MEF Standard

MEF 23.2.2

Amendment to MEF 23.2: Satellite Performance Tier

January 2021

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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.

- Bell Canada
- Intelsat
- Nokia
- TELUS

2 Abstract

This amendment to MEF 23.2 adds a Performance Tier (PT5) for satellite-based services to the existing set of Performance Tiers (PT0.3 through PT4). This amendment includes a description of the new Performance Tier, a table containing the CoS Performance Objectives (CPOs) for PT5, and an update to the CoS Performance Objective Compliance Tool described in Appendix C.

3 Numerical Prefix Conventions

This document uses the prefix notation to indicate multiplier values as shown in Table 1.

Decimal		Binary	
Symbol	**Value**	**Symbol**	**Value**
k	10^3	Ki	2^{10}
M	10^6	Mi	2^{20}
G	10^9	Gi	2^{30}
T	10^{12}	Ti	2^{40}
P	10^{15}	Pi	2^{50}
E	10^{18}	Ei	2^{60}
Z	10^{21}	Zi	2^{70}
Y	10^{24}	Yi	2^{80}

Table 1 – Numerical Prefix Conventions

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 [2], RFC 8174 [3]) when, and only when, they appear in all capitals, as shown here. All key words must be in bold text.

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

5 Introduction

The set of Performance Tiers (PT0.3 through PT4) specified in MEF 23.2[1] is defined on the basis of geographic distances appropriate for terrestrial networks. PT4 has the greatest geographical span currently at an assumed maximum distance of 27,500km, which is less than the one-way distance to a satellite in Geosynchronous Earth Orbit (GEO). As a result it is not possible for a satellite-based Carrier Ethernet service to achieve the CoS Performance Objectives (CPOs), even for PT4. By adding a new Performance Tier (PT5) for satellite-based networks, with specified CPOs for three distinct CoS Labels, this amendment provides a standard way to characterize Carrier Ethernet services delivered via satellite.

This amendment:

- Specifies the PT5 CPOs in a new table (Table A2-1).
- Updates all references to the current set of PTs and their respective CPO tables to include the new PT and its table.
- Updates the worksheets in Appendix C to incorporate the new PT.

This amendment is the second amendment to MEF 23.2. This amendment does not make any changes that affect MEF 23.2.1 [1], nor does it amend any text that was previously amended by MEF 23.2.1.

In this amendment, changes are shown as follows:

- Instructions for how to apply the amendment are shown in *blue italics*
- In content modified by the amendment, text to be removed is shown with ~~red strikethrough~~
- In content modified by the amendment, text to be added is shown in red

6 Changes to Section 8

6.1 Changes to section 8.1.2 Class of Service Label (CoS Label)

Modify the first paragraph of section 8.1.2 as shown:

A Service Provider or Operator can use many CoS Names, each with several different sets of performance objectives and associated parameters. A key goal of this document is to standardize three CoS Names and the values for the sets of performance objectives and associated parameters. These three CoS Names are called CoS Labels and are designated ***H***, ***M***, and ***L***. These informally refer to High, Medium and Low. The order of the CoS Labels is based on the traffic classes in [2] and their associated PCP values. Each CoS Label identifies ~~five~~ six Performance Tiers where each Performance Tier contains a set of performance objectives and associated parameters.

6.2 Changes to section 8.1.4 Performance Tier (PT)

Modify section 8.1.4 as shown:

Performance Objectives, with the exception of the One-way Availability Performance, apply to Qualified Frames in a EVC or OVC. Clearly, the objectives for a frame arriving at an External Interface (EI) depend on the EI that the frame will be delivered to. For example, the geographic distance between the EIs has a significant bearing on the Frame Delay. This Implementation Agreement provides guidance to Service Providers, Operators, and Subscribers by specifying ~~five~~ six sets of CoS Performance Objectives (CPOs) called Performance Tiers (PTs). Each set includes objectives for seven performance metrics for point-to-point and multi-point CPOs.

The PTs are defined on the basis of geographic distance between the EIs, but the choice of a PT can depend on several considerations such as the number of switching hops or speed of links traversed, including access links. Note that the speed and technology used for links is a factor in delay that can be significant. For example, for a 1500 byte frame the serialization delay on a 2 Mb/s link can be about 6 ms and the delay for certain multiple physical link bonding technologies and associated fragmentation and de-fragmentation can add several additional milliseconds.

This Implementation Agreement requires, for a service that uses a CoS Name that is a MEF CoS Label, that CPOs that are specified in the SLS for frames with that CoS Label be consistent with the CPO ranges specified in an appropriate Performance Tier. This connection is made by associating a PT with a subset of OEPPs in the service. This is discussed in section 8.1.5 on CoS Frame Sets.

When an Operator (in agreement with the Service Provider) chooses a PT that is most applicable for a given set of frames for a given CoS Label, the Operator may base that choice on any criteria (e.g., distance, link speed). Setting the proper PT (i.e., CPO set) for OVCs requires a concept of CPOs for each OVC that composes an EVC that are consistent with the EVC CPOs. This is discussed in section 8.3.

In terms of the requirements of this IA, distance between EIs is not a performance-related parameter that must be measured and reported by an Operator. Distance is only used to derive CPOs in this IA. Therefore precise definitions regarding how to measure and report distances

between EIs are not necessary. The CPOs for a given PT may be viewed as a set of CPOs for a particular 'field of use' or 'area of applicability' from the Operator point of view. *The Operator need not adhere to the distances used in the derivation of a PT in their use of a particular MEF PT.*

In deriving PT CPOs for CoS IA, assumptions were made about mapping of applications to one or more CoS and PT. In CEN implementations, particular applications may be mapped differently. For example, a subset of the Mobile Backhaul traffic may have some of the smaller FD/MFD value requirements and these requirements may only be achievable in a particular PT set that is based on relatively low propagation (minimum) delay. CoS IA does not normatively make such application or service exclusions however.

This IA uses distance as the primary means of describing PTs and deriving minimum delays. The distances stated for each PT can be considered as approximate distance only if the assumptions stated in Appendix A are applicable. Below are the ~~five~~ six PTs defined in this IA with the format: PT Number (PT Name) - Description (distance, derived propagation delay used in CPO constraints to establish a minimum per PT).

- PT0.3 (City PT) – derived from distances less than Metro in extent (<75 km, 0.6 ms),
- PT1 (Metro PT) – derived from typical Metro distances (<250 km, 2 ms),
- PT2 (Regional PT) - derived from typical Regional distances (<1200 km, 8 ms),
- PT3 (Continental PT) - derived from typical National/Continental distances (<7000 km, 44 ms),
- PT4 (Global PT) – derived from typical Global/Intercontinental distances (<27500 km, 172 ms)
- PT5 (Satellite PT) – derived from typical Geosynchronous Earth Orbit (GEO) satellite distances (<72000 km, 277 ms).

Appendix A describes how PT sets were derived. Distances are not normative and are only used to provide per PT delay related CPO constraints. The intent is to provide a range of PT sets that address Carrier Ethernet Networks of different geographic coverage, design and scope. Thus a ~~five~~ six PT model is adopted for MEF CoS Labels. CPO value sets are specified in a separate table per PT.

Note that in this document, the Parameters for the Performance Metrics (see section 9.2) have the same values across all Performance Tiers.

6.3 Changes to section 8. 3 Composing End-to-end CPOs

Modify the paragraph following Figure 4 in section 8.3 as shown:

The EVC will still have a UNI-to-UNI CPO set based on PT3 as represented by the bracket on top. The OVCs that compose the EVC may have CPOs as represented by the bottom brackets. In this example, the OVC in CEN1 (UNI-to-ENNI) and the OVC in CEN2 (ENNI-to-UNI) use the PT1 and PT2 set of CPOs, respectively. Note that the OVC CPO values are not likely to concatenate precisely to the EVC CPO values. How CEN Operators arrive at acceptable objectives is beyond the scope of this IA. As stated previously, the composition model includes both allocation and concatenation. While the example in Figure 4 is UNI-to-ENNI, a similar case

can be constructed that includes ENNI-to-ENNI OVCs or the case of a multipoint EVC with a subset of ordered UNI pairs mapped to a PT.

6.4 Changes to section 8.6.3 L2CP to CoS Label Mapping

Modify [D8] in section 8.6.3 as shown:

[D8] At a UNI or VUNI that lists a specific L2CP to CoS Name mapping:

- If the indicated CoS Name is a MEF CoS Label, it **SHOULD** be a CoS Label M or another CoS Label whose CoS Frame Sets have objectives for One-way Frame Loss Ratio that meet the constraints for CoS Label M for the associated Performance Tiers (as specified in Table 8 through ~~Table 12~~ Table A2-1).

- If the indicated CoS Name is not a MEF CoS Label, it **SHOULD** be associated with CoS Frame Sets that have objectives for One-way Frame Loss Ratio that meet the constraints for CoS Label M for Performance Tiers that best align with the OEPPs that the L2CPs are transported between (as specified in Table 8 through ~~Table 12~~ Table A2-1).

7 Changes to Section 9

Changes to section 9.1 Performance Metrics

Modify [R15] in section 9.1 as shown:

[R15] In an EVC or OVC that uses a MEF CoS Label, an SLS entry for a given performance metric and a given CoS Frame Set associated with that CoS Label **MUST** be specified per:

(1) The parameter values for that performance metric defined in Table 5, Table 6 and Table 7, as appropriate for the EVC/OVC type, and;

(2) The objective for that performance metric for the associated CoS Label and EVC/OVC Type in Table 8, Table 9, Table 10, Table 11, ~~or~~ Table 12, or Table A2-1 where table selection is dependent on the PT chosen for that CoS Frame Set.

7.1 Changes to section 9.2 Performance Parameters

Modify the second paragraph of section 9.2 as shown:

Table 5, Table 6, and Table 7 specify Performance Parameters required to derive and specify the CPOs in Table 8, Table 9, Table 10, Table 11, ~~and~~ Table 12, and Table A2-1.

Modify the sixth paragraph of section 9.2 as shown:

Consistent with the requirements in section 9.1, if the SLS includes a performance metric for a CoS Frame Set that is associated with a CoS Label, the parameter values need to meet the constraints in Table 5 – Table 7 and the CPO value needs to meet the constraints in Table 8 – ~~Table 12~~ Table A2-1. The entries in the tables are either a numerical limit on the parameter or CPO value, or "N/S", or both. The interpretation of these entries is as follows:

7.2 Changes to section 9.3 CoS Performance Objectives Per Performance Tier

Modify the first paragraph of section 9.3 as shown:

Table 8, Table 9, Table 10, Table11, ~~and~~ Table 12, and Table A2-1provide CPOs for each Performance metric per each CoS Label. Each Table provides CPOs for one of the PTs. These are normative as per the requirements that refer to them. Note: Multipoint also includes Rooted Multipoint as per [1] and [10].

Modify the sixth paragraph of section 9.3 as shown:

In order to meet CPOs, in the case of an EVC that is composed of multiple OVCs, alignment of CBS between Operators and/or shaping at the ENNI is recommended. Otherwise, the EVC CPOs in Table 8 – ~~Table 12~~ Table A2-1 may not be met even if CoS Label mapping is aligned. In other words, the EVC performance may be impacted enough to cause performance results that miss some CPOs for the EVC or create the need to utilize a less stringent PT. For informative guidance on these issues see Burst Size and Shaper Considerations, Appendix G. In addition, Appendix H includes guidance (informative) on the choice of value for Burst Size (CBS).

Add the following table to the end of section 9.3:

Performance Metric	CoS Label H		CoS Label M		CoS Label L[1]	
	Pt-Pt	Multipt	Pt-Pt	Multipt	Pt-Pt	Multipt
FD (ms)	≤ 370	≤ 370	≤ 450	≤ 450	≤ 600	≤ 600
MFD (ms)	≤ 300	≤ 302	≤ 350	≤ 352	≤ 470	≤ 472
One-way IFDV (ms)	≤ 50	≤ 50	≤ 75 or N/S	≤ 75 or N/S	N/S	N/S
FDR (ms)	≤ 75	≤ 75	≤ 125 or N/S	≤ 125 or N/S	N/S	N/S
FLR (percent)	≤ 1.0% i.e., 10^{-2}	≤ 1.0% i.e., 10^{-2}	≤ 1.0% i.e., 10^{-2}	≤ 1.0% i.e., 10^{-2}	N/S	N/S
Availability High Loss Interval (HLI) Consecutive HLI (CHLI) One Way Group Availability	N/S	N/S	N/S	N/S	N/S	N/S

[1]Ingress Bandwidth Profile parameters may be chosen such that no frames are subject to SLS.

Table A2-1 – PT5 CPOs

8 Changes to Appendix A

Modify Appendix A "Performance Tier Model Derivation (Informative)" as shown:

Assumptions for PTs:

- PT distances represent the path a frame would traverse and thus drive associated propagation delay minimums for FD/MFD/FDR

- Though number of switch hops generally increases with longer distance PTs, hops will not be quantified
- For simplicity, PT CPOs are expressed as constants based on the maximum distance for the PT rather than formulas with distance variables
- PTs are derived with certain distance and application assignments
- PTs can be arbitrarily assigned to given services by Operators based on factors in or outside the scope of this IA
- All links, including access links, will have a link speed of at least 10 Mb/s, with the notion that a given service may utilize a "higher" PT for slower links based on Operator discretion. For PT0.3, the minimum link speed is 1 Gbps.

A ~~five~~ six PT model is chosen to allow for sufficient granularity and cover range from small area networks and applications to global. This IA uses geographic regions ~~distance~~ as the primary means of describing PTs. Each PT is associated with a characteristic distance and a derived propagation delay. The derived propagation delay is calculated from the characteristic distance by adjusting the distance to allow for such things as indirect routing paths and path changes (e.g. dynamic routing protocols), then multiplying by the signal propagation delay per unit distance. For terrestrial PTs a 25% distance adjustment is used, with a fiber optic signal propagation delay of .005 ms/km.

For the satellite PT the characteristic distance is twice the distance from the equator to a satellite in Geosynchronous Earth Orbit (to allow a signal from a transmitting station to travel up to the satellite and back down to a receiving station). This is the minimum line-of-sight distance to the satellite. The line-of-sight distance increases with longitude and latitude of a station that is not directly below the satellite, with a maximum at 81 degrees (beyond which the satellite is below the horizon). For the satellite PT, a 16.4 % distance adjustment is used, with a signal propagation delay through the atmosphere of .0033 ms/km.

The derived propagation delay is used to establish minimum CPO constraints for the PT. The derived propagation delay does not include additional delays due to such things as switch hops, buffering, shaping, and serialization for slow speed links. Below are the ~~five~~ six PTs defined in this IA with the format: PT Number (PT Name) - Description (characteristic distance, derived propagation delay ~~used in CPO constraints to establish a minimum per PT~~).

- PT0.3 (City PT) – derived from sub-Metro distances (<75 km, 0.5ms[*])
- PT1 (Metro PT) – derived from Metro distances (<250 km, 2 ms[*])
- PT2 (Regional PT) - derived from Regional distances (<1200 km, 8 ms[*])
- PT3 (Continental PT) - derived from National/Continental distances (<7000 km, 44 ms[*])
- PT4 (Global PT) – derived from Global/Intercontinental distances (<27500 km, 172 ms[*])
    - Based on I.356 [9].
- PT5 (Satellite PT) – derived from typical Geosynchronous Earth Orbit (GEO) satellite distances (<72000 km, 277 ms).

[*] ~~Minimum Frame Delay based on distance * .005 ms/km * 1.25 where distance is in kilometers (km), .005 ms/km propagation delay and 1.25 is route/airline distance ratio.~~

~~Distance is difficult to ascertain in real-networks as path (i.e., circuit) distance is unknown or may vary due to routing or other path changes (e.g., dynamic control protocols). In real CENs there may be additional delays (e.g., switch hops, buffering, shaping, serialization for low speed links).~~

An Operator's Ethernet service compliance with this IA does not depend on adherence to PT distances. As stated in the normative sections, a given service may utilize a particular PT for reasons other than EI to EI distance of the service.

9 Changes to Appendix C

9.1 Changes to section C.2.1 Mapping Applications to CoS Labels and Performance Tiers

Replace Table 38 (including the footnote on the table caption) with the following:

CoS Label	**H**						**M**						**L**					
Performance Tier	**0.3**	**1**	**2**	**3**	**4**	**5**	**0.3**	**1**	**2**	**3**	**4**	**5**	**0.3**	**1**	**2**	**3**	**4**	**5**
VoIP		X	X	X	X	X												
VoIP & videoconf signaling								X	X	X	X	X						
Videoconf data								X	X	X	X	X						
IPTV data								X	X	X								
IPTV control								X	X	X								
Streaming media														X	X	X	X	X
Interactive gaming		X	X					X	X									
SANs synch replication	X																	
SANs asynch replication								X										
Network attached storage														X	X	X	X	X
Text & graphics terminals														X	X	X	X	X
T.38 fax over IP								X	X	X	X	X						
Database hot standby	X																	
Database WAN replication							X											
Database client/server														X	X	X	X	X
Financial/Trading	X																	
CCTV								X	X	X	X	X						
Telepresence		X	X	X														
Circuit Emulation	X																	
Mobile BH H		X																
Mobile BH M								X										
Mobile BH L														X				

Table 38: Explicit Application Mapping for Derivation of CPOs

9.2 Changes to section C.2.2 Constraints on CPO Values

Modify Table 39 by adding row for PT5 as shown:

Statistical and Inter-CoS Label Constraints	Notes
H CoS Label CPOs ≤ all other CoS Label CPOs, except H FLR ≥ M FLR	For all in-scope metrics CPO (assumes Parameters are consistent across CoS Labels)
FD – MFD >> .5 FDR *	Where .5 represents a symmetric distribution
MFD < FD	
FDR > FD – MFD *	
IFDV < FDR	
FD – FDR ≥ PD	PD = estimated max Propagation Delay for a given PT
(FD – FDR ≤ PD * 1.5) OR (FD – FDR ≤ PD + 20ms)	PD = estimated max Propagation Delay for a given PT

- *Note: can be combined into various forms, e.g., MFD + .5 FDR << FD < MFD + FDR.

PT Constraints	Notes
PTm CPO ≤ PTn CPO	Where m<n (assumes Parameters are consistent across PTs. Includes all in-scope CPOs.)
PT0.3 MFD > 0.5 ms	Estimated max Propagation Delay for PT0.3
PT1 MFD > 2 ms	Estimated max Propagation Delay for PT1
PT2 MFD > 8 ms	Estimated max Propagation Delay for PT2
PT3 MFD > 44 ms	Estimated max Propagation Delay for PT3
PT4 MFD > 172 ms	Estimated max Propagation Delay for PT4
PT5 MFD > 277 ms	Estimated max Propagation Delay for PT5

Standards and Other Constraints	Notes
MEF CPOs ≤ Y.1541 IP QoS Class Objectives CoS Label H PT1-3 for ITU QoS Class 0, 2 CoS Label H PT4 for ITU QoS Class 1 CoS Label M PT1-4 for ITU QoS Class 3 CoS Label L PT1-4 for ITU QoS Class 4 CoS Label L PT1-4 for ITU QoS Class 4 CoS Label L PT5 for ITU QoS Class 5	Includes MFD (IPTD) and FLR (IPLR). Where PT1, PT2, PT3 comparable to National and PT4 comparable to Global
PT1 (Metro) ≤ CPOs for MBH	Not including any synchronization-only driven objectives that could be developed. These are for future phase
CPOs and Parameters will be expressed as maximum or minimum values (not ranges)	

Table 39: CPO Derivation Constraints

9.3 Changes to section C.2.3 Performance Parameters

Modify the introductory text of C.2.3 "The CoS Performance Objective Compliance Tool" as shown:

The CoS Performance Objective Compliance Tool is a Microsoft Excel spreadsheet used to test candidate CPO values against the application-specific Performance Objectives and the constraints identified above. The tool comprises a worksheet for each Performance Tier as well as two summary worksheets. The first worksheet summarizes all CPO values in one table and displays whether they meet the constraint tests. The second summary worksheet shows how the CPO values compare to the mapped application-specific Performance Objectives.

Performance Tier worksheets

There ~~are a total of five~~ is one Performance Tier worksheet~~s, one~~ for each PT. At the bottom left of the table for each tier is a set of proposed CPO values (MFD, FDR, FLR, FD, and IFDV) for each class (H, M, L) in the 3-CoS Label model. The tool checks the compliance of each set of class objectives against the Application Performance Metrics objectives contained in the upper part of the table; the result of the compliance checks is displayed to the right of the application objective values.

Modify the text preceding the PT4 worksheet on page 82 of MEF 23.2 as shown:

~~Finally, the~~ The following chart illustrates the derivation of PT4 objectives:

				=Unspecified application objective							
				=Unknown application objective							
		Application Performance Attributes							MEF CPOs Compliance		
Application Attributes	Application	Context	CIR-only?	MFD (ms)	FDR (ms)	FLR (ratio)	FD (ms)	IFDV (ms)	H	M	L
Consumer Applications	VoIP	PE-PE*	FALSE	4.E+02	5.E+01	3.E-02	4.E+02	4.E+01	OK	OK	Bad
	VoIP and Videoconf Signaling	PE-PE*	FALSE	3.E+02		1.E-03	3.E+02		OK	OK	Bad
	Video Conferencing Data	PE-PE*	FALSE	3.E+02	5.E+01	1.E-02	4.E+02	4.E+01	OK	OK	Bad
	IPTV data plane	PE-PE*	FALSE	1.E+02	5.E+01	1.E-03	1.E+02	4.E+01	Bad	Bad	Bad
	IPTV control plane	PE-PE*	FALSE	8.E+01		1.E-03			Bad	Bad	Bad
	Streaming media	PE-PE*	FALSE		2.E+03	1.E-02		2.E+03	OK	OK	OK
	Interactive gaming	PE-PE*	FALSE	4.E+01	1.E+01	1.E-03	5.E+01	8.E+00	Bad	Bad	Bad
Business Applications	SANs (Synchronous Replication)	PE-PE*	FALSE	4.E+00	1.E+00	1.E-04	5.E+00	1.E+00	Bad	Bad	Bad
	SANs (Asynchronous Replication)	PE-PE*	FALSE	3.E+01	1.E+01	1.E-04	4.E+01	8.E+00	Bad	Bad	Bad
	Network Attached Storage	PE-PE*	FALSE	1.E+03		1.E-03			OK	OK	OK
	Text and Graphics Terminals	PE-PE*	FALSE	2.E+02		1.E-03			OK	Bad	Bad
	T.38 Real-time Fax over IP	PE-PE*	FALSE	4.E+02	5.E+01	3.E-02	4.E+02	4.E+01	OK	OK	Bad
	Database (Hot Standby)	PE-PE*	FALSE			1.E-05	5.E+00		Bad	Bad	Bad
	Database (WAN Replication)	PE-PE*	FALSE			1.E-05	5.E+01		Bad	Bad	Bad
	Database (Client-Server)	PE-PE*	FALSE	1.E+03		1.E-03			OK	OK	OK
	Financial/Trading	PE-PE*	FALSE	2.E+00		1.E-05			Bad	Bad	Bad
	CCTV	PE-PE*	FALSE		5.E+01	1.E-02	2.E+02		Bad	Bad	Bad
	Telepresence (includes Remote Surgery video)	PE-PE*	FALSE	1.E+02	2.E+01	3.E-04	1.E+02	1.E+01	Bad	Bad	Bad
	Circuit Emulation	PE-PE*	FALSE	2.E+01	2.E+01	1.E-06	3.E+01	1.E+01	Bad	Bad	Bad
MBH Applications	MBH H	PE-PE*	FALSE	6.E+00	3.E+00	1.E-05	8.E+00	2.E+00	Bad	Bad	Bad
	MBH M	PE-PE*	FALSE	1.E+01	1.E+01	1.E-05	2.E+01	8.E+00	Bad	Bad	Bad
	MBH L	PE-PE*	FALSE	3.E+01	2.E+01	1.E-03	4.E+01	1.E+01	Bad	Bad	Bad

				MEF CPOs (PT4)					
MEF CoS Parameter Objectives (CPOs)	Description (MEF Example Suggested Applications)	MEF CoS	CIR-only	MFD (ms)	FDR (ms)	FLR (ratio)	FD (ms)	IFDV (ms)	
(PT4, e.g., Global)	Sync, Voice, Near-RT	H	FALSE	200	40	5.E-04	230	32	
	Control/Signaling, Data	M	FALSE	220	50	5.E-04	250	40	
	Data, Background	L	FALSE	240	200	1.E-03	390	160	
	Calculated Route Delay (CRD)			Air Distanc	Variation	Prop Delay	CRD ms	Offset ms	Ratio
	CRD = Air Distance * Route Variation * Prop Delay			27500	1.250	0.0050	172	20	1.5
	Statistical Constraints			IFDV<FDR	FD-FDR < MFD and MFD < FD-FDR/2		CRD < FD-FDR < CRD+Offset or CRD < FD-FDR < CRD*Ratio		
		H		Good	Good		Good		
		M		Good	Good		Good		
		L		Good	Good		Good		
	Non-Statistical Constraints								
	As stringent as Y.1541			MFD<=IPTD		FLR<=IPLR			
		H		Good		Good			
		M		Good		Good			
		L		Good		Good			
				MFD	FDR	FLR	FD	IFDV	
	As stringent as higher tiers	H		Good	Good	Good	Good	Good	
	and less stringent than lower tiers	M		Good	Good	Good	Good	Good	
		L		Good	Good	Good	Good	Good	
				MFD	FDR	FLR	FD	IFDV	
	H<=M (FLR: H>=M)			Good	Good	Good	Good	Good	
	H<=L			Good	Good	Good	Good	Good	

Add the following text and picture after the PT4 worksheet, before the table caption, and modify the table caption as shown:

The following chart illustrates the derivation of PT5 objectives:

				=Unspecified application objective							
				=Unknown application objective							
				Application Performance Attributes					MEF CPOs Compliance		
Application Attributes	Application	Context	CIR-only?	MFD (ms)	FDR (ms)	FLR (ratio)	FD (ms)	IFDV (ms)	H	M	L
Consumer Applications	VoIP	PE-PE*	FALSE	4.E+02	5.E+01	3.E-02	4.E+02	4.E+01	Bad	Bad	Bad
	VoIP and Videoconf Signaling	PE-PE*	FALSE	3.E+02		1.E-03	3.E+02		Bad	Bad	Bad
	Video Conferencing Data	PE-PE*	FALSE	3.E+02	5.E+01	1.E-02	4.E+02	4.E+01	Bad	Bad	Bad
	IPTV data plane	PE-PE*	FALSE	1.E+02	5.E+01	1.E-03	1.E+02	4.E+01	Bad	Bad	Bad
	IPTV control plane	PE-PE*	FALSE	8.E+01		1.E-03			Bad	Bad	Bad
	Streaming media	PE-PE*	FALSE		2.E+03	1.E-02		2.E+03	OK	OK	OK
	Interactive gaming	PE-PE*	FALSE	4.E+01	1.E+01	1.E-03	5.E+01	8.E+00	Bad	Bad	Bad
Business Applications	SANs (Synchronous Replication)	PE-PE*	FALSE	4.E+00	1.E+00	1.E-04	5.E+00	1.E+00	Bad	Bad	Bad
	SANs (Asynchronous Replication)	PE-PE*	FALSE	3.E+01	1.E+01	1.E-04	4.E+01	8.E+00	Bad	Bad	Bad
	Network Attached Storage	PE-PE*	FALSE	1.E+03		1.E-03			Bad	Bad	Bad
	Text and Graphics Terminals	PE-PE*	FALSE	2.E+02		1.E-03			Bad	Bad	Bad
	T.38 Real-time Fax over IP	PE-PE*	FALSE	4.E+02	5.E+01	3.E-02	4.E+02	4.E+01	Bad	Bad	Bad
	Database (Hot Standby)	PE-PE*	FALSE			1.E-05	5.E+00		Bad	Bad	Bad
	Database (WAN Replication)	PE-PE*	FALSE			1.E-05	5.E+01		Bad	Bad	Bad
	Database (Client-Server)	PE-PE*	FALSE	1.E+03		1.E-03			Bad	Bad	Bad
	Financial/Trading	PE-PE*	FALSE	2.E+00		1.E-05			Bad	Bad	Bad
	CCTV	PE-PE*	FALSE		5.E+01	1.E-02	2.E+02		Bad	Bad	Bad
	Telepresence (includes Remote Surgery video)	PE-PE*	FALSE	1.E+02	2.E+01	3.E-04	1.E+02	1.E+01	Bad	Bad	Bad
	Circuit Emulation	PE-PE*	FALSE	2.E+01	2.E+01	1.E-06	3.E+01	1.E+01	Bad	Bad	Bad
MBH Applications	MBH H	PE-PE*	FALSE	6.E+00	3.E+00	1.E-05	8.E+00	2.E+00	Bad	Bad	Bad
	MBH M	PE-PE*	FALSE	1.E+01	1.E+01	1.E-05	2.E+01	8.E+00	Bad	Bad	Bad
	MBH L	PE-PE*	FALSE	3.E+01	2.E+01	1.E-03	4.E+01	1.E+01	Bad	Bad	Bad
				MEF CPOs (PT5)							
MEF CoS Parameter Objectives (CPOs)	Description (MEF Example Suggested Applications)	MEF CoS	CIR-only	MFD (ms)	FDR (ms)	FLR (ratio)	FD (ms)	IFDV (ms)			
(PT5, e.g., Satellite)	Sync, Voice, Near-RT	H	FALSE	300	75	1.E-02	370	50			
	Control/Signaling, Data	M	FALSE	350	125	1.E-02	450	75			
	Data, Background	L	FALSE	470	250	1.E-02	600	160			
	Calculated Route Delay (CRD)			Air Distanc	Variation	Prop Delay	CRD ms	Offset ms	Ratio		
	CRD = Air Distance * Route Variation * Prop Delay			72000	1.164	0.0033	277	20	1.5		
	Statistical Constraints			IFDV<FDR	FD-FDR < MFD and MFD < FD-FDR/2		CRD < FD-FDR < CRD+Offset or CRD < FD-FDR < CRD*Ratio				
		H		Good	Good		Good				
		M		Good	Good		Good				
		L		Good	Good		Good				
	Non-Statistical Constraints										
	As stringent as Y.1541			MFD<=IPTD		FLR<=IPLR					
		H		N/A		N/A					
		M		N/A		N/A					
		L		N/A		N/A					
				MFD	FDR	FLR	FD	IFDV			
	As stringent as higher tiers	H		Good	Good	Good	Good	Good			
	and less stringent than lower tiers	M		Good	Good	Good	Good	Good			
		L		Good	Good	Good	Good	Good			
				MFD	FDR	FLR	FD	IFDV			
	H<=M (FLR: H>=M)			Good	Good	Good	Good	Good			
	H<=L			Good	Good	Good	Good	Good			

Table 40: PT0.3 – ~~4~~ 5 CPO Derivation and Evaluation Spreadsheets

Modify the text introducing the CPO Summary worksheet, and replace Figure 7, as shown:

CPO Summary worksheet

The CPO Summary worksheet displays numerical values for all CPOs (even for those CPOs defined as "Not Specified" in Table 8 through ~~Table 12~~ Table A2-1and shows the results of the constraint tests applied to those CPO values (note that PT ~~1–4~~1-5 assume 10Mbps Ethernet for serialization delay, but PT 0.3 assumes 100Mbps in order to meet the FD requirements). Figure 7 shows the summary displays.

	(See MEF 10.2, Section 6.9 for definitions)							PT comparison									Implied values		
	MEF CoS	CIR-only	MFD (ms)	FDR (ms)	FLR (ratio)	FD (ms)	IFDV (ms)	MFD (ms)	FDR (ms)	FLR (ratio)	FD (ms)	IFDV (ms)	Minimum Delay Test	MinD = FD-FDR	Propagation Delay (ms)	Shaping delay budget factor	Serialization Delay (ms)	Queuing Delay + Shaping Delay budget (ms)	Shaping Delay from budget (ms)
PT0.3	H	FALSE	2	1.25	1.00E-05	3	0.9	Good	Good	Good	Good	Good	Good	1.75	0.5	0.50	0.32	2.21	1.11
	M	FALSE	4	3	1.00E-05	6	2.4	Good	Good	Good	Good	Good	Good	3	0.5	0.50	0.32	5.21	2.61
	L	FALSE	8	4.8	1.00E-03	11	4.2	Good	Good	Good	Good	Good	Good	6.2	0.5	0.50	0.32	10.21	5.11
PT1	H	FALSE	7	5	1.00E-04	10	3	Good	Good	Good	Good	Good	Good	5	2	0.50	3.2	5.2	2.6
	M	FALSE	13	10	1.00E-04	20	8	Good	Good	Good	Good	Good	Good	10	2	0.50	3.2	15.2	7.6
	L	FALSE	28	16	1.00E-03	37	14	Good	Good	Good	Good	Good	Good	21	2	0.50	3.2	32.2	16.1
PT2	H	FALSE	18	10	1.0E-04	25	8	Good	Good	Good	Good	Good	Good	15	8	0.50	3.2	14.3	7.2
	M	FALSE	30	50	1.0E-04	75	40	Good	Good	Good	Good	Good	Good	25	8	0.50	3.2	64.3	32.2
	L	FALSE	50	100	1.0E-03	125	80	Good	Good	Good	Good	Good	Good	25	8	0.50	3.2	114.3	57.2
PT3	H	FALSE	70	12	2.5E-04	77	10	Good	Good	Good	Good	Good	Good	65	44	0.50	3.2	30.1	15.0
	M	FALSE	80	50	2.5E-04	115	40	Good	Good	Good	Good	Good	Good	65	44	0.50	3.2	68.1	34.0
	L	FALSE	125	165	1.0E-03	230	130	Good	Good	Good	Good	Good	Good	65	44	0.50	3.2	183.1	91.5
PT4	H	FALSE	200	40	5.0E-04	230	32	Good	Good	Good	Good	Good	Good	190	172	0.50	3.2	54.9	27.5
	M	FALSE	220	50	5.0E-04	250	40	Good	Good	Good	Good	Good	Good	200	172	0.50	3.2	74.9	37.5
	L	FALSE	240	200	1.0E-03	390	160	Good	Good	Good	Good	Good	Good	190	172	0.50	3.2	214.9	107.5
PT5	H	FALSE	300	75	1.0E-03	355	50	Good	Good	Good	Good	Good	Good	280	277	0.50	3.2	75.2	37.6
	M	FALSE	350	125	1.0E-03	450	75	Good	Good	Good	Good	Good	Good	325	277	0.50	3.2	170.2	85.1
	L	FALSE	470	250	1.0E-02	600	160	Good	Good	Good	Good	Good	Good	350	277	0.50	3.2	320.2	160.1

Figure 7: CPO Summary worksheet

Replace Figure 8 as shown:

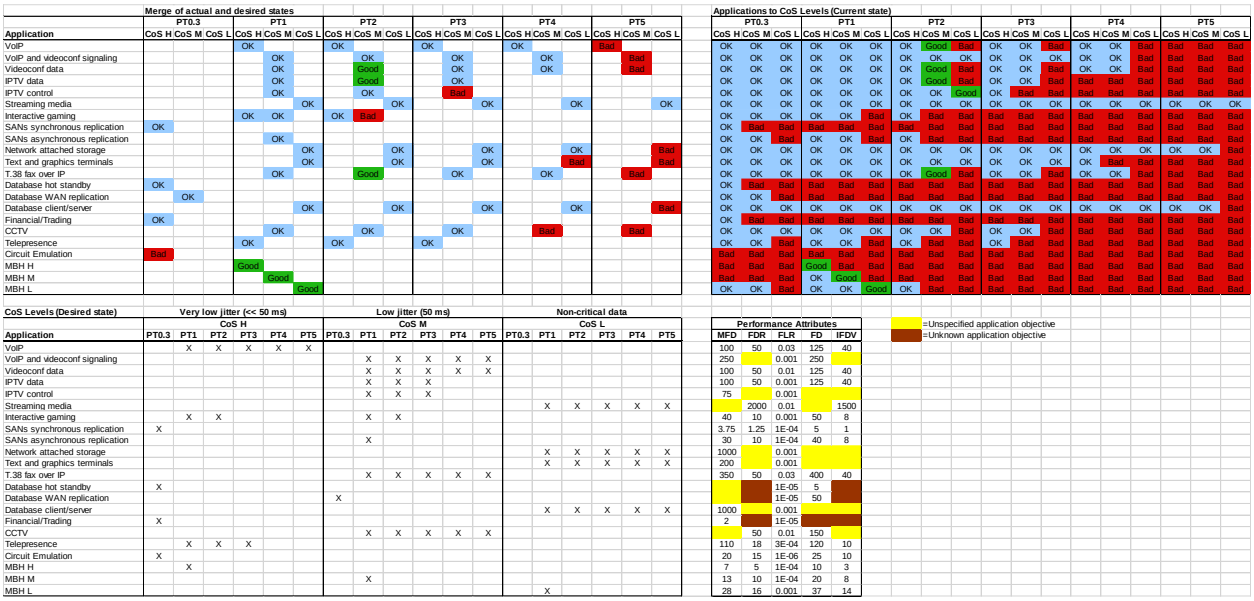

Figure 8: Application Mapping summary worksheet

10 Changes to Appendix F

Modify the first paragraph of F.1.1 "Multipoint CoS Performance Objectives" as shown:

~~Tables 7-11~~ Table 8 through Table A2-1 define less stringent CPOs for multipoint services in comparison to point-to-point services. The origin of these objectives is in relation to the additional processing required to achieve one-to-many connectivity. Multipoint services require two types of additional processing not commonly experienced in point-to-point services: frame replication and address table lookup.

Modify the second from last paragraph of F.1.1 as shown:

The relaxed objectives defined in Table 8 though ~~Table 12~~ Table A2-1 are recommended for EVCs comprising 100 or fewer UNIs. As with all CoS IA performance objectives, operators can always define more stringent objectives. If an operator constrains multipoint service design (e.g.: modest maximum EVC size, ingress rate-limiting of flooding traffic), CPOs equal to that of point-to-point services can be achieved. Operators are encouraged to test their equipment for performance impairment under flooding conditions.

11 References

MEF 23.2, Carrier Ethernet Class of Service – Phase 3, August 2016

[1] MEF 23.2.1, *Models for Bandwidth Profiles with Token Sharing*, January 2017

[2] Internet Engineering Task Force RFC 2119, *Key words for use in RFCs to Indicate Requirement Levels*, March 1997

[3] Internet Engineering Task Force RFC 8174, *Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words*, May 2017