MEF Technical Specification
MEF x.y.x Working Draft v0.09

Subscriber Layer 1 Connectivity Service Attributes

13 December 2017

Caution - this draft represents MEF work in progress and is subject to change.

Disclaimer

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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.

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Editor Note 1: Placeholder list, will be finalized at the Approval phase.

2 Abstract

The attributes of a Subscriber Layer 1 Connectivity Service (L1CS) observable at a L1CS User Network Interface (UNI) and from a L1CS UNI to L1CS UNI are defined. In addition, a framework for defining specific instances of a Subscriber L1CS is described.

3 Terminology and Acronyms

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

Term	Definition	Source
AT	Available Time	This document
Available second	A second of Available Time	This document
Available Time	A period of Available Time begins at the onset of ten consecutive non-Severely Errored Seconds and ends at the onset of ten consecutive Severely Errored Seconds. It does not include Maintenance Interval Time.	This document
BIP-8	Bit Interleaved Parity-8	ITU-T G.707 [3]
Code Violation	A specific Code Violation is defined by the corresponding technical reference, for example in the discussion on Errored Seconds.	This document

Term	Definition	Source
Coding function	Functionality which encodes bits for transmission and the corresponding decode upon reception (e.g., Ethernet PCS, Fibre Channel FC-1, SONET or SDH framer). This functionality may be used for non-intrusive monitoring purposes.	This document
CV	Code Violation	This document
EB	Errored Block	This document
Errored Block	A block which has a detectable error. In this specification, the Layer 1 Characteristic Information corresponds to a block.	This document
Errored Second	A one-second interval with at least one errored L1CI.	This document
ES	Errored Second	This document
FEC	Forward Error Correction	This document
Forward Error Correction	A specific Forward Error Correction scheme is defined by the corresponding technical reference, for example in the discussion on Coding Function.	This document
L1CI	Layer 1 Characteristic Information	This document
L1CS	Layer 1 Connectivity Service	This document
L1CS UNI	Layer 1 Connectivity Service User Network Interface	This document
L1CS User Network Interface	The demarcation point between the responsibility of the Subscriber Layer 1 Connectivity Service Provider and the responsibility of the Subscriber.	This document
L1VC	Layer 1 Virtual Connection	This document
L1VC EP	Layer 1 Virtual Connection End Point	This document
L1VC SLS	Layer 1 Virtual Connection Service Level Specification	This document
Layer 1 Characteristic Information	A block of consecutive bits which can be monitored by an error detection code. For example, a 10-bit block of an 8B/10B encoded client protocol, a 66-bit block of a 64B/66B encoded client protocol, a SONET/SDH frame of a (B1) BIP-8 encoded client protocol.	This document
Layer 1 Connectivity Service	Used for brevity in this document when referring to a Subscriber Layer 1 Connectivity Service.	This document

Term	Definition	Source
Maintenance Interval Time	A period of time agreed to by the Subscriber and Service Provider during which the Subscriber L1VC may not perform well or at all.	This document
MEF Service	A service that is specified using Service Attributes as defined in a MEF Specification.	Draft "IP Services" [4]
MIT	Maintenance Interval Time	This document
Optical interface function	Functionality which converts encoded electrical bits into an optical signal(s) and the corresponding conversion into electrical format upon reception (e.g., Ethernet PMD, Fibre Channel FC-0, SONET or SDH optical interface). This may include multiplexing/ demultiplexing functionality.	This document
OTN	Optical Transport Network	ITU-T G.709 [18]
PCS	Physical Coding Sublayer	IEEE Std 802.3 [5]
Performance Metric	A quantitative characterization of Layer 1 Characteristic Information delivery quality experienced by the Subscriber.	This document
Physical port	The combination of one coding function and one optical interface function.	This document
PM	Performance Metric	This document
PMD	Physical Medium Dependent sublayer	IEEE Std 802.3 [5]
SDH	Synchronous Digital Hierarchy	ITU-T G.707 [3]
SE	Subscriber Equipment	This document
Service Provider	An organization that provides end-to-end MEF Services to Subscribers.	Draft "IP Services" [4]
SES	Severely Errored Second	This document
Severely Errored Second	A one-second interval which contains ≥ 15% errored L1CI or a one-second defect interval.	This document
SONET	Synchronous Optical Network	Telcordia GR-253-CORE [6]
SP	Service Provider	Draft "IP Services" [4]

Term	Definition	Source
Subscriber	The end-user of an end-to-end MEF Service.	Draft "IP Services" [4]
Subscriber Equipment	Equipment on the Subscriber side of the Layer 1 Connectivity Service User Network Interface.	This document
Subscriber Layer 1 Connectivity Service	A connectivity service that is provided by a Service Provider to a Subscriber which delivers Layer 1 Characteristic Information between two Layer 1 Connectivity Service UNIs, specified using the Service Attributes described in this document.	This document
Subscriber Layer 1 Virtual Connection	An association of two Subscriber Layer 1 Virtual Connection End Points that limits the transport of Layer 1 Characteristic Information between those Subscriber Layer 1 Virtual Connection End Points.	This document
Subscriber Layer 1 Virtual Connection End Point	A logical entity at a given L1CS UNI that is associated with a given Layer 1 Characteristic Information passing over that L1CS UNI.	This document
Subscriber Layer 1 Virtual Connection Service Level Specification	The technical specification of the service level agreed to by the Service Provider and the Subscriber.	This document
UAS	Unavailable Second	This document
UAT	Unavailable Time	This document
Unavailable Second	A second during Unavailable Time.	This document
Unavailable Time	A period of Unavailable Time begins at the onset of ten consecutive Severely Errored Seconds and ends at the onset of ten consecutive non-Severely Errored Seconds. It does not include Maintenance Interval Time.	This document
UNI	Used within this document for brevity when referring to a Layer 1 Connectivity Service User Network Interface.	This document
WIS	Wide Area Network Interface Sublayer	IEEE Std 802.3 [5]

Table 1 – Terminology and Acronyms

4 Scope

This document describes Subscriber L1CS Service Attributes for services provided to a Subscriber by the Service Provider using a Subscriber Layer 1 Virtual Connection (L1VC). A Subscriber L1CS is modeled from the point of view of the Subscriber's equipment (SE) that is used to access the service. A number of Service Attributes are defined that may be offered as part of a Subscriber L1CS including the definition of a Service Level Specification (SLS). This document does not define how the Service Attributes are implemented or how SLS compliance is measured or reported.

The goals of this Technical Specification are two-fold. The first goal is to provide sufficient technical specificity to allow a Subscriber to successfully plan and integrate a Subscriber L1CS into their overall networking infrastructure. The second goal is to provide enough detail so that SE vendors can implement capabilities into their products so they can be used to successfully access a Subscriber L1CS. It follows as a corollary that vendors of Service Provider network equipment will make use of this information for implementing functions that complement the functions in the SE.

Management of a Subscriber L1CS is not addressed in this document. Further, this document does not define how a Subscriber L1CS is supported by a Service Provider's network.

5 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 [1], RFC 8174 [2]) 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**.**

Editor Note 2: The following paragraph is needed only if the conditional requirement notation that is described in the paragraph is used in the document.

A paragraph preceded by **[CRa]<** specifies a conditional mandatory requirement that **MUST** be followed if the condition(s) following the "<" have been met. For example, "**[CR1]<**[D38]" indicates that Conditional Mandatory Requirement 1 must be followed if Desirable Requirement 38 has been met. A paragraph preceded by **[CDb]<** specifies a Conditional Desirable Requirement that **SHOULD** be followed if the condition(s) following the "<" have been met. A paragraph preceded by **[COc]<** specifies a Conditional Optional Requirement that **MAY** be followed if the condition(s) following the "<" have been met.

6 Numerical Prefix Conventions

This document uses the prefix notation to indicate multiplier values as shown in Table 2.

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 2 – Numerical Prefix Conventions

7 Introduction

This document provides the model and framework for a Subscriber L1CS, which will be referred to simply as L1CS for brevity in the remainder of this document. The model is built on the reference model as shown in Figure 1. This document addresses a L1CS only from a Service Provider and thus the Subscriber sees a single network that is provided by a single Service Provider.

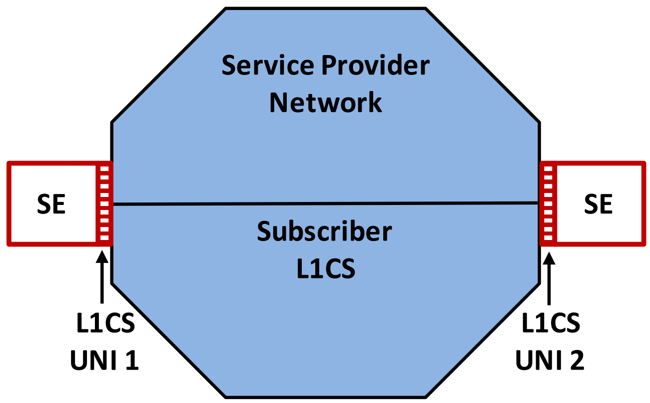

Figure 1 – Subscriber L1CS Reference Model

The technical definition of a service is in terms of what is seen by each SE. This includes the L1CS UNI, which will be referred to simply as UNI for brevity in the remainder of this document. The UNI is the physical demarcation point between the responsibility of the Service Provider and the responsibility of the Subscriber. This document takes the Subscriber's point of view and therefore all requirements in this document are on the Service Provider for that service. It should be noted that when the term 'support' is used in a normative context in this document, it means that the Service Provider is capable of enabling the functionality upon agreement between the Subscriber and the Service Provider.

[R1] A UNI **MUST** be dedicated to a single Subscriber.

[R2] A UNI **MUST** be dedicated to a single Service Provider.

The SE and the Service Provider exchange Layer 1 Characteristic Information (L1CI) across the UNI. The L1CI is a block of consecutive bits which can be monitored by an error detection code corresponding to the specific client protocol at the UNI (e.g., a 10-bit block of an 8B/10B encoded client protocol, a 66-bit block of a 64B/66B encoded client protocol, a SONET/SDH frame of a (B1) BIP-8 encoded client protocol).

A fundamental aspect of a L1CS is the Subscriber L1VC. A Subscriber L1VC is an association of two Subscriber L1VC End Points. A Subscriber L1VC End Point represents the logical attachment of a Subscriber L1VC to a UNI. A UNI pair exchanges the L1CI across a Subscriber L1VC. The pair of Subscriber L1VC End Points associated by a Subscriber L1VC are said to be "in the Subscriber L1VC." Consequently, the corresponding UNIs are said to be "in the Subscriber L1VC." A Subscriber L1VC always supports point-to-point, bi-directional (full duplex) transmission of L1CI.

In the context of this document, a Subscriber L1CS consists of a single Subscriber L1VC, associated UNIs and Subscriber L1VC End Points, that is provided to a Subscriber by a Service Provider.

7.1 L1CS Characteristics

A L1CS has the following basic characteristics:

- Topology: Only point-to-point.
- UNI: Both UNIs have the same wire speed.
- Rate: Only full wire speed of the UNIs. Rates from 155Mb/s OC-3 up to 100Gb/s Ethernet are specified in this document. Note that only client rates with optical interfaces were considered for this document.
- Client protocol: Ethernet, Fibre Channel, SONET, SDH are specified in this document.
- Transparency: The client protocol data (L1CI) is transported bit identical from ingress UNI to egress UNI. Exceptions include: the replacement of an invalid block by an error control block or the insertion of a replacement signal during the loss of L1CI (either at ingress or within the Service Provider network).
- Performance metrics: One-way Delay, One-way Errored Second, One-way Severely Errored Second, One-way Unavailable Second, One-way Availability are specified in this document.

An instance of a L1CS has:

- The same client protocol at both UNIs (i.e., one of: Ethernet, Fibre Channel, SONET, SDH).
- The physical ports at both UNIs have the same rate and coding function (e.g., 8B/10B).
- The physical port at each UNI may have a different optical interface function (e.g., long reach or extended reach).
- A single service instance per UNI (i.e., no service multiplexing).

The specific L1CI for each client protocol described in this document is listed in Table 3.

Client Protocol / Physical Port	**Rate (Gb/s)**	**Coding**	**L1CI**
Ethernet			
GigE	1.250	8B/10B	10-bit block
10GigE WAN	9.95328	Scrambled	STS-192c frame
10GigE LAN	10.3125	64B/66B	66-bit block

Client Protocol / Physical Port	**Rate (Gb/s)**	**Coding**	**L1CI**
40GigE	41.250	64B/66B	66-bit block
100GigE	103.125	64B/66B	66-bit block
Fibre Channel			
FC-100	1.0625	8B/10B	10-bit block
FC-200	2.125	8B/10B	10-bit block
FC-400	4.250	8B/10B	10-bit block
FC-800	8.500	8B/10B	10-bit block
FC-1200	10.51875	64B/66B	66-bit block
FC-1600	14.025	64B/66B	66-bit block
FC-3200	28.05	64B/66B (1)	66-bit block
SDH			
STM-1	0.15552	Scrambled	STM-1 frame
STM-4	0.62208	Scrambled	STM-4 frame
STM-16	2.48832	Scrambled	STM-16 frame
STM-64	9.95328	Scrambled	STM-64 frame
STM-256	39.81312	Scrambled	STM-256 frame
SONET			
OC-3	0.15552	Scrambled	STS-3 frame
OC-12	0.62208	Scrambled	STS-12 frame
OC-48	2.48832	Scrambled	STS-48 frame
OC-192	9.95328	Scrambled	STS-192 frame
OC-768	39.81312	Scrambled	STS-768 frame

(1) At ingress the FC-3200 L1CI is extracted after FEC decoding and 256B/257B transcoding.

Table 3 – Client Protocol L1CI

7.2 L1CS Framework

The L1CS definition framework provides a model for specifying a L1CS. A L1CS has a set of Service Attributes that define its characteristics. These Service Attributes in turn have a set of parameters associated with them that provide various options for the different Service Attributes. A specific L1CS is defined by the values of the Service Attributes. This framework is shown in Figure 2.

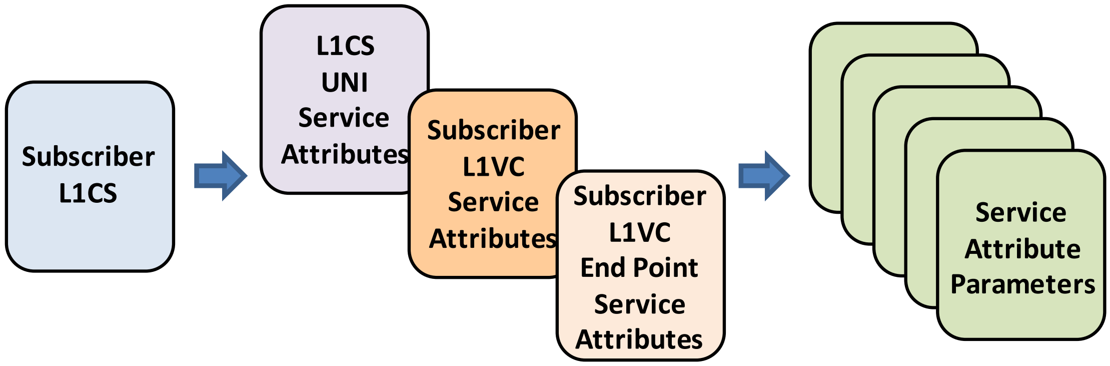

Figure 2 – Subscriber L1CS Definition Framework

The Service Attributes for the UNI are described in Section 8.1, the Subscriber L1VC Service Attributes are described in Section 8.2 and its corresponding Subscriber L1VC End Point Service Attributes in Section 8.3. This document then summarizes those Service Attributes and parameters in Section 9.

8 Subscriber L1CS Service Attribute Definitions and Requirements

8.1 UNI Service Attributes

A UNI has a number of characteristics that are important to the way that the SE sees a L1CS.

8.1.1 UNI ID Service Attribute

The value of the UNI ID Service Attribute is a string that is used to allow the Subscriber and Service Provider to uniquely identify the UNI. It is subject to the following requirements.

[R3] The UNI ID **MUST** be unique among all the Service Provider UNIs.

[R4] The UNI ID **MUST** contain no more than 45 characters.[1]

[R5] The UNI ID **MUST** be a non-null RFC 2579 [7] DisplayString but not contain the characters 0x00 through 0x1f.

As an example, the Service Provider might use "MTL-POP1-Node3-Slot2-Port1" as a UNI ID and this could signify Port 1 in Slot 2 of Node 3 in Montreal POP1.

Note that [R3] does allow two Service Providers to use the same identifier for different UNIs (one UNI per Service Provider). Of course, using globally unique identifiers for UNIs meets [R3].

8.1.2 Physical Layer Service Attribute

The value of the Physical Layer Service Attribute is a 3-tuple of the form $\langle p, c, o\rangle$ where:

- *p* is the Client Protocol, and
- *c* is the Coding Function, and
- *o* is the Optical Interface Function.

The Physical Layer Service Attribute specifies the Client Protocol, the Coding Function and the Optical Interface Function used by the Service Provider for the physical link implementing the UNI. A Physical Port is composed of one Coding Function and one Optical Interface Function. Note that only Single Mode Fibre (SMF) Optical Interface Functions were considered.

[R6] The Client Protocol $\langle p\rangle$ **MUST** be one of the following values:

- *Ethernet*, or
- *Fibre Channel*, or

[1] The limit of 45 characters is intended to establish limits on field lengths in existing or future protocols that will carry the identifier.

- *SDH*, or
- *SONET*.

[R7] When *p* has the value *Ethernet*, the 3-tuple ⟨*Ethernet*, *c*, *o*⟩ **MUST** use one of the 13 possible ⟨*c*, *o*⟩ values for the Coding Function and Optical Interface Function shown in Table 4.

Coding Function ⟨*c*⟩ (1)	**Optical Interface Function ⟨*o*⟩** (1)
1000BASE-X PCS clause 36 coding function	SX PMD clause 38
	LX PMD clause 38
	LX10 PMD clause 59
	BX10 PMD clause 59
10GBASE-W (WAN PHY) PCS clause 49 and WIS clause 50 coding function	LW PMD clause 52
	EW PMD clause 52
10GBASE-R (LAN PHY) PCS clause 49 coding function	LR PMD clause 52
	ER PMD clause 52
40GBASE-R PCS clause 82 coding function	LR4 PMD clause 87
	ER4 PMD clause 87
	FR PMD clause 89
100GBASE-R PCS clause 82 coding function	LR4 PMD clause 88
	ER4 PMD clause 88

(1) The clause references are in IEEE Std 802.3 [5].

Table 4 – Ethernet Physical Port Component Functions

Note that each Coding Function reference and Optical Interface Function reference includes the rate.

For example, if the value of the Client Protocol ⟨*p*⟩ is *Ethernet* for the L1VC that the UNI is in, then ⟨*c*, *o*⟩ could be ⟨*10GBASE-R PCS clause 49, LR PMD clause 52*⟩.

Another example of ⟨*c*, *o*⟩ for an *Ethernet* Client Protocol is ⟨*10GBASE-R PCS clause 49, ER PMD clause 52*⟩.

[R8] When *p* has the value *Fibre Channel*, the 3-tuple ⟨*Fibre Channel*, *c*, *o*⟩ **MUST** use one of the 10 possible ⟨*c*, *o*⟩ values for the Coding Function and Optical Interface Function shown in Table 5.

Coding Function ⟨*c*⟩	**Optical Interface Function ⟨*o*⟩**
FC-100 (1.0625 Gb/s) FC-FS-2 [8] clause 5 FC-1 8B/10B coding function	FC-PI-2 [9] clause 6.3 FC-0 100-SM-LC-L
FC-200 (2.125 Gb/s) FC-FS-2 [8] clause 5 FC-1	FC-PI-2 [9] clause 6.3 FC-0 200-SM-LC-L

Coding Function ⟨*c*⟩	**Optical Interface Function ⟨*o*⟩**
8B/10B coding function	
FC-400 (4.250 Gb/s) FC-FS-2 [8] clause 5 FC-1 8B/10B coding function	FC-PI-5 [10] clause 6.3 FC-0:
	400-SM-LC-L
	400-SM-LC-M
FC-800 (8.500 Gb/s) FC-FS-2 [8] clause 5 FC-1 8B/10B coding function	FC-PI-5 [10] clause 6.3 FC-0:
	800-SM-LC-L
	800-SM-LC-I
FC-1200 (10.51875 Gb/s) FC-10GFC [11] clause 13 FC-1 coding function	FC-10GFC [11] clause 6.4 FC-0 1200-SM-LL-L
FC-1600 (14.025 Gb/s) FC-FS-3 [12] clause 5 FC-1 64B/66B coding function	FC-PI-5 [10] clause 6.3 FC-0:
	1600-SM-LC-L
	1600-SM-LZ-I
FC-3200 (28.05 Gb/s) FC-FS-4 [13] clause 5 FC-1 64B/66B coding function plus 256B/257B transcoding and FEC encoding	FC-PI-6 [14] clause 5.3 FC-0 3200-SM-LC-L

Table 5 – Fibre Channel Physical Port Component Functions

Note that the rate is specified for each Coding Function because the reference is rate independent. The rate of 28.05 Gb/s for the FC-3200 Coding Function corresponds to both the 64B/66B encoded L1CI rate and the rate after 256B/257B transcoding and FEC encoding (i.e., those two codings do not alter the rate). Each Optical Interface Function reference includes the rate.

For example, if the value of the Client Protocol ⟨*p*⟩ is *Fibre Channel* for the L1VC that the UNI is in, then ⟨*c*, *o*⟩ could be ⟨*FC-800 (8.500 Gb/s) FC-FS-2 clause 5 FC-1 8B/10B, FC-PI-5 clause 6.3 FC-0 800-SM-LC-L*⟩.

Another example of ⟨*c*, *o*⟩ for a *Fibre Channel* Client Protocol is ⟨*FC-800 (8.500 Gb/s) FC-FS-2 clause 5 FC-1 8B/10B, FC-PI-5 clause 6.3 FC-0 800-SM-LC-I*⟩.

[R9] When *p* has the value *SDH*, the 3-tuple ⟨*SDH*, *c*, *o*⟩ **MUST** use one of the 42 possible ⟨*c*, *o*⟩ values for the Coding Function and Optical Interface Function shown in Table 6.

Coding Function ⟨*c*⟩	**Optical Interface Function ⟨*o*⟩**
STM-1 ITU-T G.707 [3] framer, N=1	ITU-T G.957 [15]:
	I-1
	S-1.1
	S-1.2
	L-1.1
	L-1.2
	L-1.3

Coding Function ⟨*c*⟩	**Optical Interface Function ⟨*o*⟩**
STM-4 ITU-T G.707 [3] framer, N=4	ITU-T G.957 [15]:
	I-4
	S-4.1
	S-4.2
	L-4.1
	L-4.2
	L-4.3
STM-16 ITU-T G.707 [3] framer, N=16	ITU-T G.957 [15]:
	I-16
	S-16.1
	S-16.2
	L-16.1
	L-16.2
	L-16.3
STM-64 ITU-T G.707 [3] framer, N=64	ITU-T G.691 [16]:
	I-64.lr
	I-64.l
	I-64.2r
	I-64.2
	I-64.3
	I-64.5
	S-64.1
	S-64.2
	S-64.3
	S-64.5
	L-64.1
	L-64.2
	L-64.3
STM-256 ITU-T G.707 [3] framer, N=256	ITU-T G.693 [17]:
	VSR2000-3R1
	VSR2000-3R2
	VSR2000-3R3
	VSR2000-3R5
	VSR2000-3M1
	VSR2000-3M2
	VSR2000-3M3
	VSR2000-3M5
	VSR2000-3H2
	VSR2000-3H3
	VSR2000-3H5

Table 6 – SDH Physical Port Component Functions

Note that each Coding Function reference and Optical Interface Function reference includes the rate.

For example, if the value of the Client Protocol ⟨*p*⟩ is *SDH* for the L1VC that the UNI is in, then ⟨*c*, *o*⟩ could be ⟨*STM-64 ITU-T G.707 framer N=64, ITU-T G.691 L-64.1*⟩.

Another example of ⟨*c*, *o*⟩ for an *SDH* Client Protocol is ⟨*STM-64 ITU-T G.707 framer N=64, ITU-T G.691 S-64.3*⟩.

[R10] When *p* has the value *SONET*, the 3-tuple ⟨*SONET*, *c*, *o*⟩ **MUST** use one of the 49 possible ⟨*c*, *o*⟩ values for the Coding Function and Optical Interface Function shown in Table 7.

Coding Function ⟨*c*⟩	**Optical Interface Function ⟨*o*⟩**
OC-3 GR-253-CORE [6] framer, N=3	GR-253-CORE [6] clause 4.1:
	SR-1
	IR-1
	IR-2
	LR-1
	LR-2
	LR-3
OC-12 GR-253-CORE [6] framer, N=12	GR-253-CORE [6] clause 4.1:
	SR-1
	IR-1
	IR-2
	LR-1
	LR-2
	LR-3
	VR-1
	VR-2
	VR-3
	UR-2
	UR-3
OC-48 GR-253-CORE [6] framer, N=48	GR-253-CORE [6] clause 4.1:
	SR-1
	IR-1
	IR-2
	LR-1
	LR-2
	LR-3
	VR-2
	VR-3
	UR-2
	UR-3
OC-192	GR-253-CORE [6] clause 4.1:

Coding Function ⟨*c*⟩	**Optical Interface Function ⟨*o*⟩**
GR-253-CORE [6] framer, N=192	SR-1
	SR-2
	IR-1
	IR-2
	IR-3
	LR-1
	LR-2
	LR-2a
	LR-2b
	LR-2c
	LR-3
	VR-2a
	VR-2b
	VR-3
OC-768 GR-253-CORE [6] framer, N=768	GR-253-CORE [6] clause 4.1:
	SR-1
	SR-2
	IR-1
	IR-2
	IR-3
	LR-1
	LR-2
	LR-3

Table 7 – SONET Physical Port Component Functions

Note that each Coding Function reference and Optical Interface Function reference includes the rate.

For example, if the value of the Client Protocol ⟨*p*⟩ is *SONET* for the L1VC that the UNI is in, then ⟨*c*, *o*⟩ could be ⟨*OC-192 GR-253-CORE framer N=192, GR-253-CORE clause 4.1 LR-2b*⟩.

Another example of ⟨*c*, *o*⟩ for a *SONET* Client Protocol is ⟨*OC-192 GR-253-CORE framer N=192, GR-253-CORE clause 4.1 IR-3*⟩.

The following general requirements apply:

[R11] The Physical Layer **MUST** operate in full duplex mode.

[R12] The value of the Client Protocol ⟨*p*⟩ **MUST** be the same at both UNIs that are in the L1VC.

[R13] The value of the Coding Function ⟨*c*⟩ **MUST** be the same at both UNIs that are in the L1VC.

[O1] The value of the Optical Interface Function ⟨*o*⟩ **MAY** be different at each UNI in the L1VC.

A Physical Port at one UNI in an L1VC could have the first ⟨*c, o*⟩ example value following Table 4 while the Physical Port at the other UNI in the L1VC could have the second ⟨*c, o*⟩ example value following Table 4. That pair of Physical Port examples satisfies [O1]. Similarly, for the pairs of Physical Port examples following Table 5, Table 6 and Table 7.

Editor Note 3: The lists of Optical Interface Functions in the SDH and SONET tables are quite long (due to 3-4 reach options and 3 fiber types). Input is requested from Service Providers for which ones they deploy.

8.2 Subscriber L1VC Service Attributes

A Subscriber L1VC is an association of two Subscriber L1VC End Points. A Subscriber L1VC End Point represents the logical attachment of a Subscriber L1VC to a UNI. A given UNI can only support one Subscriber L1VC End Point.

The L1CI of a L1CS that is mapped to an ingress UNI and Subscriber L1VC End Point associated by the Subscriber L1VC is delivered to the corresponding egress Subscriber L1VC End Point and UNI.

[R14] If the egress L1CI mapped to a Subscriber L1VC End Point results from ingress L1CI mapped to a Subscriber L1VC End Point, there **MUST** be a Subscriber L1VC that associates the two Subscriber L1VC End Points.

[R15] If the egress L1CI mapped to a Subscriber L1VC End Point results from ingress L1CI mapped to a Subscriber L1VC End Point, the two Subscriber L1VC End Points **MUST** be different from each other.

[R16] A given UNI **MUST** support exactly one Subscriber L1VC End Point.

Note that a consequence of [R16] is that at a given UNI, a Subscriber L1VC associates exactly one Subscriber L1VC End Point. A Subscriber L1VC always supports point-to-point, bidirectional (full duplex) transmission of L1CI. That is, each Subscriber L1VC End Point associated by the Subscriber L1VC always supports ingress and egress L1CI for that Subscriber L1VC. See Figure 3. Note the drawing convention used in this document depicts a Subscriber L1VC by a dotted line and a L1CS by a solid line.

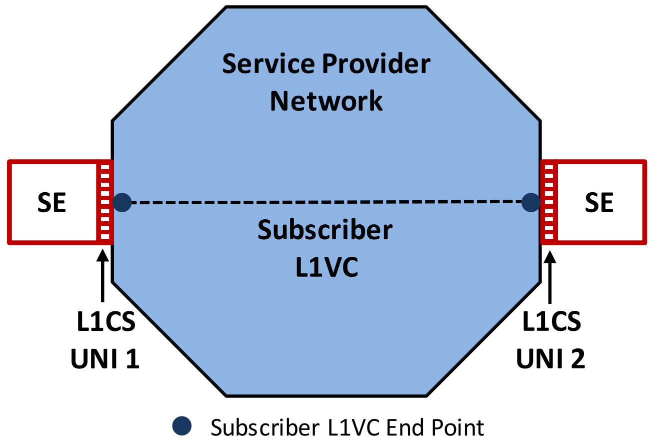

Figure 3 – Subscriber L1VC

The following sections describe the Service Attributes for a Subscriber L1VC.

8.2.1 Subscriber L1VC ID Service Attribute

The value of the Subscriber L1VC ID Service Attribute is a string that is used to identify a Subscriber L1VC within the Service Provider network. It is subject to the following requirements.

[R17] The Subscriber L1VC ID **MUST** be unique across all the Service Provider's Subscriber L1VCs.

[R18] The Subscriber L1VC ID **MUST** contain no more than 45 characters.[2]

[R19] The Subscriber L1VC ID **MUST** be a non-null RFC 2579 [7] DisplayString but not contain the characters 0x00 through 0x1f.

As an example, the LightTransport Service Provider might use "Subscriber-L1VC-0001867-LT-MEGAMART" to represent the 1867th Subscriber L1VC in its network, where the Subscriber for the Subscriber L1VC is MegaMart.

8.2.2 Subscriber L1VC End Point List Service Attribute

The value of the Subscriber L1VC End Point List Service Attribute is a list of Subscriber L1VC End Point ID Service Attribute values (Section 8.3.1). The list contains one Subscriber L1VC End Point ID Service Attribute value for each Subscriber L1VC End Point associated by the Subscriber L1VC.

[R20] The Subscriber L1VC End Point List **MUST** contain exactly two Subscriber L1VC End Point IDs.

[R21] The values of the Subscriber L1VC End Point IDs in the Subscriber L1VC End Point List **MUST** be different.

[2] The limit of 45 characters is intended to establish limits on field lengths in existing or future protocols that will carry the identifier.

8.2.3 Subscriber L1VC Service Level Specification Service Attribute

The Subscriber L1VC Service Level Specification (SLS) Service Attribute is the technical specification of aspects of the service performance agreed to by the Service Provider and the Subscriber. For any given SLS, a given Performance Metric may or may not be specified.

The value of the Subscriber L1VC SLS Service Attribute is either *None* or a 3-tuple of the form $\langle t_s, T, PM\rangle$ where:

- t_s is a time that represents the date and time for the start of the SLS.

  [R22] t_s **MUST** be specified to the nearest second.

- T is a duration that is used in conjunction with t_s to specify a contiguous sequence of time intervals for determining when performance objectives are met. The units for T are not constrained. For example, a calendar month is an allowable value. Since the duration of a month varies it could be specified as, e.g. from midnight on the 10th of one month up to but not including midnight on the 10th of the following month.

  [R23] T **MUST** contain an integer number of seconds with boundaries aligned with the one second intervals used by the performance metrics.

- *PM* is a list where each element in the list consists of a Performance Metric Name, a list of parameter values specific to the definition of the Performance Metric, and Performance Metric Objective.

A Performance Metric is a quantitative characterization of L1CI delivery quality experienced by the Subscriber. Methods for the Service Provider and the Subscriber to monitor the Subscriber L1VC performance to estimate this user experience are beyond the scope of this document. This section specifies the following Performance Metrics:

1. The One-way Delay Performance Metric (Section 8.2.3.3),
2. The One-way Errored Second Performance Metric (Section 8.2.3.4),
3. The One-way Severely Errored Second Performance Metric (Section 8.2.3.5),
4. The One-way Unavailable Second Performance Metric (Section 8.2.3.6), and
5. The One-way Availability Performance Metric (Section 8.2.3.7).

[R24] If *PM* contains an entry with a given Performance Metric Name, then the entry **MUST** specify the related parameters and the Performance Objective for that Performance Metric.

An example of a Subscriber L1VC SLS Service Attribute (3-tuple) is shown in Table 8.

Subscriber L1VC Service Level Specification	
Tuple Entry	**Value**
t_s	*2017-07-01, 08:00:00 UTC*
T	*one calendar month*
PM	*One-way Availability Performance Metric*
	Ordered Subscriber L1VC End Point pairs ⟨U1, U2⟩ and ⟨U2, U1⟩
	$\hat{A} = 99.99\%$

Table 8 – Example of a Subscriber L1VC SLS

PM can contain multiple entries with a given Performance Metric Name, but one or more of the parameter values associated with each objective for a given Performance Metric Name need to be different from each other. For example, PM could contain two objectives for the One-way Delay Performance Metric, each corresponding to a different value of the percentile P_d (see Section 8.2.3.3).

[D1] The Service Provider **SHOULD** be able to provide an SLS with at least one Performance Objective (the PMs are: One-way Delay, One-way ES, One-way SES, One-way UAS, One-way Availability).

[D2] The Service Provider **SHOULD** be able to provide an SLS which includes a separate Performance Objective for each ordered Subscriber L1VC End Point pair in the Subscriber L1VC End Point List.

For example, given a Subscriber L1VC End Point List ⟨*A*, *B*⟩, the One-way Delay Performance Objective for ordered Subscriber L1VC End Point pair ⟨*A*, *B*⟩ could be different than the One-way Delay Performance Objective for ordered Subscriber L1VC End Point pair ⟨*B*, *A*⟩ when the connectivity is provided over a uni-directional ring.

8.2.3.1 Basic Time Constructs

For the SLS, the sequence $\{T_l, l = 0,1,2, \dots\}$ is used where

$$T_l = [t_s + lT, t_s + (l + 1)T]$$

Each element of the sequence $\{T_l\}$, referred to as an interval T_l , is used for assessing the success of the Subscriber L1VC in meeting the Performance Metric objectives of the SLS. Note that an interval T_l has a date and time for its start and end, whereas T is simply a duration with no specified start and end time. Further, an interval T_l is specified with respect to the start of the SLS (i.e., t_s).

A sequence of seconds $\{\sigma_k , k = 0,1,2, \dots\}$ is defined where

$$\sigma_k = [t_s + k, t_s + k + 1]$$

A L1CI is considered to be in a σ_k second (e.g., to evaluate errored L1CI) when the last bit of that L1CI arrives at the UNI of interest within that σ_k second.

8.2.3.2 Hierarchy of Time

An SLS interval T_l is divided into three categories: Available Time, Unavailable Time and Maintenance Interval Time. The SLS performance metric objectives for the One-way Delay PM, One-way Errored Second PM and One-way Severely Errored Second PM only apply during Available Time[3]. Figure 4 illustrates the relationship between the three categories of time in an SLS interval T_l[4].

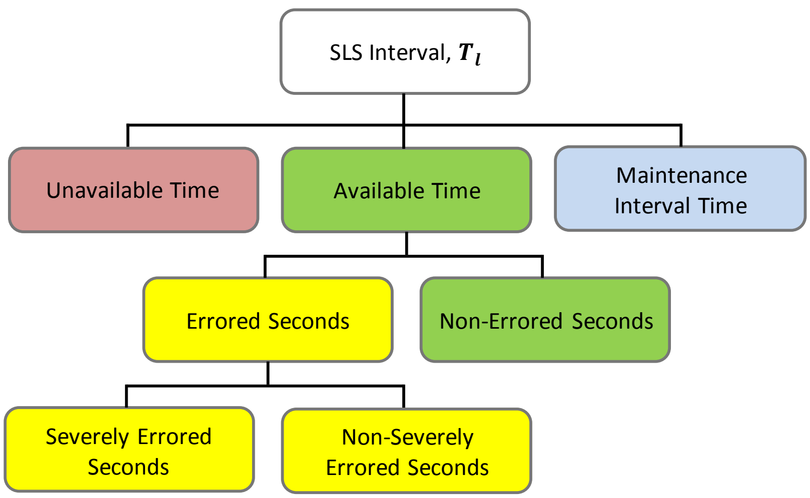

Figure 4 – Hierarchy of Time

For a given ordered Subscriber L1VC End Point pair $\langle i,j \rangle$ and a given T_l let

$$Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_k) = E_{SES}^{\langle j \rangle}(\sigma_k) - I_{SES}^{\langle i \rangle}(\sigma_k)$$

Where $E_{SES}^{\langle j \rangle}(\sigma_k)$ and $I_{SES}^{\langle i \rangle}(\sigma_k)$ are defined in Section 8.2.3.5[5]. Informally, *availability detected* occurs following ten consecutive seconds when

$$Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_k) \leq 0$$

For a given second σ_k, the set of egress L1CI will be different than the set of ingress L1CI due to the transit delay (e.g., 5ms for 1000km of fibre), which may result in a negative value. Informally, *unavailability detected* occurs following ten consecutive seconds when

[3] This is consistent with Note 6 of Figure I.1 in G.8201 [20] Appendix I.

[4] Based on similar figure in MEF 10.4 [22].

[5] The value of $Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_k)$ can be approximated by the service provider by comparing the same set of L1CI at ingress and egress using well-known transport supervision techniques, such as subnetwork connection non-intrusive monitoring (G.805 [23] clause 5.4.1.2) using Incoming Error Count (IEC) based signal quality supervision (G.806 [24] clause 8.3 Figure 8-6). However, measurement techniques are beyond the scope of this document.

$$Subscriber\ L1VC_{SES}^{\langle i,j\rangle}(\sigma_k) = 1$$

Figure 5 illustrates an example of the detection of unavailability and availability[6].

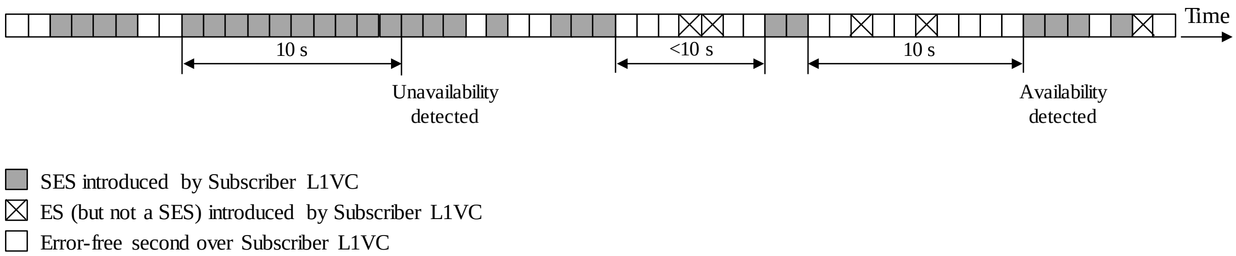

Figure 5 – Example of Detection of Unavailability and Availability

Maintenance Interval Time (MIT) for $\langle i, j\rangle$, $MIT(i, j)$, is defined as the set of σ_k's within T_l agreed to by the Subscriber and Service Provider during which the Subscriber L1VC may not perform well or at all. Examples of a Maintenance Interval include[7]:

- An interval during which the Service Provider may disable the Subscriber L1VC for network maintenance such as equipment replacement.
- An interval during which the Subscriber and Service Provider may perform joint fault isolation testing.
- An interval during which the Service Provider makes Subscriber requested changes and making such changes may disrupt the Subscriber L1VC.

The sliding window of ten seconds used to detect availability or unavailability operates independently of MIT. Consequently, a period of Unavailable Time (UAT) or Available Time (AT) (defined formally below) of less than ten seconds could be entered prior to a Maintenance Interval. Similarly, a period of AT or UAT could be entered immediately following a Maintenance Interval. Figure 6 illustrates an example of a Maintenance Interval. Note that the consecutive SES introduced by the Subscriber L1VC resulting in the detection of UAT are Unavailable Seconds (UAS) and do not contribute towards the One-way Severely Errored Second Performance Metric.

[6] This figure is based on Figure A.1 in G.8201 [20] Annex A.
[7] This is consistent with G.7710 [19] clause 10.1.5.

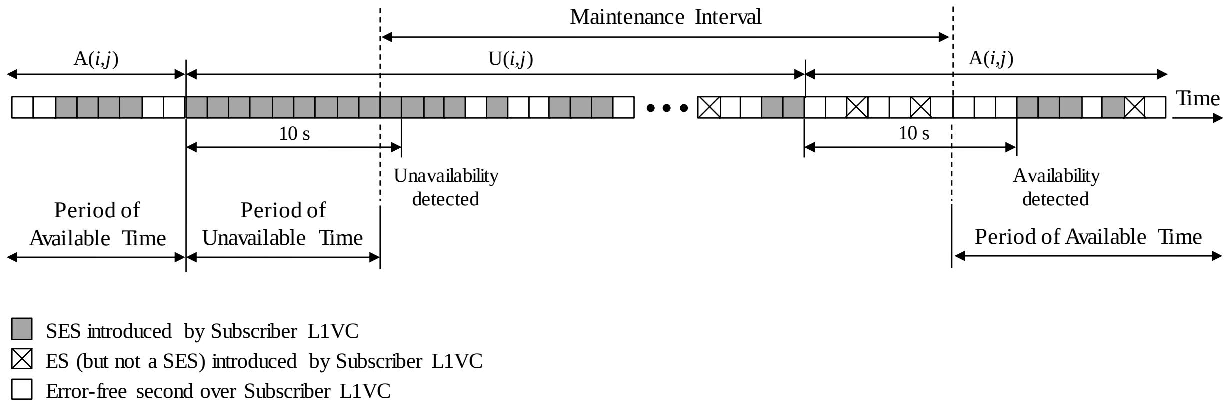

Figure 6 – Example of a Maintenance Interval

The formal definitions of AT and UAT follow. Each $\sigma_k, k = 0,1,2, ...$ belongs to one of two sets; $A(i,j)$ or $U(i,j)$. The membership is determined by the following two expressions:

$$\sigma_0 \in A(i,j)$$

For $k = 1,2, ...$

$$\sigma_k \in \begin{cases} A(i,j) \text{ if } \sigma_{k-1} \in A(i,j) \text{ and there exists } m \in \{k, k+1, \dots, k+9\} \text{ such that } Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_m) \leq 0 \\ U(i,j) \text{ if } \sigma_{k-1} \in A(i,j) \text{ and } Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_m) = 1 \text{ for } m = k, k+1, \dots, k+9 \\ U(i,j) \text{ if } \sigma_{k-1} \in U(i,j) \text{ and there exists } m \in \{k, k+1, \dots, k+9\} \text{ such that } Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_m) = 1 \\ A(i,j) \text{ if } \sigma_{k-1} \in U(i,j) \text{ and } Subscriber\ L1VC_{SES}^{\langle i,j \rangle}(\sigma_m) \leq 0 \text{ for } m = k, k+1, \dots, k+9 \end{cases}$$

Then Available Time for $\langle i,j \rangle$ and T_l is defined as

$$AT(i,j,T_l) = \{\sigma_k, k = 0,1, \dots \mid \sigma_k \in A(i,j), \sigma_k \subseteq T_l, \sigma_k \notin MIT(i,j)\}$$

and Unavailable Time for $\langle i,j \rangle$ and T_l is defined as

$$UAT(i,j,T_l) = \{\sigma_k, k = 0,1, \dots \mid \sigma_k \in U(i,j), \sigma_k \subseteq T_l, \sigma_k \notin MIT(i,j)\}$$

8.2.3.3 One-way Delay Performance Metric

The One-way Delay[8] for the L1CI that ingresses at UNI_1 and that egresses at UNI_2 is defined as the time elapsed from the reception of the first bit of the ingress L1CI at UNI_1 until the reception of that first bit of the corresponding L1CI egressing at UNI_2[9]. This definition is illustrated in Figure 7.

[8] One-way delay is difficult to measure and therefore one-way delay may be approximated from two-way measurements. However, measurement techniques are beyond the scope of this document.
[9] This definition is consistent with G.7710 [19] clause 10.1.2.

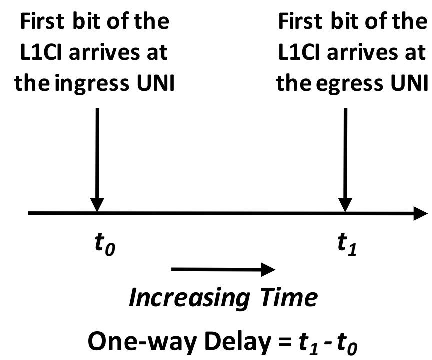

Figure 7 – One-way Delay for L1CI

[R25] For a given ordered Subscriber L1VC End Point pair and a given T_l, the SLS **MUST** define the One-way Delay Performance Metric as the value of the P_d-percentile of the one-way L1CI delay values for the ordered Subscriber L1VC End Point pair within Available Time.

The value of the One-way Delay Performance Metric is represented by the symbol D.

Note that the P_d-percentile approach was introduced to allow the One-way Delay PM Objective to be met although different delays may occur following a protection switch. To place an upper bound on any longer delays a second One-way Delay PM Objective for a higher P_d-percentile value (e.g., 100^{th}) may be specified.

The One-way Delay *PM* entry contains: One-way Delay Performance Metric, ordered Subscriber L1VC End Point pair, P_d, $\widehat{D}$. Where $\widehat{D}$ in time units > 0 is the One-way Delay Performance Metric Objective.

[R26] The SLS **MUST** define the One-way Delay Performance Metric Objective as met during Available Time over T_l for a *PM* entry of the form above if and only if $D \leq \widehat{D}$.

Note that two One-way Delay Performance Metric Objectives $\widehat{D_1}$ and $\widehat{D_2}$ could be specified with corresponding parameters P_1 and P_2 respectively, where $P_2 > P_1$ ($\widehat{D_2}$ being a longer delay objective associated with a higher percentile P_2 to bound potentially longer delays).

8.2.3.4 One-way Errored Second Performance Metric

An errored second (ES) is defined as one second σ_k in Available Time with at least one errored block (EB)[10]. An EB is defined as a block in which one or more bits are in error[11]. In this specification the L1CI corresponds to a block. The definition of an errored L1CI (EB) for each category of client protocol is listed in Table 9.

[10] This definition is consistent with G.8201 [20] Annex A and G.7710 [19] clause 10.1.2.
[11] This definition is consistent with G.8201 [20] clause 3.1.1 and G.7710 [19] clause 10.1.2.

Client Protocol / Physical Port	**Coding**	**Errored L1CI Definition (1)**
Ethernet		
GigE	8B/10B	An invalid code-group is defined in clause 36.2.4.6 in IEEE Std 802.3 [5]
10GigE WAN	Scrambled	A Section BIP-8 anomaly/error is defined in clause 50.3.2.5 in IEEE Std 802.3 [5]
10GigE LAN	64B/66B	An invalid block is defined in Clause 49.2.4.6 in IEEE Std 802.3 [5]
40GigE	64B/66B	An invalid block is defined in clause 82.2.3.5 in IEEE Std 802.3 [5]
100GigE	64B/66B	
Fibre Channel		
FC-100	8B/10B	A code violation is defined in Clause 5.3.3.3 in FC-FS-2 [8]
FC-200	8B/10B	
FC-400	8B/10B	
FC-800	8B/10B	
FC-1200	64B/66B	Clause 13 in FC-10GFC [11] points to IEEE Std 802.3 [5]
FC-1600	64B/66B	A code violation is defined in clause 5.3 in FC-FS-3 [12]
FC-3200	64B/66B	A code violation is defined in clause 5.3 in FC-FS-4 [13]
SDH		
STM-1	Scrambled	A Regenerator Section B1 error and errored block are defined in clause 10.2.1.2 in ITU-T G.783 [21]
STM-4	Scrambled	
STM-16	Scrambled	
STM-64	Scrambled	
STM-256	Scrambled	
SONET		
OC-3	Scrambled	Section B1 error monitoring is defined in clause 3.3.2.1 in Telcordia GR-253-CORE [6]
OC-12	Scrambled	
OC-48	Scrambled	
OC-192	Scrambled	
OC-768	Scrambled	

(1) The error detection capability of the coding functions varies. In some cases a data error may not be detected.

Table 9 – Errored L1CI Definition per Client Protocol

Note that since the Subscriber L1VC is a transparent layer 1 service, an ES at the ingress UNI will result in an ES at the egress UNI. To quantify the performance of the Subscriber L1VC the One-way Errored Second Performance Metric is defined as the difference between egress ES and ingress ES.

[R27] For a given ordered Subscriber L1VC End Point pair and a given T_l, the SLS **MUST** define the One-way Errored Second Performance Metric as follows:

- Let $I_{ES}^{\langle i \rangle}(\sigma_k) = \begin{cases} 1 \text{ if } \sigma_k \text{ is an Errored Second} \\ 0 \text{ otherwise} \end{cases}$

  denote whether there is an ingress ES during one second σ_k of Available Time over T_l at the UNI where Subscriber L1VC End Point *i* is located.

- Let $E_{ES}^{\langle j \rangle}(\sigma_k) = \begin{cases} 1 \text{ if } \sigma_k \text{ is an Errored Second} \\ 0 \text{ otherwise} \end{cases}$

  denote whether there is an egress ES during the same one second σ_k of Available Time over T_l at the UNI where Subscriber L1VC End Point *j* is located.

- Then the One-way Errored Second Performance Metric **MUST** be defined as:

$$\sum_{\sigma_k \subseteq AT(i,j,T_l)} \left(E_{ES}^{\langle j \rangle}(\sigma_k) - I_{ES}^{\langle i \rangle}(\sigma_k) \right)$$

The value of the One-way Errored Second Performance Metric is represented by the symbol *Errored Second PM*.

For a given second σ_k of Available Time, the set of egress L1CI will be different than the set of ingress L1CI due to the transit delay (e.g., 5ms for 1000km of fibre). However, the net effect on an *Errored Second PM* is expected to be negligible.

The One-way Errored Second *PM* entry contains: One-way Errored Second Performance Metric, ordered Subscriber L1VC End Point pair, $\widehat{ES}$. Where $\widehat{ES}$ is the One-way Errored Second Performance Metric Objective. It is an integer count ≥ 0.

[R28] The SLS **MUST** define the One-way Errored Second Performance Metric Objective as met during Available Time over T_l for a *PM* entry of the form above if and only if *Errored Second PM* $\leq \widehat{ES}$.

8.2.3.5 One-way Severely Errored Second Performance Metric

A Severely Errored Second (SES) is defined as:

- One second σ_k which contains ≥ 15% errored L1CI[12], where an errored L1CI is defined in Section 8.2.3.4, or

- One second σ_k which contains a defect (e.g., loss of signal)[13], where a defect on ingress to (client protocol specific), or within the Service Provider's network (transport technology specific) may result in the insertion of a replacement signal (transport technology specific). Note that if a replacement signal is not inserted, a defect (such as a loss of signal) may propagate.

[12] This definition is consistent with G.8201 [20] clause 3.1.2.
[13] This definition is consistent with G.8201 [20] clause 7.1.2 and G.7710 [19] clause 10.1.2.

For example, if the L1CS is provided by an Optical Transport Network (OTN), the client protocol defect, transport defect and replacement signal reference for each category of client protocol are listed in Table 10.

Client Protocol / Physical Port	**Defects and Replacement signal** Clause reference in G.709 [18]
Ethernet	
GigE	17.7.1
10GigE WAN	17.2
10GigE LAN	17.2
40GigE	17.7.4
100GigE	17.7.5
Fibre Channel	
FC-100	17.7.1
FC-200	17.7.2
FC-400	17.9.1
FC-800	17.9.1
FC-1200	17.8.2
FC-1600	17.9.2
FC-3200	17.9.3
SDH	
STM-1	17.7.1
STM-4	17.7.1
STM-16	17.2
STM-64	17.2
STM-256	17.2
SONET	
OC-3	17.7.1
OC-12	17.7.1
OC-48	17.2
OC-192	17.2
OC-768	17.2

Table 10 – Defects and Replacement Signal per Client Protocol in OTN

Note that since the Subscriber L1VC is a transparent layer 1 service, an SES at the ingress UNI will result in an SES at the egress UNI. To quantify the performance of the Subscriber L1VC the One-way Severely Errored Second Performance Metric is defined as the difference between egress SES and ingress SES.

[R29] For a given ordered Subscriber L1VC End Point pair and a given T_l, the SLS **MUST** define the One-way Severely Errored Second Performance Metric as follows:

- Let $I_{SES}^{\langle i \rangle}(\sigma_k) = \begin{cases} 1 \text{ if } \sigma_k \text{ is a Severely Errored Second} \\ 0 \text{ otherwise} \end{cases}$

denote whether there is an ingress SES during one second σ_k within T_l at the UNI where Subscriber L1VC End Point *i* is located.

- Let $E_{SES}^{\langle j \rangle}(\sigma_k) = \begin{cases} 1 \text{ if } \sigma_k \text{ is a Severely Errored Second} \\ 0 \text{ otherwise} \end{cases}$

  denote whether there is an egress SES during the same one second σ_k within T_l at the UNI where Subscriber L1VC End Point *j* is located.

- Then the One-way Severely Errored Second Performance Metric **MUST** be defined as:

$$\sum_{\sigma_k \subseteq AT(i,j,T_l)} \left(E_{SES}^{\langle j \rangle}(\sigma_k) - I_{SES}^{\langle i \rangle}(\sigma_k) \right)$$

The value of the One-way Severely Errored Second Performance Metric is represented by the symbol *Severely Errored Second PM*.

For a given second σ_k of Available Time, the set of egress L1CI will be different than the set of ingress L1CI due to the transit delay (e.g., 5ms for 1000km of fibre). However, the net effect on a *Severely Errored Second PM* is expected to be negligible.

The One-way Severely Errored Second *PM* entry contains: One-way Severely Errored Second Performance Metric, ordered Subscriber L1VC End Point pair, $\widehat{SES}$. Where $\widehat{SES}$ is the One-way Severely Errored Second Performance Metric Objective. It is an integer count ≥ 0.

[R30] The SLS **MUST** define the One-way Severely Errored Second Performance Metric Objective as met during Available Time over T_l for a *PM* entry of the form above if and only if *Severely Errored Second PM* $\leq \widehat{SES}$.

8.2.3.6 One-way Unavailable Second Performance Metric

An Unavailable Second (UAS) is defined as a second during Unavailable Time (UAT) (Section 8.2.3.2).

[R31] For a given ordered Subscriber L1VC End Point pair and a given T_l, the SLS **MUST** define the One-way Unavailable Second Performance Metric as the total number of UAS for the ordered Subscriber L1VC End Point pair over T_l.

The value of the One-way Unavailable Second Performance Metric is represented by the symbol *Unavailable Seconds PM.*

The One-way Unavailable Second *PM* entry contains: One-way Unavailable Second Performance Metric, ordered Subscriber L1VC End Point pair, $\widehat{UAS}$. Where $\widehat{UAS}$ is the One-way Unavailable Second Performance Metric Objective. It is an integer count ≥ 0.

[R32] The SLS **MUST** define the One-way Unavailable Second Performance Metric Objective as met over T_l for a *PM* entry of the form above if and only if *Unavailable Seconds PM* $\leq \widehat{UAS}$.

Editor Note 4: UAS is a commonly reported performance metric for transport network paths (c.f., ITU-T G.7710 section 10.1.6.1 Performance Data Collection for common transport requirements, also discussed in ITU-T G.8201 Appendix I Note 5 for OTN). Service Provider input has been requested whether UAS is also useful as a L1CS PM, or is just the Availability PM sufficient?

8.2.3.7 One-way Availability Performance Metric

Availability is defined as the percentage of Available Time over a given interval T_l which does not include Maintenance Interval Time (MIT) (Section 8.2.3.2).

[R33] For a given ordered Subscriber L1VC End Point pair and a given T_l, the SLS **MUST** define the One-way Availability Performance Metric for the ordered Subscriber L1VC End Point pair over the time interval T_l as:

$$\frac{|AT(i,j,T_l)|}{|AT(i,j,T_l)| + |UAT(i,j,T_l)|} \; x \; 100\%$$

when $(|AT(i,j,T_l)| + |UAT(i,j,T_l)|) > 0$ and 100% otherwise

where the vertical bars around each set indicate the number of elements in the set.

The value of the One-way Availability Performance Metric is represented by the symbol *Availability PM*.

For example, for $|AT(i,j,T_l)|$ = *2,591,974* and $|UAT(i,j,T_l)|$ = *26*, then the *Availability PM* is *99.999%*.

The One-way Availability *PM* entry contains: One-way Availability Performance Metric, ordered Subscriber L1VC End Point pair, $\hat{A}$. Where $\hat{A}$ is the One-way Availability Performance Metric Objective specified as a percentage > 0.

[R34] The SLS **MUST** define the One-way Availability Performance Metric Objective as met over T_l for a *PM* entry of the form above if and only if *Availability PM* $\geq \hat{A}$.

8.3 Subscriber L1VC End Point Service Attributes

A Subscriber L1VC End Point is a logical entity at a given UNI that is associated with L1CI passing over that UNI. Per Section 8.2, a Subscriber L1VC is an association of two Subscriber L1VC End Points. A Subscriber L1VC End Point represents the logical attachment of a Subscriber L1VC to a UNI.

8.3.1 Subscriber L1VC End Point ID Service Attribute

The value of the Subscriber L1VC End Point ID Service Attribute is a string that is used to allow the Subscriber and Service Provider to uniquely identify the Subscriber L1VC End Point.

[R35] The Subscriber L1VC End Point ID **MUST** be unique across all the Service Provider Subscriber L1VC End Points.

[R36] The Subscriber L1VC End Point ID **MUST** contain no more than 45 characters.[14]

[R37] The Subscriber L1VC End Point ID **MUST** be a non-null RFC 2579 [7] DisplayString but not contain the characters 0x00 through 0x1f.

8.3.2 Subscriber L1VC End Point UNI Service Attribute

The value of the Subscriber L1VC End Point UNI Service Attribute is a UNI ID Service Attribute value per Section 8.1.1, which serves to specify the UNI where the Subscriber L1VC End Point is located. The Subscriber L1VC End Point is said to be at this UNI.

[14] The limit of 45 characters is intended to establish limits on field lengths in existing or future protocols that will carry the identifier.

9 Subscriber L1CS Service Attributes Summary

The parameter values for the Service Attributes define the capabilities of a Subscriber L1CS. Some or all of the Service Attributes may apply to a Subscriber L1CS. For a particular Subscriber L1CS, there are three types of Service Attributes, those that apply to a UNI as described in Section 8.1, those that apply to a Subscriber L1VC as described in Section 8.2 and those that apply to a Subscriber L1VC End Point as described in Section 8.3.

The first column in Table 11 identifies the UNI Service Attributes as defined in Section 8.1 of this document. The entries in the second column specify the values. For a given instance of a Subscriber L1CS, a table like that of Table 11 needs to be specified for each UNI in the Subscriber L1VC associated with the service.

UNI Service Attribute	**Values and Description**
UNI ID	***String*** as specified in Section 8.1.1
Physical Layer	A 3-tuple of the form $\langle \boldsymbol{p}, \boldsymbol{c}, \boldsymbol{o} \rangle$ as specified in Section 8.1.2

Table 11 – UNI Service Attributes

The first column in Table 12 identifies the Subscriber L1VC Service Attributes as defined in Section 8.2 of this document. The entries in the second column specify the values. For a given instance of a Subscriber L1CS, a table like that of Table 12 needs to be specified for the Subscriber L1VC associated with the service.

Subscriber L1VC Service Attribute	**Values and Description**
Subscriber L1VC ID	***String*** as specified in Section 8.2.1
Subscriber L1VC End Point List	***Two Subscriber L1VC End Point ID values*** as specified in Section 8.2.2 for the two Subscriber L1VC End Points associated by the Subscriber L1VC
Subscriber L1VC Service Level Specification	***None*** or a 3-tuple of the form $\langle \boldsymbol{t_s}, \boldsymbol{T}, \boldsymbol{PM} \rangle$ as specified in Section 8.2.3

Table 12 – Subscriber L1VC Service Attributes

The first column in Table 13 identifies the Subscriber L1VC End Point Service Attributes as defined in Section 8.3 of this document. The entries in the second column specify the values. For a given instance of a Subscriber L1CS, a table like that of Table 13 needs to be specified for the location of each UNI in the Subscriber L1VC associated with the service.

Subscriber L1VC End Point Service Attribute	**Values and Description**
Subscriber L1VC End Point ID	***String*** as specified in Section 8.3.1
Subscriber L1VC End Point UNI	***String*** as specified in Section 8.3.2

Table 13 – Subscriber L1VC End Point Service Attributes

10 References

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

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

[3] ITU-T G.707, *Network node interface for the synchronous digital hierarchy (SDH)*, January 2007.

[4] Metro Ethernet Forum MEF tbd, *IP Services Attributes*, tbd 2017.

[5] IEEE 802.3, *IEEE Standard for Ethernet*, 2015.

[6] Telcordia GR-253-CORE, *Synchronous Optical Network Transport Systems: Common Generic Criteria, Issue 5*, October 2009.

[7] Internet Engineering Task Force RFC 2579, *Textual Conventions for SMIv2*, April 1999.

[8] ANSI INCITS 424-2007[R2012], *Fibre Channel – Framing and Signaling – 2 (FC-FS-2)*, February 2007.

[9] ANSI INCITS 404-2006, *Fibre Channel – Physical Interfaces – 2 (FC-PI-2)*, August 2006.

[10] ANSI INCITS 479-2011, *Fibre Channel – Physical Interfaces – 5 (FC-PI-5)*, November 2011.

[11] ANSI INCITS 364-2003, *Fibre Channel – 10 Gigabit (FC-10GFC)*, November 2003.

[12] ANSI INCITS 470-2011, *Fibre Channel – Framing and Signaling – 3 (FC-FS-3)*, December 2011.

[13] ANSI INCITS 488-2016, *Fibre Channel – Framing and Signaling – 4 (FC-FS-4)*, December 2016.

[14] ANSI INCITS 512-2015, *Fibre Channel – Physical Interfaces – 6 (FC-PI-6)*, January 2015.

[15] ITU-T G.957, *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*, March 2006.

[16] ITU-T G.691, *Optical interfaces for single channel STM-64 and other SDH systems with optical amplifiers*, March 2006.

[17] ITU-T G.693, *Optical interfaces for intra-office systems*, November 2009.

[18] ITU-T G.709, *Interfaces for the optical transport network*, June 2016.

[19] ITU-T G.7710, *Common equipment management function requirements*, February 2012.

[20] ITU-T G.8201, *Error performance parameters and objectives for multi-operator international paths within optical transport networks*, April 2011.

[21] ITU-T G.783, *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*, March 2006.

[22] Metro Ethernet Forum MEF 10.4, *Ethernet Services Attributes Phase 4*, tbd 2017.

[23] ITU-T G.805, *Generic functional architecture of transport networks*, March 2000.

[24] ITU-T G.806, *Characteristics of transport equipment – Description methodology and generic functionality*, February 2012.

Appendix A Use Cases (Informative)

The following sections provide examples of Subscriber L1CS use cases.

A.1 Enterprise Outsourcing

In this use case an Enterprise has a multi-site network composed of branch offices, a headquarters and a remote site used for Business Continuity or Disaster Recovery (the distinction being either a zero Recovery Time Objective or some non-zero value, respectively). See Figure 8. The Enterprise could be financial, medical, government, research and education or a large corporation.

The multi-site connectivity is provided by either an Ethernet Virtual Private Local Area Network (EVP-LAN) or an Internet Protocol Virtual Private Network (IP VPN) service, which may have a back-up connection to the co-location site. The focus of this use case is the point-to-point Subscriber L1CS between the headquarters (UNI_1) and the remote co-location site (UNI_2).

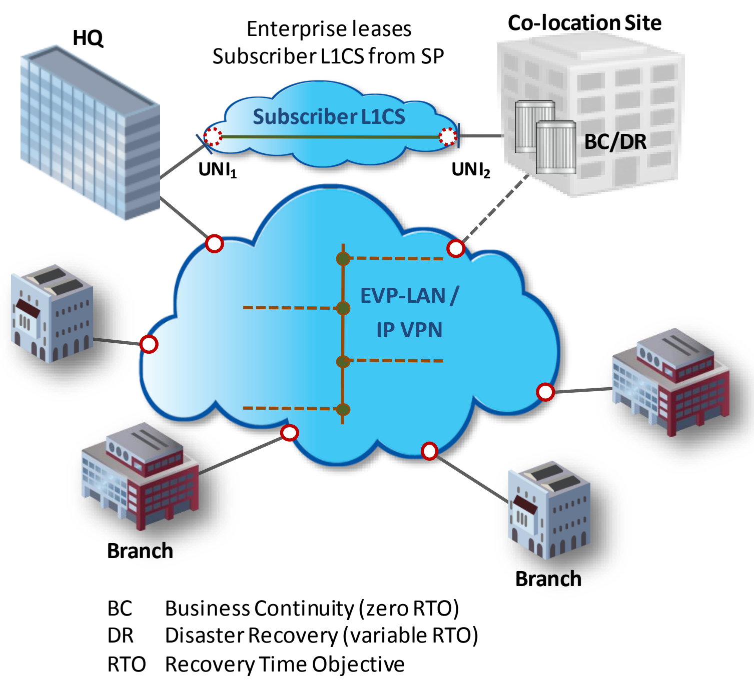

Figure 8 – Enterprise Outsourcing Use Case

The connectivity between the Enterprise headquarters and the co-location site is provided by a Subscriber L1CS leased from a Service Provider. The Subscriber L1CS could carry an Ethernet client protocol (for Local Area Network extension) or a Fibre Channel client protocol (for Storage Area Network extension). Example Service Attribute values for an Ethernet client protocol Subscriber L1CS are listed in Table 14, Table 15 and Table 16.

UNI Service Attribute	UNI-1	UNI-2
UNI ID	*MTL-HQ-Node3-Slot2-Port1*	*MTL-STL-Node5-Slot4-Port3*

Physical Layer	*⟨Ethernet, 10GBASE-R PCS clause 49, LR PMD clause 52⟩*	*⟨Ethernet, 10GBASE-R PCS clause 49, ER PMD clause 52⟩*

Table 14 – Example UNI Service Attribute Values for Enterprise Use Case

Subscriber L1VC Service Attribute	**Subscriber L1VC-1**	
Subscriber L1VC ID	*Sub-L1VC-1867-LT-MEGAMART*	
Subscriber L1VC End Point List	*⟨MTL-HQ_1867-MEGAMART, MTL-STL_1867-MEGAMART⟩*	
Subscriber L1VC Service Level Specification	t_s	*2017-07-01, 08:00:00 UTC*
	T	*one calendar month*
	PM	*One-way Availability Performance Metric*
	Ordered Subscriber L1VC End Point pairs	*⟨MTL-HQ_1867-MEGAMART, MTL-STL_1867-MEGAMART⟩ and ⟨MTL-STL_1867-MEGAMART, MTL-HQ_1867-MEGAMART⟩*
	$\widehat{A}$	*99.999%*

Table 15 – Example Subscriber L1VC Service Attribute Values for Enterprise Use Case

Subscriber L1VC End Point Service Attribute	**Location of UNI-1**	**Location of UNI-2**
Subscriber L1VC End Point ID	*MTL-HQ_1867-MEGAMART*	*MTL-STL_1867-MEGAMART*
Subscriber L1VC End Point UNI	*MTL-HQ-Node3-Slot2-Port1*	*MTL-STL-Node5-Slot4-Port3*

Table 16 – Example Subscriber L1VC End Point Service Attribute Values for Enterprise Use Case

A.1.1 Delay Considerations

A consideration for the Enterprise outsourcing use case is whether there might be a delay limit for the Subscriber L1CS, determined by the application it is supporting. For example, if the client protocol is Ethernet and live Virtual Machine migration is intended, a maximum round-trip time of 10ms between the UNI pair might apply (vendor specific). Assuming equal forward and reverse path delays, that implies a maximum One-way Delay PM objective of 5ms.

If the client protocol is Fibre Channel there may be a round-trip time limit of about 2ms to allow link initialization/handshaking to complete (vendor specific). Assuming equal forward and reverse path delays, that implies a maximum One-way Delay PM objective of 1ms.

A.2 Subscriber Interconnect

In this use case an Enterprise has a multi-site network composed of two branch offices and a headquarters. Each branch office is connected to the headquarters by a Subscriber L1CS. See Figure 9.

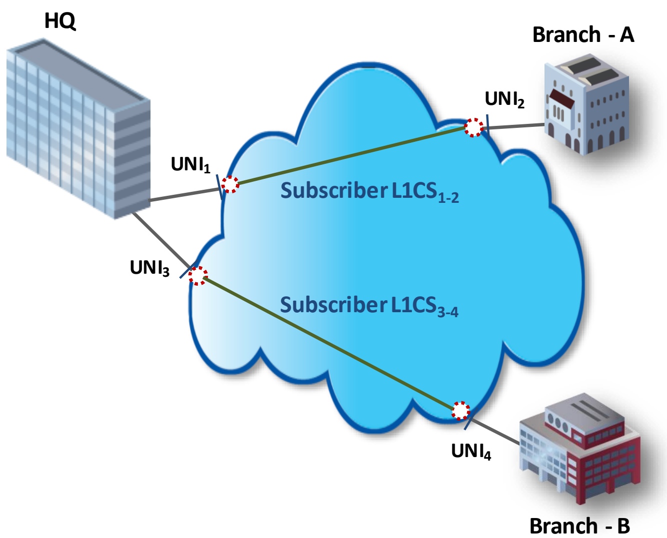

Figure 9 – Subscriber Interconnect Use Case

The legacy Subscriber Equipment platforms at the branch offices and headquarters have SONET line-side ports. Example Service Attribute values for a SONET client protocol Subscriber $L1CS_{1-2}$ between the Branch-A UNI_2 and the headquarters UNI_1 are listed in Table 17, Table 18 and Table 19.

UNI Service Attribute	UNI-1	UNI-2
UNI ID	*VAN-HQ-Node3-Slot2-Port1*	*VAN-BR-A-Node5-Slot4-Port3*
Physical Layer	*⟨SONET, OC-192 GR-253-CORE framer N=192, GR-253-CORE clause 4.1 SR-1⟩*	*⟨SONET, OC-192 GR-253-CORE framer N=192, GR-253-CORE clause 4.1 IR-1⟩*

Table 17 – Example UNI Service Attribute Values for Subscriber Interconnect Use Case

Subscriber L1VC Service Attribute	Subscriber L1VC-12	
Subscriber L1VC ID	*Sub-L1VC-2017-LT-LULU*	
Subscriber L1VC End Point List	*⟨VAN-HQ_2017-LULU, VAN-BR-A_2017-LULU⟩*	
Subscriber L1VC Service Level Specification	t_s	*2017-07-01, 08:00:00 UTC*
	T	*one calendar month*
	PM	*One-way Availability Performance Metric*
	Ordered Subscriber	*⟨VAN-HQ_2017-LULU, VAN-BR-A_2017-*

Subscriber L1VC Service Attribute	**Subscriber L1VC-12**	
	L1VC End Point pairs	*LULU⟩ and ⟨VAN-BR-A_2017-LULU, VAN-HQ_2017-LULU⟩*
	$\hat{A}$	*99.99%*

Table 18 – Example Subscriber L1VC Service Attribute Values for Subscriber Interconnect Use Case

Subscriber L1VC End Point Service Attribute	**Location of UNI-1**	**Location of UNI-2**
Subscriber L1VC End Point ID	*VAN-HQ_2017-LULU*	*VAN-BR-A_2017-LULU*
Subscriber L1VC End Point UNI	*VAN-HQ-Node3-Slot2-Port1*	*VAN-BR-A-Node5-Slot4-Port3*

Table 19 – Example Subscriber L1VC End Point Service Attribute Values for Subscriber Interconnect Use Case

A.3 Control Plane Restoration and the Availability Performance Metric

In this use case, Subscriber L1CS$_{1-2}$ has an Availability performance metric objective of 99.99%. Subscriber L1CS$_{3-4}$ has an Availability performance metric objective of 99.9%. See Figure 10. The client protocol for each Subscriber L1CS is unspecified.

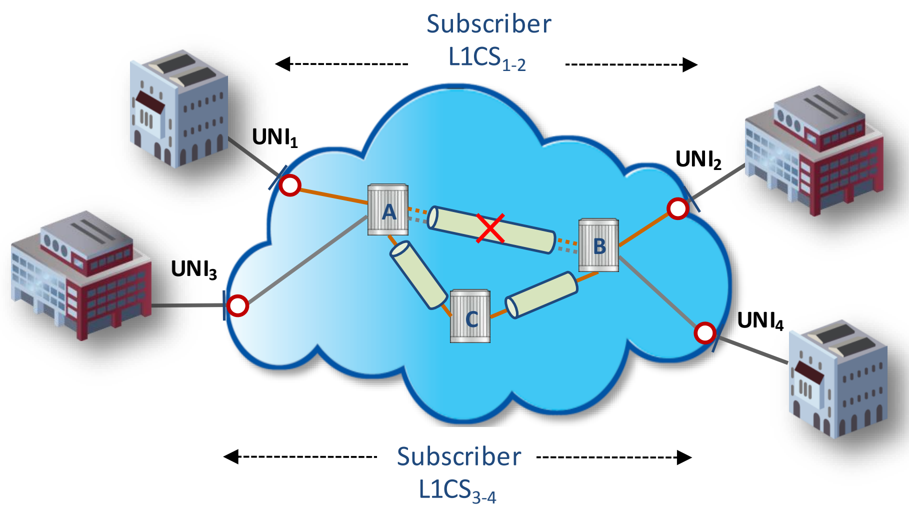

Figure 10 – Control Plane Restoration Example

Both Subscriber L1CS's are initially routed over the same network link A-B which later experiences a hard fault. Subscriber L1CS$_{1-2}$ is re-routed via node C by the control plane in order to meet the high Availability performance metric objective. Subscriber L1CS$_{3-4}$ is not re-routed due to its lower Availability performance metric objective (either because it could still be met or due to resource contention). Consequently, Subscriber L1CS$_{1-2}$ remains available while Subscriber L1CS$_{3-4}$ becomes unavailable.

A variation on this scenario could be that Subscriber L1CS$_{1-2}$ does not have an associated Delay performance metric objective while Subscriber L1CS$_{3-4}$ does, and its Delay performance metric objective would be exceeded by re-routing over the longer restoration path.

Appendix B Evaluation of One-way Errored Second PM (Informative)

The One-way Errored Second Performance Metric is defined in section 8.2.3.4 as:

$$\sum_{\sigma_k \subseteq AT(i,j,T_l)} \left(E_{ES}^{\langle j\rangle}(\sigma_k) - I_{ES}^{\langle i\rangle}(\sigma_k)\right)$$

As discussed, for a given second σ_k of Available Time, the set of egress L1CI will be different than the set of ingress L1CI due to the transit delay (e.g., 5ms for 1000km of fibre). An example of the effect of this delay on the evaluation of the Errored Second PM is illustrated in Figure 11.

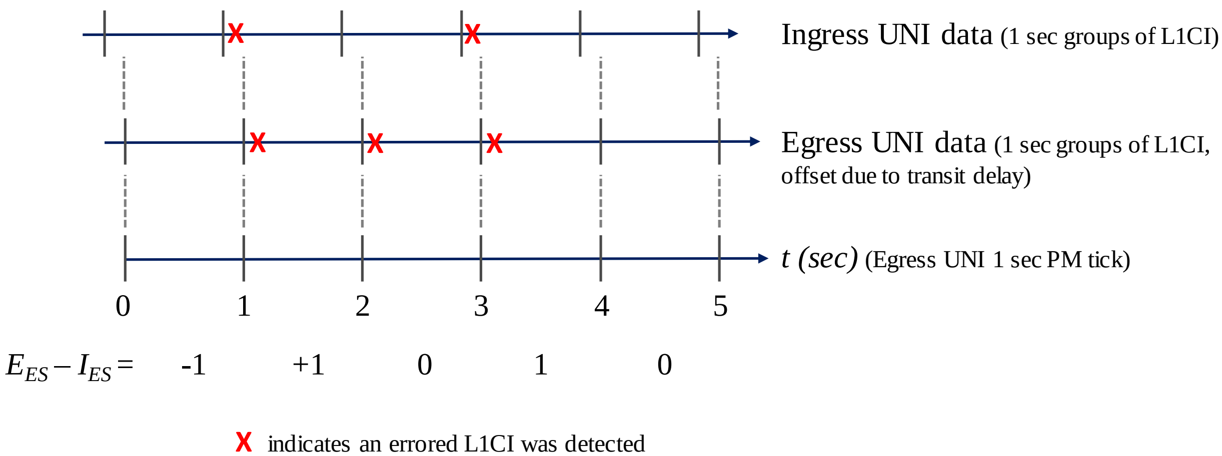

Figure 11 – Example Evaluation of One-way Errored Second PM

In the example, the egress UNI σ_k (1 sec PM tick) is used to determine whether there was an ingress or egress ES. For a delay of 5ms, 0.5% of the L1CI arriving at the ingress UNI during a given σ_k will be evaluated in the following σ_k at the egress UNI. Note there is a similar effect on the evaluation of the One-way Severely Errored Second PM.