Technical Specification

MEF 10.3.1

Composite Performance Metric (CPM) Amendment to MEF 10.3

February 2015

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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.

- Albis Technologies
- Altera Corporation
- Ciena Corporation
- Colt Telecommunications
- Comcast
- HFR, Inc.
- Infinera Corporation
- InfoVista
- Lightpath
- Omnitron Systems Technology, Inc.
- PLDT Corp.
- RAD Data Communications
- Tata Communications
- T-Mobile USA
- Transition Network
- Verizon

2. Introduction

This amendment makes the following changes to MEF 10.3:

1. Section 8.8.7 is added to define the Composite Performance Metric.
2. New terms are added to Table 1 of MEF 10.3.
3. New entry is added to Reference of MEF 10.3.
4. New appendix is added to MEF 10.3 as Appendix D.

3. Terminology

The following entries are added to Table 1 of MEF 10.3.

U	The Composite Performance Indicator threshold which if exceeded suggests a severely errored time interval, U is in the range of (0,1)
n	The number of consecutive short time intervals, Δt, over which to assess the Availability Performance Metric or Composite Performance Metric
W_{fl}	The indicator for frame loss characteristic. Equals 0 or 1
W_{fd}	The indicator for frame delay characteristic. Equals 0 or 1
W_{fdv}	The indicator for inter-frame delay variation characteristic. Equals 0 or 1
DL	One way frame delay threshold
Jt	One way inter-frame delay variation threshold
S	Non-empty subset of the ordered UNI pairs in an EVC
$c\hat{A}$	Composite Performance Metric Objective expressed as a percentage

4. New Section in MEF 10.3

The following text is added to MEF 10.3 as Section 8.8.7.

8.8.7 One-way Composite Performance Metric for an EVC

The One-way Composite Performance Metric (CPM) specifies how often an EVC meets or exceeds the frame delay, inter-frame delay variation and frame loss service performance over the time interval *T*. The One-way Composite Performance Metric is expressed as the percentage of time intervals contained in time period *T*, that are deemed to have "Acceptable Performance". "Acceptable Performance" for a short time interval, Δt, is based on combinations of three Service Frame delivery characteristics (frame delay, inter-frame delay variation and frame loss) and thresholds in the SLS. (The precise definition is presented in the following paragraphs.) The combination of three Service Frame delivery characteristics for the short time interval, Δt_k, is denoted as Composite Performance Indicator, $D(\Delta t_k)$, which is defined in following paragraphs.

Informally, Composite Performance Metric is based on Composite Performance Indicators during a sequence of consecutive short time intervals. When the previous sequence was defined as Acceptable, if the Composite Performance Indicator exceeds its pre-set threshold for each short time interval in the current sequence, then the short time interval at the beginning of the current sequence is defined as Unacceptable; otherwise it is defined as Acceptable. On the other hand, when the previous sequence was defined as Unacceptable, if the Composite Performance Indicator is within its threshold for each short time interval in the current sequence, then the short time interval at the beginning of the current sequence is defined as Acceptable; otherwise, it is defined as Unacceptable. The formal definition follows.

For a time interval *T*, and a given Class of Service Name, the Composite Performance Metric from ingress UNI *i* to egress UNI *j* of the EVC is based on the following parameters:

- Δt, a time interval much smaller than *T*.
- U, the Composite Performance Indicator threshold which if exceeded suggests a severely errored time interval. U is in the range of (0,1).
- n, the number of consecutive short time intervals, Δt, over which to assess the Availability Performance Metric or Composite Performance Metric.
- W_{fl}, the indicator for frame loss characteristic. Equals 0 or 1.
- W_{fd}, the indicator for frame delay characteristic. Equals 0 or 1.
- W_{fdv}, the indicator for inter-frame delay variation characteristic. Equals 0 or 1.
- *DL*, one way frame delay threshold.

- Jt, one way inter-frame delay variation threshold.

For an ordered pair of UNIs, <*i*, *j*>, in the EVC, each Δt_k in T is defined to be either "Acceptable" or "Unacceptable". This is represented by $cA_{\langle i,j\rangle}(\Delta t_k)$ where $cA_{\langle i,j\rangle}(\Delta t_k)=1$ means that Δt_k is Acceptable and $cA_{\langle i,j\rangle}(\Delta t_k)=0$ means that Δt_k is Unacceptable. $cA_{\langle i,j\rangle}(\Delta t_k)$ is based on the Composite Performance Indicator, $D_{\langle i,j\rangle}(\Delta t_k)$, over a number of consecutive short time intervals.

The Composite Performance Indicator, $D_{\langle i,j\rangle}(\Delta t_k)$, is based on the frame delivery characteristics of ingress Qualified Service Frames [R31] at ingress UNI *i* that should have been delivered to UNI *j* according to the Service Frame Delivery service attributes (see Section 8.5), during the short time interval, Δt_k. The short time interval, Δt_k, is considered as a severely errored interval if $D_{\langle i,j\rangle}(\Delta t_k)>U$.

Let M_k be the number of ingress Qualified Service Frames that arrived at UNI *i* during the short time interval, Δt_k. Let ingress Qualified Service Frames arrived during the short time interval, Δt_k, be numbered from 1 to M_k, where Qualified Service Frame *k* arrived at the ingress UNI *i* before Qualified Service Frame *l* if and only if $k < l$.

Let M_{ke} be the number of unique (not duplicate) egress Service Frames where each Service Frame is the first unerrored egress Service Frame at UNI *j* that results from a Service Frame counted in M_k. A Service Frame is considered lost if the ingress Qualified Service Frame does not result in an egress Service Frame at UNI *j*.

For each ingress Qualified Service Frame, there are three frame delivery characteristics:

- Frame loss characteristic

$$fl_{\langle i,j\rangle}(m)=\begin{cases}1 & \text{if the } m\text{th Service Frame gets lost}\\ 0 & \text{otherwise}\end{cases}$$

- Frame delay characteristic

$$fd_{\langle i,j\rangle}(m)=\begin{cases}1 & \text{if } fl_{\langle i,j\rangle}(m)\neq 1 \text{ and } fd_m(m)>DL\\ 0 & \text{otherwise}\end{cases}$$

$fd_m(m)$ is the one-way frame delay of the *m*th Service Frame. The one-way frame delay is defined in Section 8.8.1. *DL* is the one-way frame delay threshold parameter in the SLS.

- Inter-frame delay variation characteristic

$$fdv_{\langle i,j\rangle}(m)=\begin{cases}1 & \text{if } fl_{\langle i,j\rangle}(m)\neq 1 \text{ and } fl_{\langle i,j\rangle}(m\text{-}1)\neq 1 \text{ and } fdv_m(m) > Jt, 2\leq m\leq M_k \\ 0 & \text{otherwise}\end{cases}$$

$fdv_m(m)=\left|fd_m(m)-fd_m(m-1)\right|, m>1$, is the inter-frame delay variation between two consecutive Service Frames: *m*th frame and *(m-1)*th frame. *Jt* is the one-way inter-frame delay variation threshold parameter in the SLS.

$D_{\langle i,j\rangle}(\Delta t_k)$ is defined as the ratio of the number of those Service Frame delivery characteristics with the value of 1 (i.e., failed characteristics) to the number of all frame delivery characteristics counted during the short time interval, Δt_k. If the ingress Qualified Service Frame does not result in an egress Service Frame (i.e., gets lost), then its frame delay and inter-frame delay variation characteristics are not counted in the number of all frame delivery characteristics during the short time interval, Δt_k.

$$D_{\langle i,j\rangle}(\Delta t_k)=\begin{cases}0 & \text{if } M_k=0 \\ 1 \text{ if } (W_{fl}=0 \text{ and } M_{ke}=0) \text{ or if } (W_{fl}=W_{fd}=0)\,\&\,(\sum_{m=2}^{M_k} v_{\langle i,j\rangle}(m)=0) & \\ \dfrac{\sum_{m=1}^{M_k}(fl_{\langle i,j\rangle}(m)*W_{fl}+fd_{\langle i,j\rangle}(m)*W_{fd}+fdv_{\langle i,j\rangle}(m)*W_{fdv})}{M_k*W_{fl}+(M_k-\sum_{m=1}^{M_k} fl_{\langle i,j\rangle}(m))*W_{fd}+(\sum_{m=2}^{M_k} v_{\langle i,j\rangle}(m))*W_{fdv}}, & \text{otherwise}\end{cases}$$

Where

$$v_{\langle i,j\rangle}(m)=\begin{cases}1 & \text{if } fl_{\langle i,j\rangle}(m)\neq 1 \text{ and } fl_{\langle i,j\rangle}(m\text{-}1)\neq 1 \\ 0 & \text{otherwise}\end{cases}$$

is the indicator and $v_{\langle i,j\rangle}(m)=1$ means that the inter-frame delay variation characteristic between *m*th and *(m-1)*th frames is counted in the number of all frame delivery characteristics during the short time interval, Δt_k.

[R1A] At least, one of three indicators: W_{fl}, W_{fd} and W_{fdv}, **MUST** be one.

Δt_0 is the first short time interval agreed upon by the Service Provider and Subscriber at or after turn-up of the EVC. $cA_{\langle i,j\rangle}(\Delta t_k)$ is defined by the flow diagram in Figure A for $k=0,1,2,\ldots$.

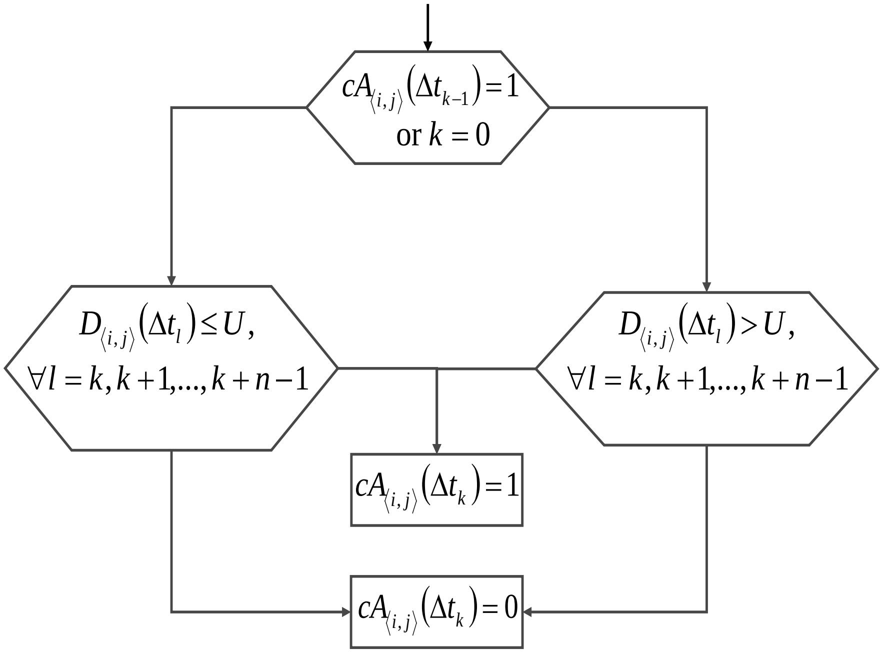

Figure A – Flowchart Definition of $cA_{\langle i,j\rangle}(\Delta t_k)$

An alternative way of expressing $cA_{\langle i,j\rangle}(\Delta t_k)$ for $k=0$ is

$$cA_{\langle i,j\rangle}(\Delta t_0)=\begin{cases}0 \text{ if } D_{\langle i,j\rangle}(\Delta t_l)>U, \forall l=0,1,\ldots n-1\\ 1 \text{ otherwise}\end{cases}$$

and for $k=1,2,\ldots$ is

$$cA_{\langle i,j\rangle}(\Delta t_k)=\begin{cases}0 \text{ if } cA_{\langle i,j\rangle}(\Delta t_{k-1})=1 \text{ and } D_{\langle i,j\rangle}(\Delta t_l)>U, \forall l=k,k+1,\ldots,k+n-1\\ 1 \text{ if } cA_{\langle i,j\rangle}(\Delta t_{k-1})=0 \text{ and } D_{\langle i,j\rangle}(\Delta t_l)\le U, \forall l=k,k+1,\ldots,k+n-1\\ cA_{\langle i,j\rangle}(\Delta t_{k-1}) \text{ otherwise}\end{cases}.$$

In the event of a conflict between the above equations and Figure A, the content of Figure A is controlling.

The Acceptable status for Δt_k is based on the Composite Performance Indicator during the short time interval and each of the following $n-1$ short time intervals and the Acceptable status of the previous short time interval. In other words, a sliding window of width $n\Delta t$ is used to determine Composite Performance Metric. This use of a sliding window is similar to that of ITU-T Y.1563 [6].

Figure B presents an example of the determination of the Acceptable status for the short time intervals with a sliding window of 10 short time intervals.

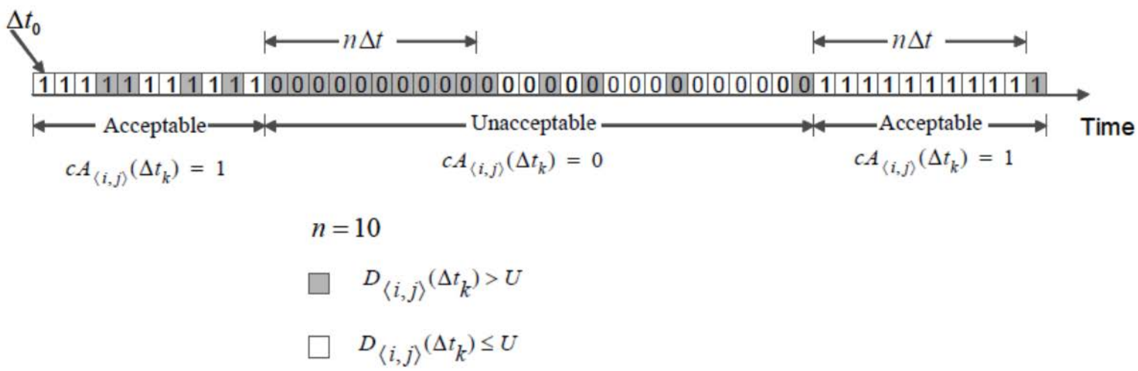

Figure B – Example of the Determination of $cA_{\langle i,j \rangle}(\Delta t_k)$

Similar to the one-way Availability Performance, the Maintenance Interval defined in Section 8.8.4 is excluded in the calculation of the Composite Performance Metric.

Figure C shows an example of the elimination of short time intervals for a Maintenance Interval.

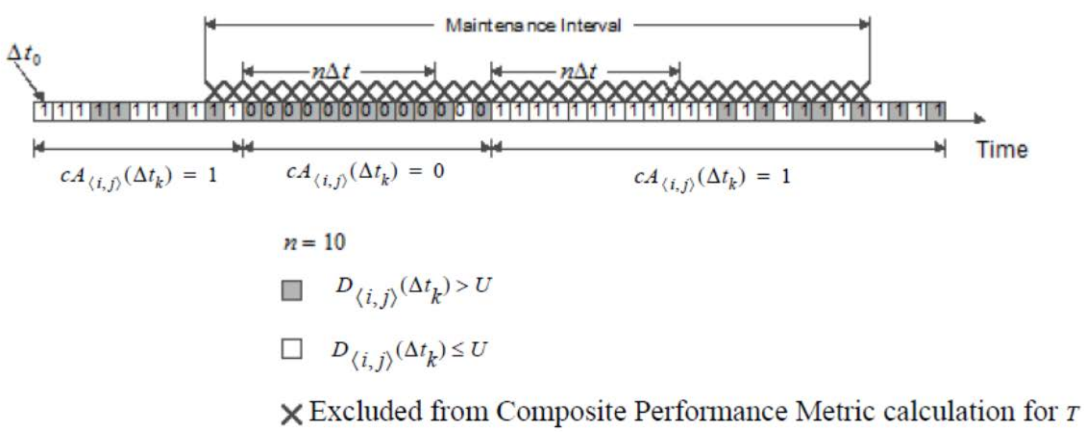

Figure C – Example of the Impact of a Maintenance Interval

Then the **Composite Performance Metric** (CPM) (%) for a particular Class of Service Name from UNI *i* to UNI *j* for a time interval T is defined by

$$cA_T^{\langle i,j \rangle} = \begin{cases} \frac{100}{|W_T|} \sum_{\Delta t_k \in W_T} cA_{\langle i,j \rangle}(\Delta t_k) \text{if } |W_T| > 0 \\ 100 \text{ otherwise} \end{cases}.$$

W_T is defined in Section 8.8.4.

[R2A] For a given non-empty set of ordered pairs of UNIs, *S*, a time interval *T*, a time interval Δt, and a given Class of Service Name, the SLS **MUST** define the One-way Composite Performance Metric as follows:

- Let the UNIs associated by the EVC be numbered: $1,2,...,M$.
- Let S be a non-empty subset of the ordered pairs of UNIs, i.e., $S \subseteq \{\langle i, j \rangle \mid i = 1,2,...M, j = 1,2,...,M, i \neq j\}, S \neq \varnothing$.
- Then the Composite Performance Metric for a particular Class of Service Name for the set *S* is defined by $cA_T^S = \min\{cA_T^{\langle i,j \rangle} \mid \langle i, j \rangle \in S\}$.

The parameters of the One-way Composite Performance Metric are given in Table A. Note that there are constraints on Δt and *n* per [R28], [R29], and [R30] in Section 8.8.

Parameter	Description
T	The time interval
S	Non-empty subset of the ordered UNI pairs in an EVC
Δt	A time interval much smaller than *T*
CoS_Name	The class of service name
U	The Composite Performance Indicator threshold which if exceeded suggests a severely errored time interval. U is in the range of (0,1)
n	The number of consecutive short time intervals over which to assess the Availability Performance Metric or Composite Performance Metric
DL	One way frame delay threshold
Jt	One way inter-frame delay variation threshold
W_{fl}	The indicator for frame loss characteristic. Equals 0 or 1
W_{fd}	The indicator for frame delay characteristic. Equals 0 or 1
W_{fdv}	The indicator for inter-frame delay characteristic. Equals 0 or 1
$c\hat{A}$	Composite Performance Metric Objective expressed as a percentage

Table A – CPM Performance Parameters for an EVC

[R3A] Given *parameters in Table A*, the SLS **MUST** define the One-way Composite Performance Objective as being met if and only if $cA_T^S \geq c\hat{A}$.

As noted in [R2A] and Table A, the subset S has to be a non-empty subset of the ordered pairs of UNIs in the EVC. This is the only requirement on S for Point-to-Point and Multipoint-to-Multipoint EVCs. For example, S can contain just one of the ordered UNI pairs in a Point-to-Point EVC. Rooted-Multipoint EVCs have an additional requirement on S per [R4A].

[R4A] For a Rooted-Multipoint EVC, *S* **MUST** be a non-empty subset of the ordered pairs of UNIs in the EVC, such that all ordered pairs in *S* contain at least one UNI that has the Root Role.

5. New Reference in MEF 10.3

The following entry is added to Reference of MEF 10.3.

[32] IEEE Std 1588™ – 2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, IEEE, 24 July 2008.

6. New Appendix in MEF 10.3

The following appendix is added to MEF 10.3 as Appendix D.

Appendix D: Use of CPM and Its SLS Parameter Values

This appendix contains a use case example for the CPM metric specified in Section 8.8.7. The SLS parameter example values are provided for the use case of mobile backhaul with Packet based methods for synchronization traffic class (e.g., IEEE 1588v2 frames [32]).

D.1 Use Example of CPM

Figure D shows a typical example of radio base station synchronization over a mobile backhaul CEN [21]. A Master clock, from the Mobile Operator or the CEN Operator, is locked to the Primary Reference Clock (PRC) via GPS. This Master clock sends timing packets with a configured rate (e.g., 128 packets/s) and packet size (e.g., 80 ~ 90 bytes) to the Slave clock deployed at a RAN BS as described in Figure 21, Section 12.2 of MEF 22.1 [21]. The Slave clock performs synchronization with the Master clock. Then the Slave clock feeds a clock signal to radio base stations (e.g., NodeB/eNodeB) to support air interface radio connections. Alternatively, the Slave clock is implemented in radio base stations.

MEF 22.1 summarizes the performance requirements for synchronization. In addition, the Slave clock's initial synchronization acquiring time and re-locking time after synchronization lost are also important factors.

The EVC for mobile backhaul can have performance objectives for the packet synchronization traffic class using metrics such as inter-frame delay variation, frame delay, and frame loss.

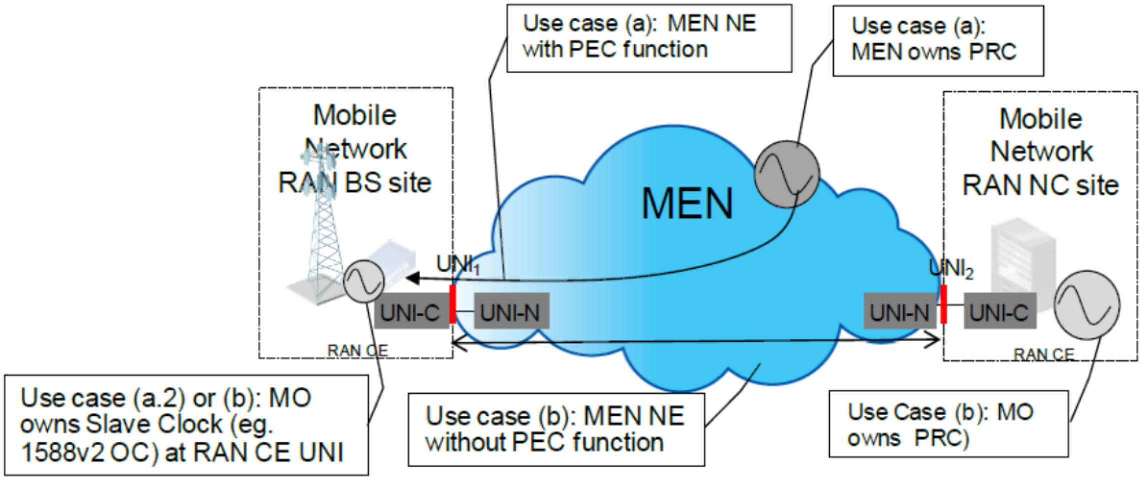

Figure D – Packet Method to Distribute Reference Timing (Figure 21 of MEF 22.1[21])

The packet synchronization method is vulnerable to network congestions and traffic variation. Therefore, the frequency accuracy, initial synchronization acquiring time, and re-locking time of the Slave clock are very sensitive to EVC's inter-frame delay variation and frame delay, but less sensitive to frame loss. Consecutive intervals of larger inter-frame delay variations in timing packet traffic class may result in the loss of Slave clock synchronization with the Master clock. Acquiring and re-locking times severely depend on a sequence of smaller inter-frame delay variations. The Slave clock may not be able to get re-locked again if inter-frame delay variations and frame delays become larger after the synchronization got lost. The inter-frame delay variation is actually time error/noise to the Slave clock synchronization.

As specified in MEF 22.1, Mobile Operators could map synchronization traffic to the H Class together with other radio network control messages. Performance requirements for the H Class in this use case are specified based on: (1) Slave clock's Local Oscillator performance, (2) Air interface RF performance requirements, (3) EVC performance attributes. From the mobile network operation perspective, Mobile Operators would like to consider the impact of EVC's inter-frame delay variation and frame delay performance metrics to determine the state of the EVC (i.e., Available or Unavailable) because the performance of radio station synchronizations can be predicted and assured. The one-way Availability performance metric specified in Section 8.8.4 of MEF 10.3 is not adequate to address this use example of mobile backhaul since it does not include inter-frame delay variation and frame delay performance.

Mobile Operators can include CPM in the SLS for mobile backhaul services with the Packet synchronization traffic class. The parameter values to use are presented in next section.

D.2 SLS Parameter Reference Values of CPM

Table B shows parameter values for CPM.

Parameter	Description	Value
T	The time interval	30 days
S	Non-empty subset of the ordered UNI pairs in an EVC	Example of Point-to-Point EVC: {RAN NC* UNI, RAN BS UNI} * Set S might have only one Ordered UNI pair. The performance might be different in the opposite direction.
Δt	A time interval much smaller than T	1 Second
CoS_Name	The class of service name	H or H+
U	The Composite Performance Indicator threshold which if exceeded suggests a severely errored time interval. U is in the range of (0,1)	> 1/3
n	The number of consecutive short time intervals over which to assess the Availability Performance Metric or Composite Performance Metric	10
DL	One way frame delay threshold	< 8ms MEF 22.1 [21] recommends ≤10ms for H and H+ Classes when E-Line Services)
Jt	One way inter-frame delay variation threshold	< 2ms MEF 22.1 [21] and MEF 23.1 [22] recommends ≤3ms for H Class when E-Line Services)
W_{fl}	The indicator for frame loss characteristic. Equals 0 or 1	1
W_{fd}	The indicator for frame delay characteristic. Equals 0 or 1	1
W_{fdv}	The indicator for inter-frame delay characteristic. Equals 0 or 1	1
$c\hat{A}$	Composite Performance Metric Objective expressed as a percentage	>99.9% ~99.99%

Table B – CPM SLS Parameter Reference Values