
- Add an S-tag to the C-tag, creating a double tagged frame.

This leads to several tagging cases, illustrated in

Figure 11 below:

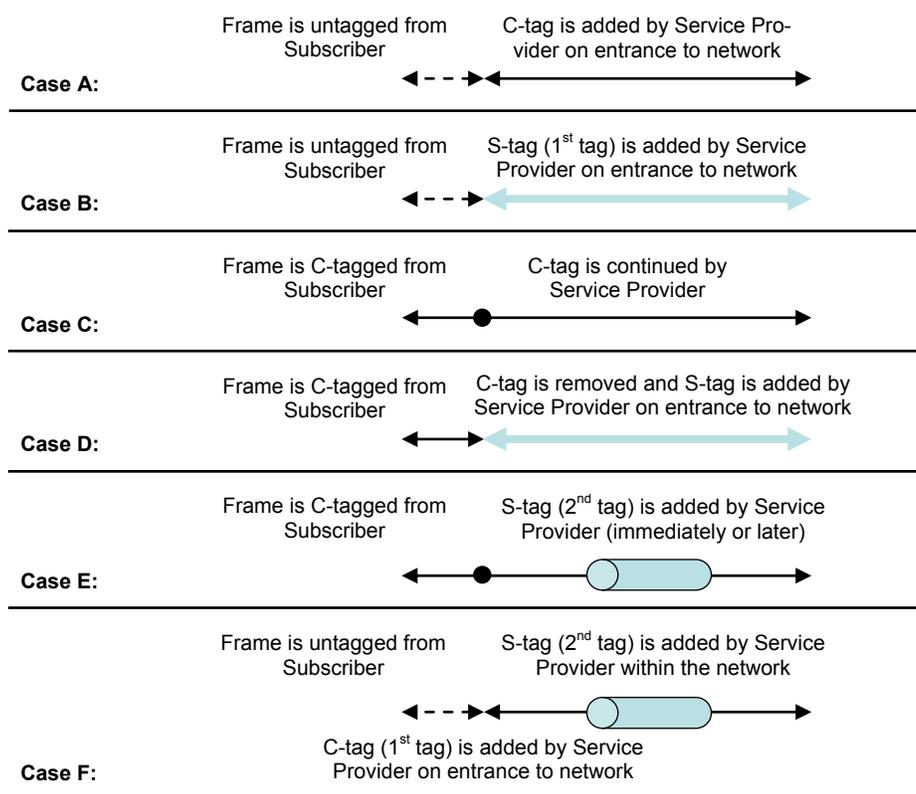


Figure 11 –VLAN Tagging Cases

In cases A, B, C, and D, a SOAM PDU is initiated by the customer, and as it flows over the data path it continues to be processed and treated as a SOAM PDU. These frames exist in the OAM Flow Space seen by the Service Provider and Operator. Therefore, MEG Levels used at any point can be seen by any other point in the path (subject to the [IEEE 802.1ag] restrictions of the extent of various MEG Levels). Stated otherwise, different parties, such as the Service Provider and Operator, must coordinate the use of any levels that they share.

Cases E and F are different from the prior cases. The SOAM PDUs that were inserted in the untagged or single-tagged portions of the path are invisible to all points that are double tagged. This is because the double-tagged portion of the path (i.e., “the tunnel”) has hidden the fact that a frame is a SOAM PDU with the addition of a second (outer) tag. These frames do not exist in the OAM Flow Space seen by the Service Provider and Operator. Within the double-tagging, SOAM PDUs can be inserted and they can use any desired MEG Level without having to consider the MEG levels used by SOAM PDUs that use single tags.

This is illustrated for case F, in Figure 12 below:

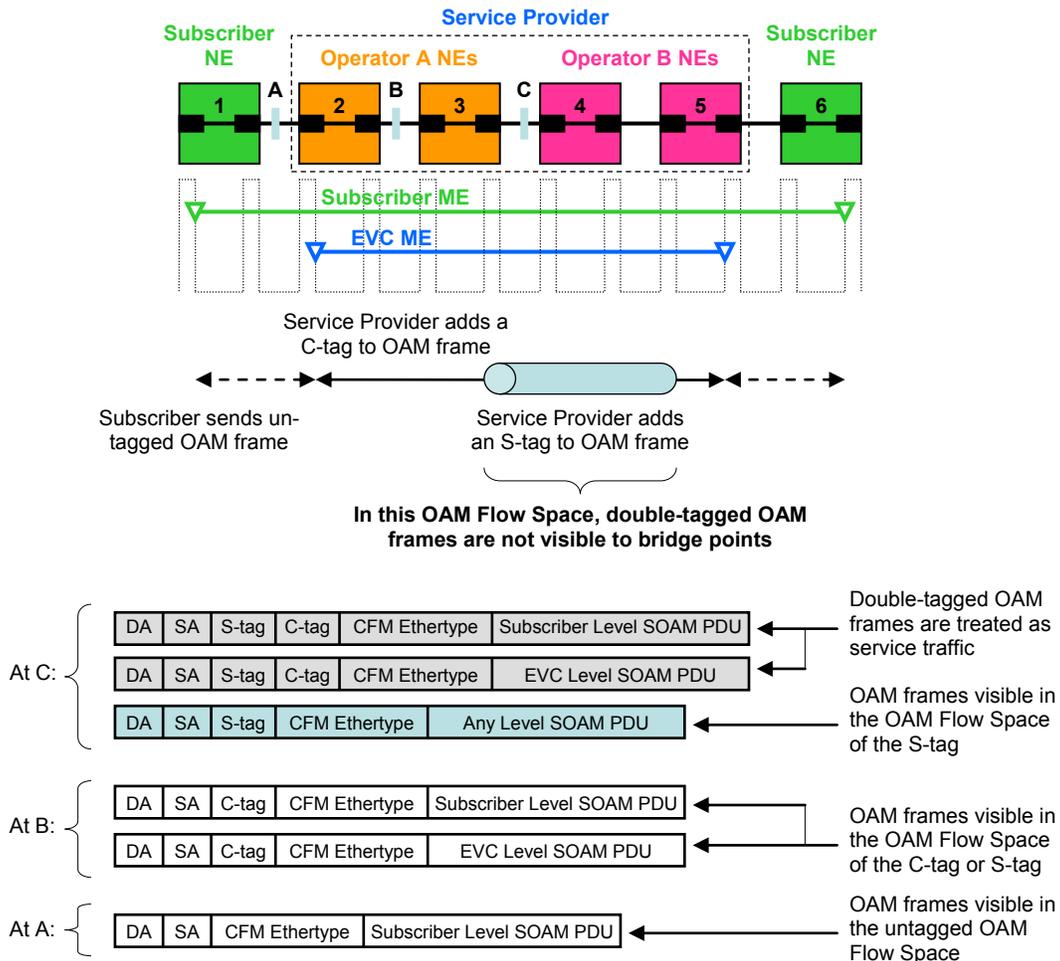


Figure 12 – SOAM PDU Formats

12. Appendix C – Mapping Between 802.1ag and Y.1731 Terms [Informative]

The relationship between the relevant terms used by [IEEE 802.1ag] and [ITU-T Y.1731] is shown in Table 5.

ITU-T Y.1731 Term	IEEE 802.1ag Term	Comments
Maintenance Entity Group (MEG)	Maintenance Association (MA)	This document uses MEG.
Maintenance Entity Group Identifier (MEG ID)	Maintenance Association Identifier (MAID)	This document uses both MEG ID and MAID.
—	Maintenance Domain (MD)	There is no ITU equivalent of this term. This document uses MD only in when describing the format of a MAID.
Maintenance Entity Group Level (MEG level)	Maintenance Domain Level (MD Level)	This document uses MEG level.

Table 5 – Terminology Mappings