MEF Standard

MEF 72

Network Resource Model - Subscriber Layer 1

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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.

- CenturyLink
- NEC Corporation
- Nokia

2 Abstract

This specification describes the MEF Network Resource Management Information Model (NRM IM), specifically for Layer 1 Connectivity related management features.

Lifecycle Service Orchestration Reference Architecture (LSO RA, MEF 55 [5]) extends the traditional MEF scope concerning Service Modeling, from a pure view "from outside the network" to cover a range of Operational, Orchestration, and Network Management behaviors, including SDN and NFV paradigms.

In support to MEF 55 [5], NRM IM (MEF 59 [6]) and NRP IPS (MEF 60 [7]) have been defined to manage the Network Infrastructure, through SDN Controllers, WAN Controllers, OTN Subnetwork Managers, and other legacy Network Management Systems.

This document adds to MEF 59 [6] the management features related to Layer 1 Connectivity, as defined by *Subscriber Layer 1 Service Attributes Technical Specification* (MEF 63 [8]). This model can be used as the basis for LSO RA PRESTO Interface Profiles defining APIs for the Layer 1.

The NRM IM structure is based on current and developing best network management solutions by ITU-T, ONF, TM Forum, to allow wider and future proof interoperability across multi-vendor and multi-technology networks. Examples of reference network management solutions are ITU-T G.7711/Y.1702 [10], ONF TR-512 [11], ONF TR-527 [12], TM Forum MTNM [16] and MTOSI [17].

This document normatively includes the content of the following Papyrus [14] UML files as if they were contained within this document (pull request **#718,** GitHub Repository [9]):

- NRM_L1.di
- NRM_L1.notation
- NRM_L1.uml

3 Terminology and Abbreviations

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

In addition, terms defined in MEF 4 [3], MEF 7.3 [4], MEF 55 [5], TMF GB922 [15] are included in this document by reference, and are not repeated in the table below, unless when mentioned in local definitions, e.g. ICM.

Term	Definition	Reference
ICM	Infrastructure Control and Management: The set of functionality providing domain specific network and topology view resource management capabilities including configuration, control and supervision of the network infrastructure.	MEF 55 [5]
Internal Network-to-Network Interface (INNI)	A reference point representing the boundary between two networks or network elements that are operated within the same administrative domain. Note: In this specification, the "networks or network elements" refers to those in a given ICM Domain, hence, between two ICM domains.	MEF 4 [3] MEF 55 [5]
NRM IM	Network Resource Management Information Model	This document
Product Instance	Specific implementation of a Product Offering dedicated to the benefit of a party.	TMF GB922 [15]
Product Offering	An externally facing representation of a Service and/or Resource procurable by the Customer.	TMF GB922 [15]
Product Specification	The detailed description of product characteristics and behavior used in the definition of Product Offerings.	TMF GB922 [15]
Resource	A physical or non-physical component (or some combination of these) within a Service Provider's infrastructure or inventory.	TMF GB922 [15]
Service	Represents the Customer experience of a Product Instance that has been realized within the Service Provider's and / or Partners' infrastructure.	TMF GB922 [15]
Service Component	A segment or element of a Service that is managed independently by the Service Provider.	MEF 55 [5]
TAPI or T-API	Transport API Information Model	ONF TR-527 [12] ONF TAPI IM [13]
UML	Unified Modeling Language	OMG UML, Infrastructure, Version 2.5

Table 1 – Terminology and Abbreviations

4 Compliance Levels

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**NOT RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 (RFC 2119 [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**.**

5 Introduction

The scope of this specification is a protocol neutral definition of the information, i.e., the attributes (or properties), of the network resource management objects modeling the Layer 1 Connectivity features according to the requirements defined by MEF 63 [8] Technical Specification.

MEF 59 [6] includes Carrier Ethernet connectivity resource management features, identified as the set of management features supported by MEF 7.3 [4] at service level. The model defined in this specification adds Layer 1 management features to MEF 59.

Similarly to MEF 59 [6], the MEF NRM L1 IM reuses and extends the definitions of the ONF Transport API Information Model (TAPI IM [12], [13]), which is derived from the ONF Core Information Model ([11]). For more information regarding the ONF Specification approach and the usage of Papyrus [14] UML constructs, refer to MEF 59 related chapters.

The ONF Core IM is a common information model for network/transport technologies, evolution of TMF and ITU-T models. It is extensible to new features/functions.

The TAPI model is derived from the ONF Core IM to make this more oriented to an implementation of transport network management interface. It standardizes a single core technology-agnostic model that abstracts common transport network functions.

The TAPI capabilities are extended through the specification approach. The essential concept is to associate an instance of a TAPI class with a set of extensions that account for the specific case (specification class). These specification classes are definitions of specific cases of usage of a class to be extended.

The modeling of capability necessarily involves the modeling of constraints and rules, as a specific capability is always restricted in some way with respect to the maximum possible capability. The ONF Specification approach focusses on model of constrained capability.

Clearly a UML class model provides a definition of capability in terms of things that can be created and values that can be set. However, the full ONF Core IM and TAPI go way beyond the capability of any real solution. It is therefore necessary for any particular solution to be able to state its specific capabilities. The term used by ONF for the modeling of capabilities is "Capability Specification" or "Specification" or "Spec" for short.

See TR-512.7 Specification Model [11], “2.2 Rationale for, and features of, the ONF Specification approach”.

The MEF 59 [6], (NRM IM Connectivity model) is designed around a set of *specification classes* which extends, or augments, TAPI classes. See Figure 1.

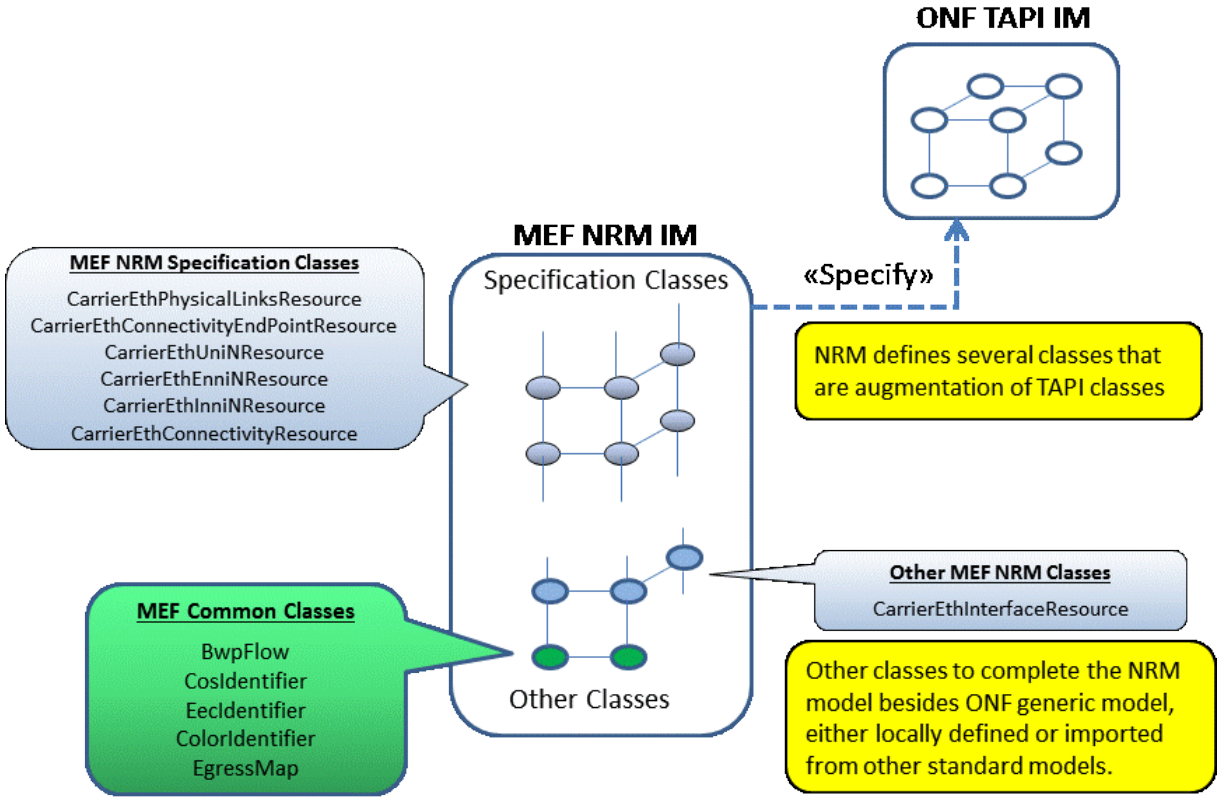

Figure 1 - MEF NRM extending ONF TAPI

The MEF NRM IM classes are applicable to PRESTO Interface Reference Point (MEF 55 [5]), see Figure 2.

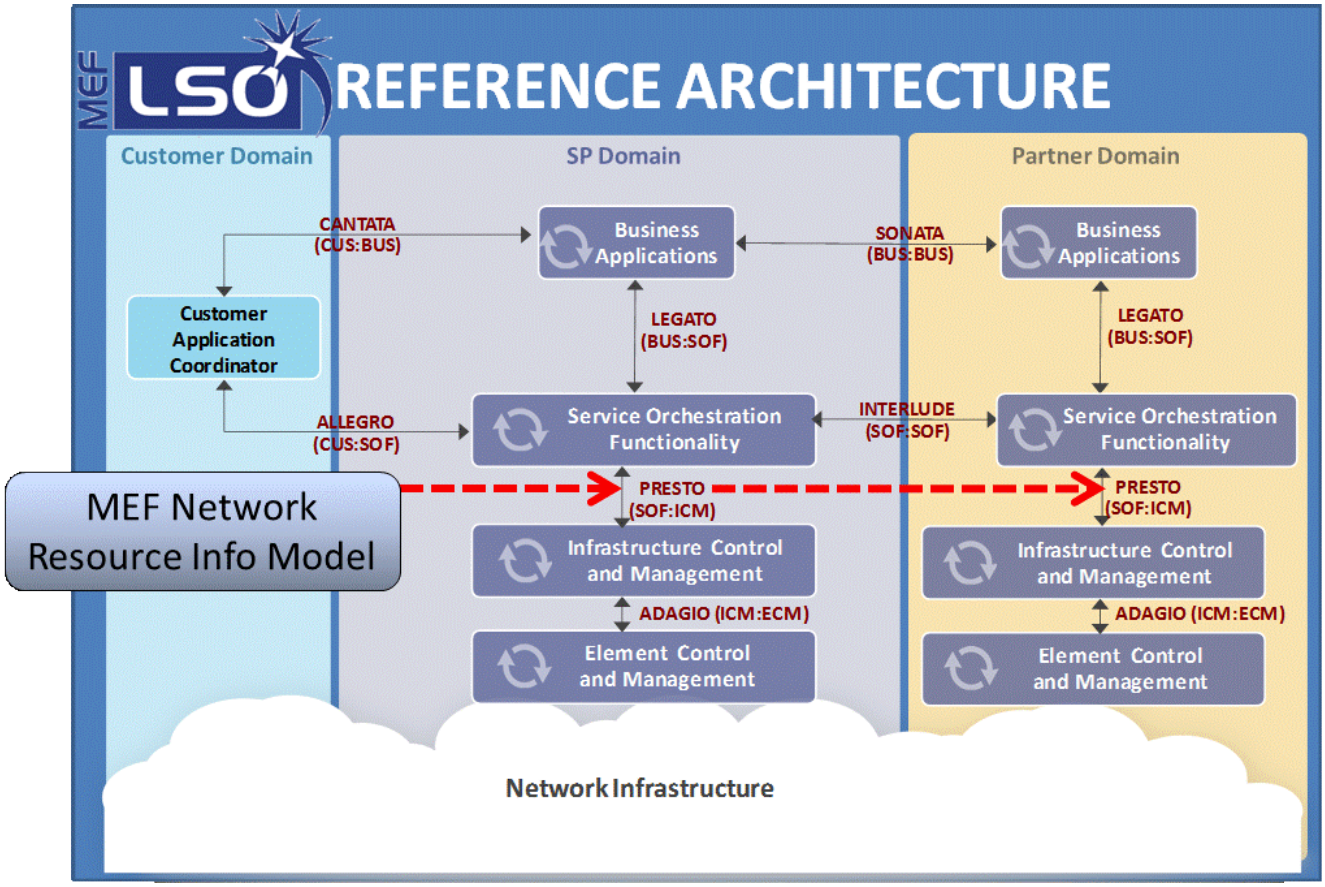

Figure 2 - MEF NRM positioning in LSO RA

This specification includes the L1 resource management features as defined by MEF 63.

Some of the UML diagrams are very dense. To view them either zoom (sometimes to 400%) or open the corresponding UML diagram via Papyrus [14] (for each figure with a UML diagram the UML model diagram name is provided under the figure in italic font).

6 Contents

The following sections of this document include:

- The overview of NRM IM Layer 1 classes (7)
- The list of all defined object classes and their attributes for:
  - Layer 1 Connectivity Classes (8.1)
  - Layer 1 Service Level Specification Classes (8.2)
  - Layer 1 Ethernet and Fibre Channel coding and optical interface functions (8.3)
  - Layer 1 SDH and SONET *coding* and *optical interface* functions (8.4)
- The definitions of data types (9, 10)
- References (11)
- Appendix A lists the relevant network scenarios

7 Network Resource Information Model Overview

Figure 3 shows an example of class instances and their augmentations. There is a ConnectivityService instance, which is ended by two ConnectivityServiceEndPoints, which are augmented by MEF specific L1ConnectivityEndPointResource classes. The ConnectivityService has a ServiceLevelSpecification object instance associated, which is augmented by MEF specific L1ServiceLevelSpecification.

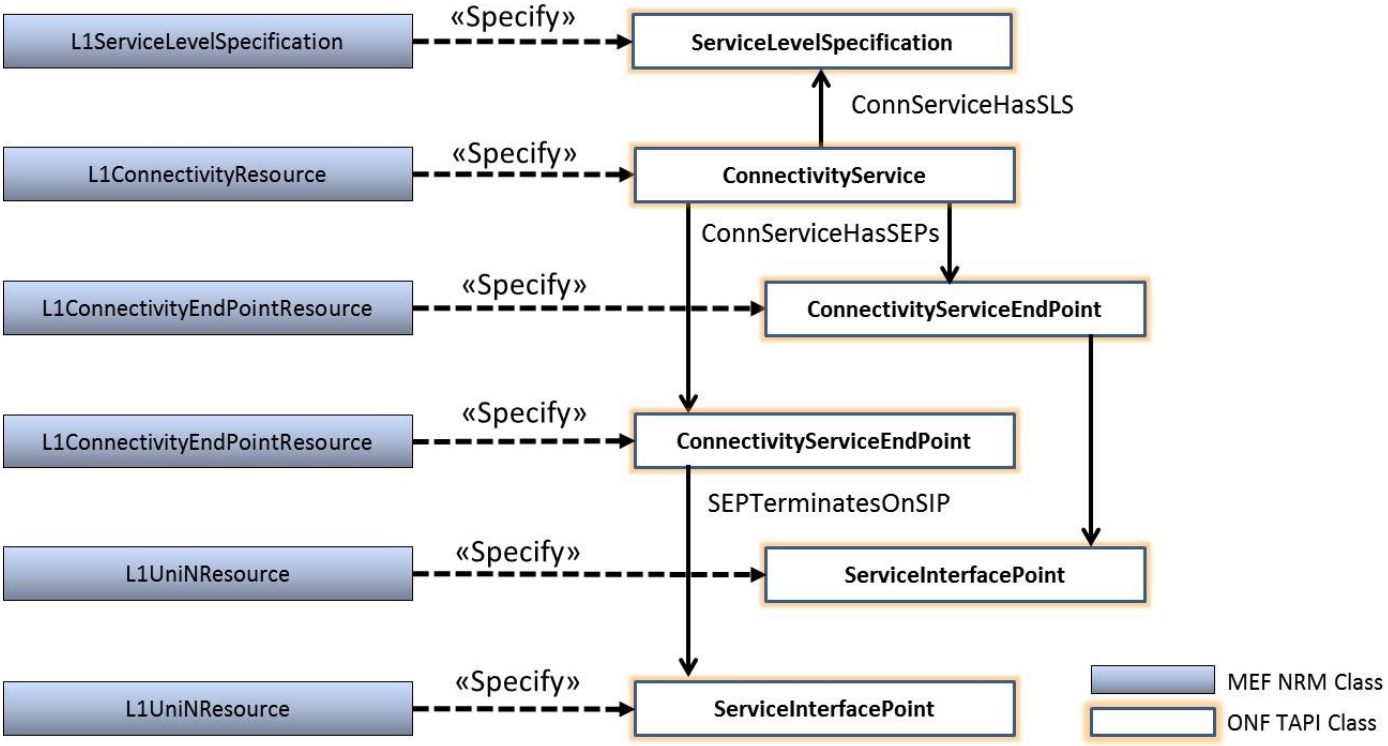

Figure 3 - Relationships with ONF TAPI

- The **L1ServiceLevelSpecification** represents the MEF Layer 1 SLS, as defined by MEF 63. It augments the TAPI **ServiceLevelSpecification**.

- The **L1ConnectivityResource** represents the Layer 1 end to end connectivity at resource level. It augments the TAPI **ConnectivityService** class, which represents the request for connectivity between two or more TAPI **ConnectivityServiceEndPoint**. More detailed connection and routing information are modeled by different constructs of TAPI.

- The **L1ConnectivityEndPointResource** class models the service end point. It augments the TAPI **ConnectivityServiceEndPoint**.

The relationship between **L1ConnectivityResource** and its two[1] **L1ConnectivityEndPointResource** is modeled through the relationship between **ConnectivityService** and **ConnectivityServiceEndPoint** of TAPI model.

- The **L1UniNResource** class represents the UNI-N management functions related to the layer 1. The physical layer at UNIs is optical. The **L1UniNResource** augments the TAPI **ServiceInterfacePoint**.

- The relationship between **L1ConnectivityEndPointResource** and its **L1UniNResource**[2] is modeled through the relationship between **ConnectivityServiceEndPoint** and **ServiceInterfacePoint** of TAPI model.

Following sections specify all defined NRM L1 classes and the TAPI classes being augmented.

[1] A Subscriber L1 Service has only point-to-point topology.
[2] An instance of a Subscriber L1 Service has a single service instance per UNI (i.e., no service multiplexing).

8 Network Resource Information Model Classes

8.1 Layer 1 Connectivity

Figure 4 illustrates the NRM L1 IM *specification classes* representing L1 Connectivity Service, L1 Service End Point and L1 UNI, with their attributes and associations with other object classes.

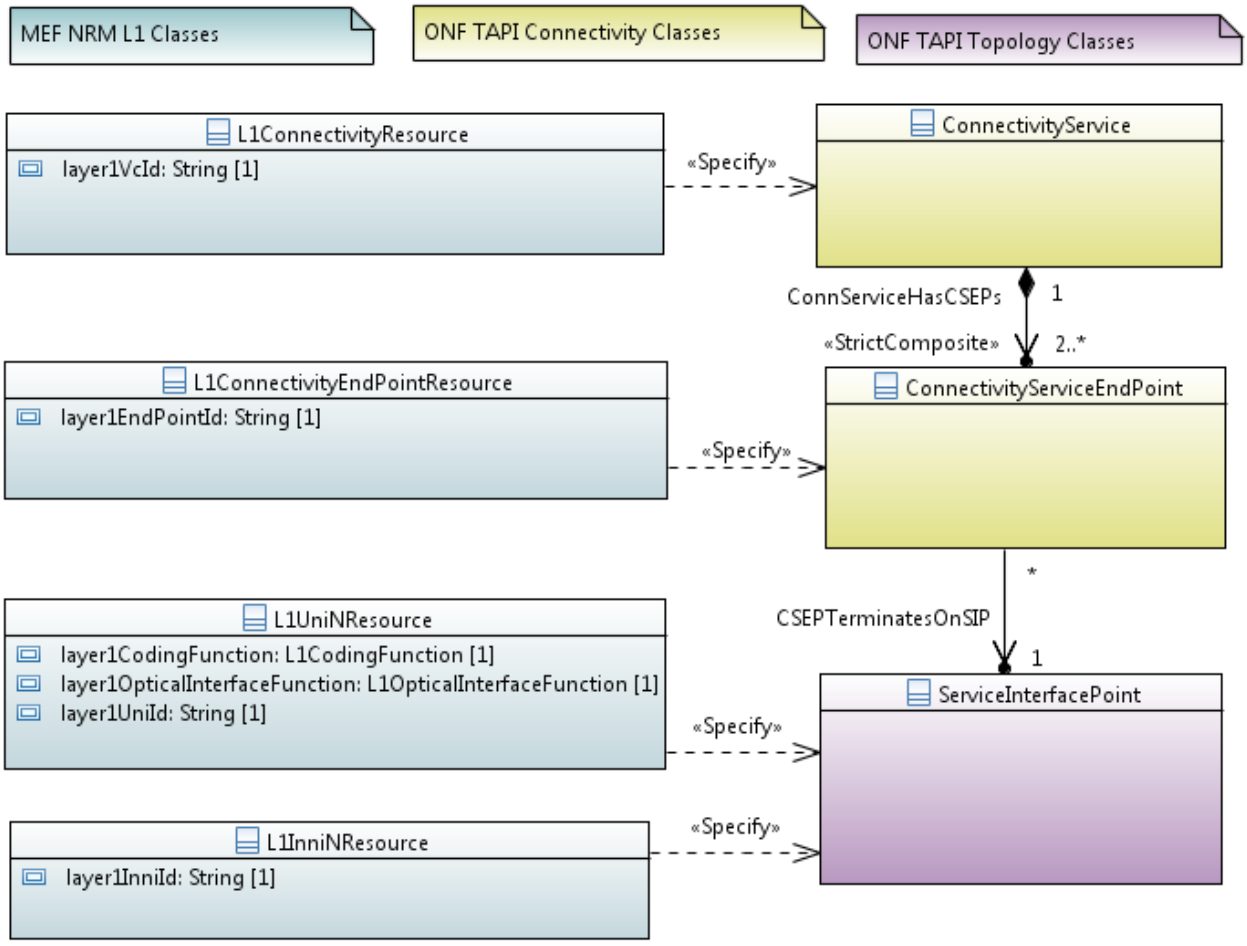

Figure 4 – *NRM_L1_Connectivity* Diagram

8.1.1 L1ConnectivityEndPointResource

MEF 63: Subscriber Layer 1 Virtual Connection End Point represents the logical attachment of a Subscriber Layer 1 Virtual Connection to a L1 UNI.

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
layer1EndPointId	String	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: [R36] The Subscriber L1VC End Point ID MUST be unique across all the Service Provider's Subscriber L1VC End Points. [R37] The Subscriber L1VC End Point ID MUST contain no more than 45 charac-ters. [R38] The Subscriber L1VC End Point ID MUST be a non-null RFC 2579 DisplayString but not contain the characters 0x00 through 0x1f.

8.1.2 L1ConnectivityResource

MEF 63: A Layer 1 Service is connectivity service which delivers Layer 1 Characteristic Information that is specified using Service Attributes as defined in a MEF Specification. A fundamental aspect of a Subscriber L1 Service is the Subscriber L1VC, L1 Virtual Connection: An association of two Layer 1 Virtual Connection End Points that limits the transport of Layer 1 Characteristic Information between those Layer 1 Virtual Connection End Points. A Subscriber L1 Service has the following basic characteristics: 1) Topology: Only point-to-point. 2) UNI: Both UNIs have the same rate. The physical layer at both UNIs is optical. 3) Rate: Only full port speed of the UNIs. 4) Client protocol: Ethernet, Fibre Channel, SONET, SDH. 5) Transparency: The client protocol data (L1CI) is transported bit identical from the ingress UNI to egress UNI at the same frequency (aka timing transparent). 6) Performance metrics (SLS) An instance of a Subscriber L1 Service has: 1) The same client protocol at both UNIs (i.e., one of: Ethernet, Fibre Channel, SONET, SDH). 2) The physical ports at both UNIs have the same rate and same coding function (e.g., 8B/10B). 3) The physical port at each UNI may have a different optical interface function (e.g., long reach or extended reach). 4) A single service instance per UNI (i.e., no service multiplexing).

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
layer1VcId	String	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: [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. [R19] The Subscriber L1VC ID MUST be a non-null RFC 2579 DisplayString but not contain the characters 0x00 through 0x1f.

8.1.3 L1InniNResource

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
layer1InniId	String	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	

8.1.4 L1UniNResource

MEF 63: Layer 1 User Network Interface.

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
layer1CodingFunction	L1CodingFunction	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	
layer1OpticalInterfaceFunction	L1OpticalInterface Function	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY • condition:	
layer1UniId	String	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: [R3] The UNI ID MUST be unique among all the Service Provider's UNIs. [R4] The UNI ID MUST contain no more than 45 characters. [R5] The UNI ID MUST be a non-null RFC 2579 DisplayString but not contain the characters 0x00 through 0x1f.

8.2 Layer 1 Service Level Specification

Figure 5 illustrates the NRM L1 IM *specification classes* representing MEF specific Layer 1 Service Level Specification, with their attributes and associations with other object classes.

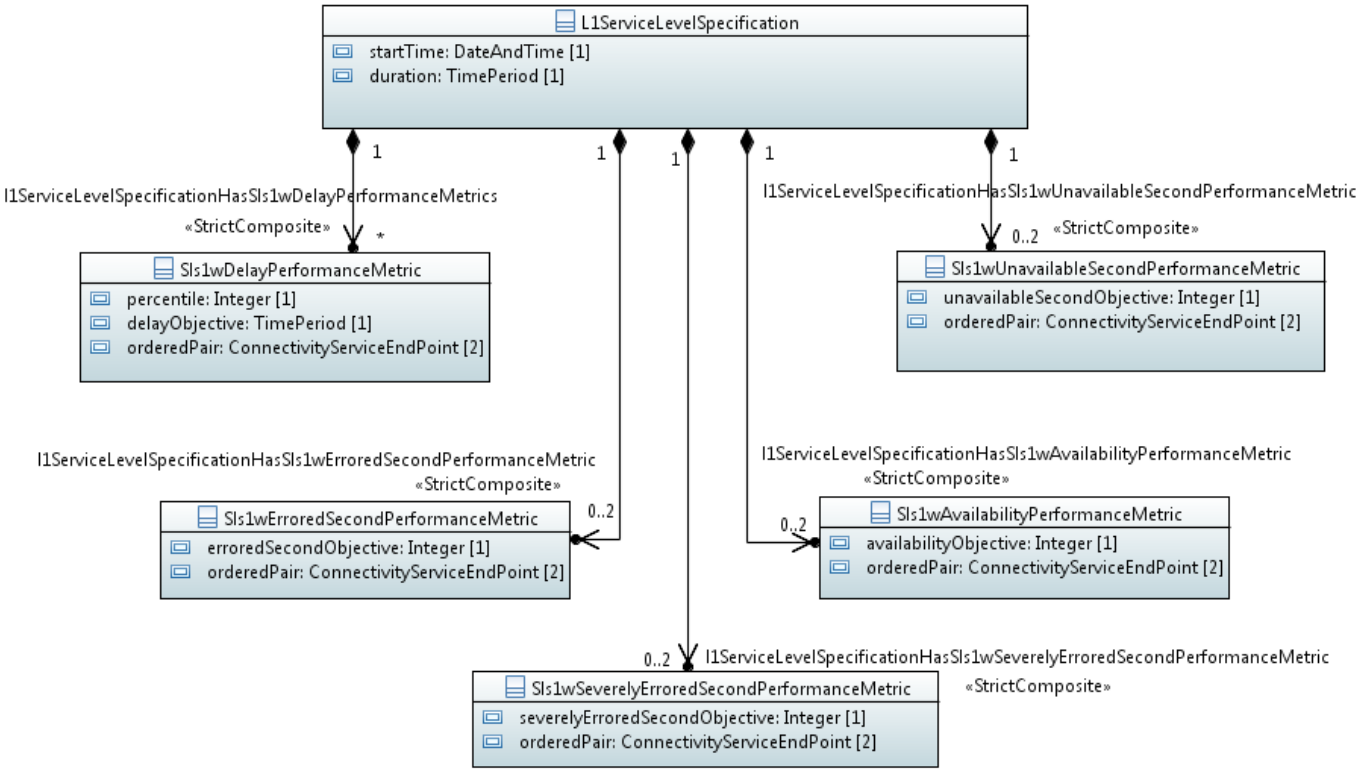

Figure 5 – *NRM_L1_SLS* Diagram

8.2.1 L1ServiceLevelSpecification

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 Sub-scriber. 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 (t-s, T, PM) where: 1) t-s is a time that represents the date and time for the start of the SLS. 2) 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. 3) 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.

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
startTime	DateAndTime	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: t-start is a time that represents the date and time for the start of the SLS. [R22] t-start MUST be specified to the nearest second.
duration	TimePeriod	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: T is a duration that is used in conjunction with ts 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.
_sls1wDelayPerformanceMetric	Sls1wDelayPerformanceMetric	0..*	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	
_sls1wErroredSecondPerformanceMetric	Sls1wErroredSecondPerformanceMetric	0..2	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	
_sls1wSeverelyErroredSecondPerformanceMetric	Sls1wSeverelyErroredSecondPerformanceMetric	0..2	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	
_sls1wUnavailableSecondPerformanceMetric	Sls1wUnavailableSecondPerformanceMetric	0..2	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	

Attribute Name	Type	Mult.	Access	Stereotypes	Description
_sls1wAvailabilityPerformanceMetric	Sls1wAvailabilityPerformanceMetric	0..2	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	

8.2.2 Sls1wDelayPerformanceMetric

MEF 63: The One-way Delay 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. [R27] The SLS MUST define the One-way Delay Performance Metric Objective as met during Available Time over T-l for a PM entry if and only if measured delay D <= delayObjective.

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
percentile	Integer	1	RW	OpenModelAttribute • isInvariant: false • valueRange: (0,100] • support: MANDATORY	MEF 63: the Pd-percentile allows the One-way Delay Performance Metric 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 Performance Metric Objective for a higher Pd_percentile value (e.g., 100th) may be specified.
delayObjective	TimePeriod	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: The value of the One-way Delay Performance Metric, time units>0
orderedPair	ConnectivityServiceEndPoint	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: Ordered pair of Subscriber L1VC EPs.

8.2.3 Sls1wErroredSecondPerformanceMetric

MEF 63: An errored second (ES) is defined as one second sigma-k in Available Time with at least one errored block (EB) and is not a SES. An EB is defined as a block in which one or more bits are in error. In this specification the L1CI corresponds to a block. [R29] The SLS MUST define the One-way Errored Second Performance Metric Objective as met during Available Time over T-l for a PM entry if and only if measured Errored Second PM <= erroredSecondObjective.

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
erroredSecondObjective	Integer	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: The value of the One-way Errored Second Performance Metric, integer >=0
orderedPair	ConnectivityServiceEndPoint	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: Ordered pair of Subscriber L1VC EPs.

8.2.4 Sls1wSeverelyErroredSecondPerformanceMetric

MEF 63: A Severely Errored Second (SES) is defined as: - One second sigma-k which contains >= 15% errored L1CI , or - One second sigma-k which contains a defect (e.g., loss of signal), 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 to the egress UNI. Note that a SES is not counted as a ES. [R31] 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 if and only if measured Severely Errored Second PM <= severelyErroredSecondObjective.

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
severelyErroredSecondObjective	Integer	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: The value of the One-way Severely Errored Second Performance Metric, integer >=0
orderedPair	ConnectivityServiceEndPoint	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: Ordered pair of Subscriber L1VC EPs.

8.2.5 Sls1wUnavailableSecondPerformanceMetric

MEF 63: An Unavailable Second (UAS) is defined as a second during Unavailable Time (UAT). [R33] The SLS MUST define the One-way Unavailable Second Performance Metric Objective as met over T-l for a PM entry if and only if measured Unavailable Seconds PM <= unavailableSecondObjective

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
unavailableSecondObjective	Integer	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: The value of the One-way Unavailable Second Performance Metric, integer >=0
orderedPair	ConnectivityServiceEndPoint	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: Ordered pair of Subscriber L1VC EPs.

8.2.6 Sls1wAvailabilityPerformanceMetric

MEF 63: Availability is defined as the percentage of Available Time over a given interval T-l which does not include Maintenance Interval Time (MIT). [R35] The SLS MUST define the One-way Availability Performance Metric Objective as met over T-l for a PM entry if and only if measured Availability PM >= availabilityObjective

Applied stereotypes:

- OpenModelClass
  - support: MANDATORY

Attribute Name	Type	Mult.	Access	Stereotypes	Description
availabilityObjective	Integer	1	RW	OpenModelAttribute • isInvariant: false • valueRange: (0,100] • support: MANDATORY	MEF 63: The value of the One-way Availability Performance Metric, percentage > 0
orderedPair	ConnectivityServiceEndPoint	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY	MEF 63: Ordered pair of Subscriber L1VC EPs.

8.3 Ethernet and Fibre Channel *coding* and *optical interface* functions

Figure 6 illustrates the NRM L1 IM *enumerations* representing MEF specific Layer 1 Ethernet and Fibre Channel *coding* and *optical interface* functions.

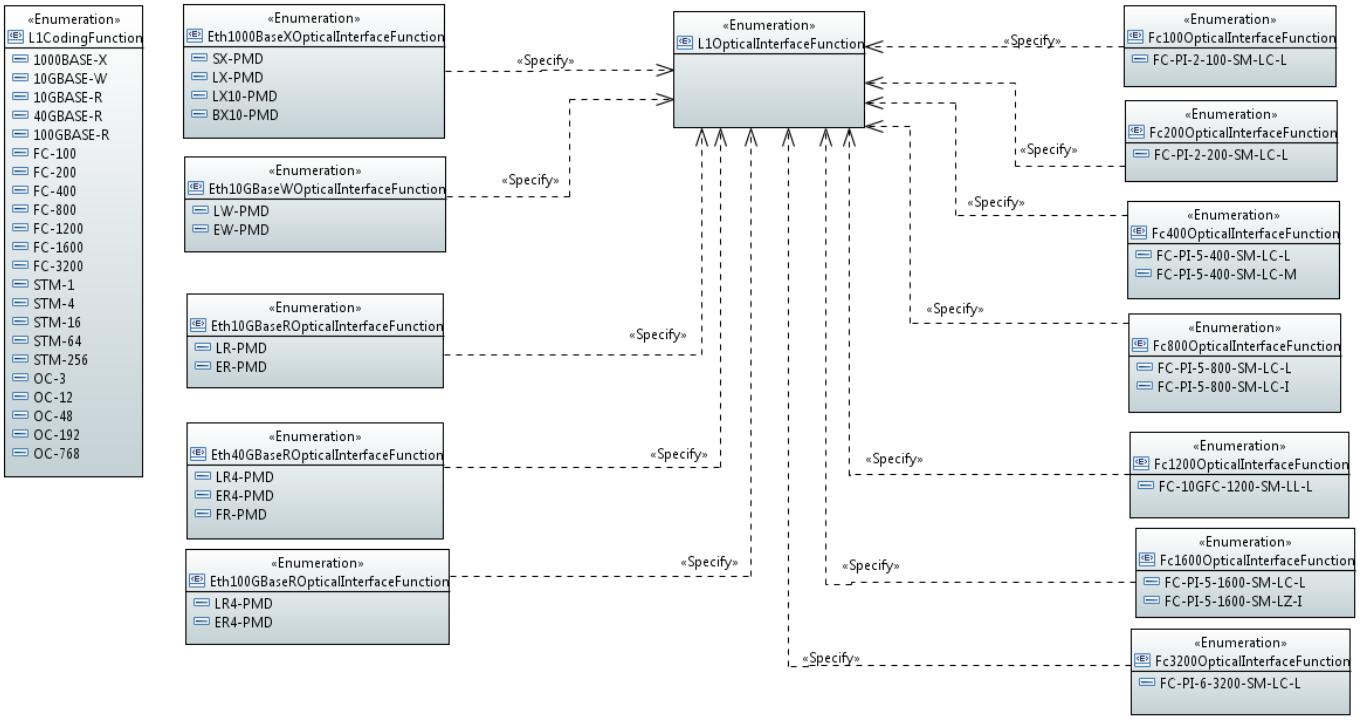

Figure 6 – *NRM_L1_ETH_FC* Diagram

8.4 SDH and SONET *coding* and *optical interface* functions

Figure 7 illustrates the NRM L1 IM *enumerations* representing MEF specific Layer 1 SDH and SONET *coding* and *optical interface* functions.

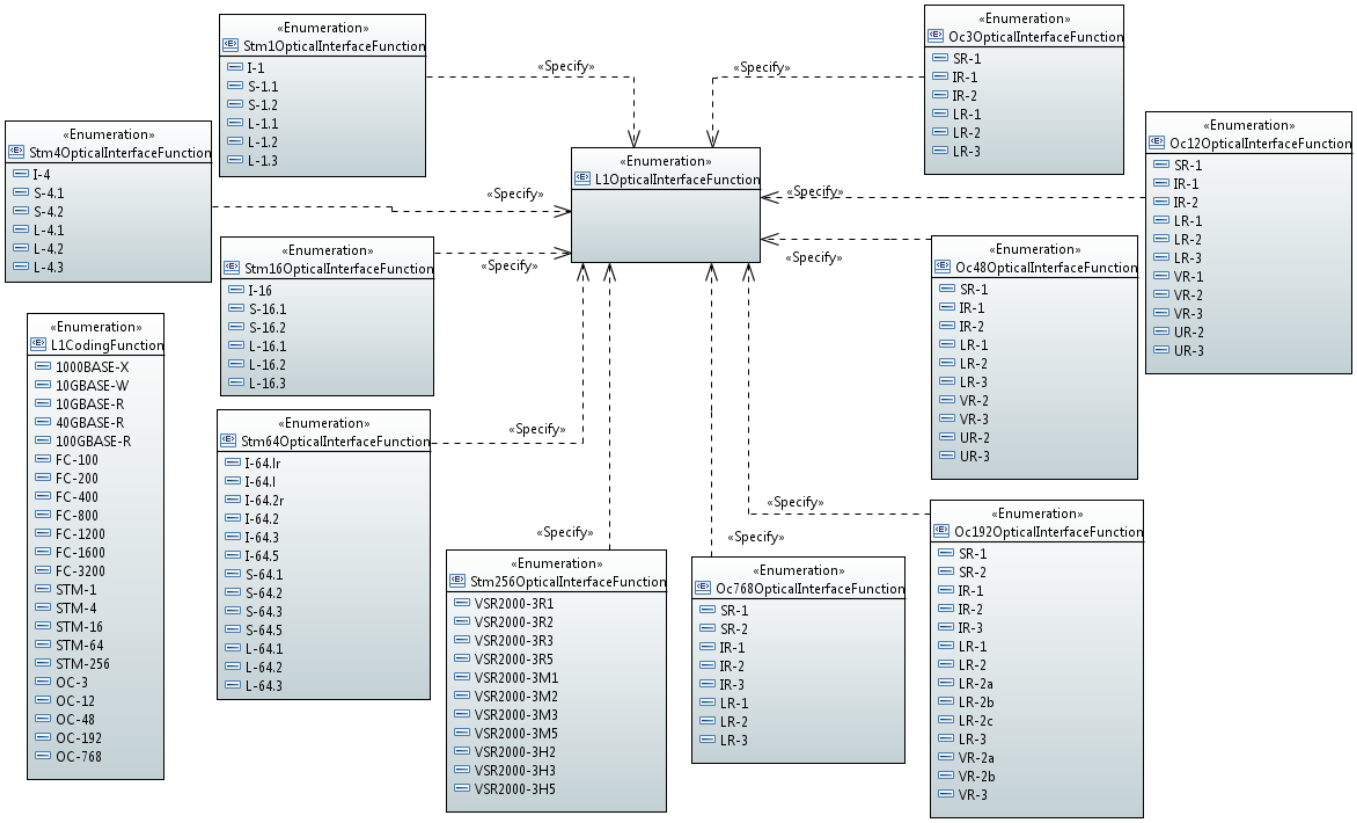

Figure 7 – *NRM_L1_SDH_SONET* Diagram

9 Network Resource Information Model Type Definitions

9.1 Data Types

The following data types are locally defined by NRM L1 IM, i.e. are not imported from any other model.

No data types defined

9.2 Enumerations

The following enumerations are locally defined by NRM OAM IM, i.e. are not imported from any other model.

9.2.1 L1CodingFunction

MEF 63 Coding Function <c>, functionality which encodes bits for transmission and the corresponding decode upon reception.

Contains Enumeration Literals:

- 1000BASE-X:
  - IEEE Std 802.3: PCS clause 36 coding function
- 10GBASE-W:
  - IEEE Std 802.3: PCS clause 49 and WIS clause 50 coding function (WAN PHY)
- 10GBASE-R:
  - IEEE Std 802.3: PCS clause 49 coding function (LAN PHY)
- 40GBASE-R:
  - IEEE Std 802.3: PCS clause 82 coding function
- 100GBASE-R:
  - IEEE Std 802.3: PCS clause 82 coding function
- FC-100:
  - ANSI INCITS 424-2007[R2012], February 2007: FC-FS-2 clause 5 FC-1 8B/10B coding function (1.0625 Gb/s)
- FC-200:
  - ANSI INCITS 424-2007[R2012], February 2007: FC-FS-2 clause 5 FC-1 8B/10B coding function (2.125 Gb/s)
- FC-400:
  - ANSI INCITS 424-2007[R2012], February 2007: FC-FS-2 clause 5 FC-1 8B/10B coding function (4.250 Gb/s)
- FC-800:
  - ANSI INCITS 424-2007[R2012], February 2007: FC-FS-2 clause 5 FC-1 8B/10B coding function (8.500 Gb/s)
- FC-1200:
  - MEF 63: ANSI INCITS 364-2003, November 2003: FC-10GFC clause 13 FC-1 coding function (10.51875 Gb/s)

- FC-1600:
  - ANSI INCITS 470-2011, December 2011: FC-FS-3 clause 5 FC-1 64B/66B coding function (14.025 Gb/s)
- FC-3200:
  - ANSI INCITS 488-2016, December 2016: FC-FS-4 clause 5 FC-1 64B/66B coding function plus 256B/257B transcoding and FEC encoding (28.05 Gb/s)
- STM-1:
  - ITU-T G.707/Y.1322 January 2007: framer, N=1
- STM-4:
  - ITU-T G.707/Y.1322 January 2007: framer, N=4
- STM-16:
  - ITU-T G.707/Y.1322 January 2007: framer, N=16
- STM-64:
  - ITU-T G.707/Y.1322 January 2007: framer, N=64
- STM-256:
  - ITU-T G.707/Y.1322 January 2007: framer, N=256
- OC-3:
  - Telcordia GR-253-CORE Issue 5, October 2009: framer, N=3
- OC-12:
  - Telcordia GR-253-CORE Issue 5, October 2009: framer, N=12
- OC-48:
  - Telcordia GR-253-CORE Issue 5, October 2009: framer, N=48
- OC-192:
  - Telcordia GR-253-CORE Issue 5, October 2009: framer, N=192
- OC-768:
  - Telcordia GR-253-CORE Issue 5, October 2009: framer, N=768

9.2.2 L1OpticalInterfaceFunction

MEF 63 Optical Interface Function <o>, functionality which converts encoded electrical bits into an optical signal(s) and the corresponding conversion into electrical format upon reception.

Contains Enumeration Literals:

9.2.3 Eth1000BaseXOpticalInterfaceFunction

MEF 63: IEEE Std 802.3: 1000BASE-X PCS clause 36 coding function

Contains Enumeration Literals:

- SX-PMD:
  - IEEE Std 802.3: clause 38
- LX-PMD:
  - IEEE Std 802.3: clause 38
- LX10-PMD:
  - IEEE Std 802.3: clause 59
- BX10-PMD:
  - IEEE Std 802.3: clause 59

9.2.4 Eth10GBaseWOpticalInterfaceFunction

MEF 63: IEEE Std 802.3: 10GBASE-W (WAN PHY) PCS clause 49 and WIS clause 50 coding function

Contains Enumeration Literals:

- LW-PMD:
  - IEEE Std 802.3: clause 52
- EW-PMD:
  - IEEE Std 802.3: clause 52

9.2.5 Eth10GBaseROpticalInterfaceFunction

MEF 63: IEEE Std 802.3: 10GBASE-R (LAN PHY) PCS clause 49 coding function

Contains Enumeration Literals:

- LR-PMD:
  - IEEE Std 802.3: clause 52
- ER-PMD:
  - IEEE Std 802.3: clause 52

9.2.6 Eth40GBaseROpticalInterfaceFunction

MEF 63: IEEE Std 802.3: 40GBASE-R PCS clause 82 coding function

Contains Enumeration Literals:

- LR4-PMD:
  - IEEE Std 802.3: clause 87
- ER4-PMD:
  - IEEE Std 802.3: clause 87
- FR-PMD:
  - IEEE Std 802.3: clause 89

9.2.7 Eth100GBaseROpticalInterfaceFunction

MEF 63: IEEE Std 802.3: 100GBASE-R PCS clause 82 coding function

Contains Enumeration Literals:

- LR4-PMD:
  - IEEE Std 802.3: clause 88
- ER4-PMD:
  - IEEE Std 802.3: clause 88

9.2.8 Fc100OpticalInterfaceFunction

MEF 63: ANSI INCITS 424-2007[R2012], February 2007: FC-100 FC-FS-2 clause 5 FC-1 8B/10B coding function (1.0625 Gb/s)

Contains Enumeration Literals:

- FC-PI-2-100-SM-LC-L:
  - MEF 63: ANSI INCITS 404-2006, August 2006: FC-PI-2 clause 6.3 FC-0 100-SM-LC-L

9.2.9 Fc200OpticalInterfaceFunction

MEF 63: ANSI INCITS 424-2007[R2012], February 2007: FC-200 FC-FS-2 clause 5 FC-1 8B/10B coding function (2.125 Gb/s)

Contains Enumeration Literals:

- FC-PI-2-200-SM-LC-L:
  - MEF 63: ANSI INCITS 404-2006, August 2006: FC-PI-2 clause 6.3 FC-0 200-SM-LC-L

9.2.10 Fc400OpticalInterfaceFunction

MEF 63: ANSI INCITS 424-2007[R2012], February 2007: FC-400 FC-FS-2 clause 5 FC-1 8B/10B coding function (4.250 Gb/s)

Contains Enumeration Literals:

- FC-PI-5-400-SM-LC-L:
  - MEF 63: ANSI INCITS 479-2011, November 2011: FC-PI-5 clause 6.3 FC-0: 400-SM-LC-L
- FC-PI-5-400-SM-LC-M:
  - MEF 63: ANSI INCITS 479-2011, November 2011: FC-PI-5 clause 6.3 FC-0: 400-SM-LC-M

9.2.11 Fc800OpticalInterfaceFunction

MEF 63: ANSI INCITS 424-2007[R2012], February 2007: FC-800 FC-FS-2 clause 5 FC-1 8B/10B coding function (8.500 Gb/s)

Contains Enumeration Literals:

- FC-PI-5-800-SM-LC-L:
  - MEF 63: ANSI INCITS 479-2011, November 2011: FC-PI-5 clause 6.3 FC-0: 800-SM-LC-L
- FC-PI-5-800-SM-LC-I:
  - MEF 63: ANSI INCITS 479-2011, November 2011: FC-PI-5 clause 6.3 FC-0: 800-SM-LC-I

9.2.12 Fc1200OpticalInterfaceFunction

MEF 63: ANSI INCITS 364-2003, November 2003: FC-1200 (10.51875 Gb/s) FC-10GFC clause 13 FC-1 coding function (10.51875 Gb/s)

Contains Enumeration Literals:

- FC-10GFC-1200-SM-LL-L:
  - MEF 63: ANSI INCITS 364-2003, November 2003: FC-10GFC clause 6.4 FC-0: 1200-SM-LL-L

9.2.13 Fc1600OpticalInterfaceFunction

MEF 63: ANSI INCITS 470-2011, December 2011: FC-FS-3 clause 5 FC-1 64B/66B coding function (14.025 Gb/s)

Contains Enumeration Literals:

- FC-PI-5-1600-SM-LC-L:
  - MEF 63: ANSI INCITS 479-2011, November 2011: FC-PI-5 clause 6.3 FC-0: 1600-SM-LC-L
- FC-PI-5-1600-SM-LZ-I:
  - MEF 63: ANSI INCITS 479-2011, November 2011: FC-PI-5 clause 6.3 FC-0: 1600-SM-LZ-I

9.2.14 Fc3200OpticalInterfaceFunction

MEF 63: ANSI INCITS 488-2016, December 2016: FC-FS-4 clause 5 FC-1 64B/66B coding function plus 256B/257B transcoding and FEC encoding (28.05 Gb/s)

Contains Enumeration Literals:

- FC-PI-6-3200-SM-LC-L:
  - MEF 63: ANSI INCITS 512-2015, January 2015: FC-PI-6 clause 5.3 FC-0: 3200-SM-LC-L

9.2.15 Oc3OpticalInterfaceFunction

Telcordia GR-253-CORE Issue 5, October 2009: framer, N=3

Contains Enumeration Literals:

- SR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-1
- IR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-1
- IR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-2
- LR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-1
- LR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2
- LR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-3

9.2.16 Oc12OpticalInterfaceFunction

Telcordia GR-253-CORE Issue 5, October 2009: framer, N=12

Contains Enumeration Literals:

- SR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-1
- IR-1:

  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-1
- IR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-2
- LR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-1
- LR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2
- LR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-3
- VR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-1
- VR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-2
- VR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-3
- UR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: UR-2
- UR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: UR-3

9.2.17 Oc48OpticalInterfaceFunction

Telcordia GR-253-CORE Issue 5, October 2009: framer, N=48

Contains Enumeration Literals:

- SR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-1
- IR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-1
- IR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-2
- LR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-1
- LR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2
- LR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-3
- VR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-2
- VR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-3
- UR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: UR-2
- UR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: UR-3

9.2.18 Oc192OpticalInterfaceFunction

Telcordia GR-253-CORE Issue 5, October 2009: framer, N=192

Contains Enumeration Literals:

- SR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-1
- SR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-2
- IR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-1
- IR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-2
- IR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-3
- LR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-1
- LR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2
- LR-2a:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2a
- LR-2b:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2b
- LR-2c:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2c
- LR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-3
- VR-2a:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-2a
- VR-2b:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-2b
- VR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: VR-3

9.2.19 Oc768OpticalInterfaceFunction

Telcordia GR-253-CORE Issue 5, October 2009: framer, N=768

Contains Enumeration Literals:

- SR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-1
- SR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: SR-2
- IR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-1
- IR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-2

- IR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: IR-3
- LR-1:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-1
- LR-2:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-2
- LR-3:
  - Telcordia GR-253-CORE, Issue 5, October 2009, clause 4.1: LR-3

9.2.20 Stm1OpticalInterfaceFunction

ITU-T G.707/Y.1322, January 2007: framer, N=1

Contains Enumeration Literals:

- I-1:
  - ITU-T G.957, March 2006: I-1
- S-1.1:
  - ITU-T G.957, March 2006: S-1.1
- S-1.2:
  - ITU-T G.957, March 2006: S-1.2
- L-1.1:
  - ITU-T G.957, March 2006: L-1.1
- L-1.2:
  - ITU-T G.957, March 2006: L-1.2
- L-1.3:
  - ITU-T G.957, March 2006: L-1.3

9.2.21 Stm4OpticalInterfaceFunction

ITU-T G.707/Y.1322, January 2007: framer, N=4

Contains Enumeration Literals:

- I-4:
  - ITU-T G.957, March 2006: I-4
- S-4.1:
  - ITU-T G.957, March 2006: S-4.1
- S-4.2:
  - ITU-T G.957, March 2006: S-4.2
- L-4.1:
  - ITU-T G.957, March 2006: L-4.1
- L-4.2:
  - ITU-T G.957, March 2006: L-4.2
- L-4.3:
  - ITU-T G.957, March 2006: L-4.3

9.2.22 Stm16OpticalInterfaceFunction

ITU-T G.707/Y.1322, January 2007: framer, N=16

Contains Enumeration Literals:

- I-16:
  - ITU-T G.957, March 2006: I-16
- S-16.1:
  - ITU-T G.957, March 2006: S-16.1
- S-16.2:
  - ITU-T G.957, March 2006: S-16.2
- L-16.1:
  - ITU-T G.957, March 2006: L-16.1
- L-16.2:
  - ITU-T G.957, March 2006: L-16.2
- L-16.3:
  - ITU-T G.957, March 2006: L-16.3

9.2.23 Stm64OpticalInterfaceFunction

ITU-T G.707/Y.1322, January 2007: framer, N=64

Contains Enumeration Literals:

- I-64.lr:
  - ITU-T G.957, March 2006: I-64.lr
- I-64.l:
  - ITU-T G.957, March 2006: I-64.l
- I-64.2r:
  - ITU-T G.957, March 2006: I-64.2r
- I-64.2:
  - ITU-T G.957, March 2006: I-64.2
- I-64.3:
  - ITU-T G.957, March 2006: I-64.3
- I-64.5:
  - ITU-T G.957, March 2006: I-64.5
- S-64.1:
  - ITU-T G.957, March 2006: S-64.1
- S-64.2:
  - ITU-T G.957, March 2006: S-64.2
- S-64.3:
  - ITU-T G.957, March 2006: S-64.3
- S-64.5:
  - ITU-T G.957, March 2006: S-64.5
- L-64.1:
  - ITU-T G.957, March 2006: L-64.1
- L-64.2:
  - ITU-T G.957, March 2006: L-64.2
- L-64.3:
  - ITU-T G.957, March 2006: L-64.3

9.2.24 Stm256OpticalInterfaceFunction

ITU-T G.707/Y.1322, January 2007: framer, N=256

Contains Enumeration Literals:

- VSR2000-3R1:
  - ITU-T G.693, November 2009: VSR2000-3R1
- VSR2000-3R2:
  - ITU-T G.693, November 2009: VSR2000-3R2
- VSR2000-3R3:
  - ITU-T G.693, November 2009: VSR2000-3R3
- VSR2000-3R5:
  - ITU-T G.693, November 2009: VSR2000-3R5
- VSR2000-3M1:
  - ITU-T G.693, November 2009: VSR2000-3M1
- VSR2000-3M2:
  - ITU-T G.693, November 2009: VSR2000-3M2
- VSR2000-3M3:
  - ITU-T G.693, November 2009: VSR2000-3M3
- VSR2000-3M5:
  - ITU-T G.693, November 2009: VSR2000-3M5
- VSR2000-3H2:
  - ITU-T G.693, November 2009: VSR2000-3H2
- VSR2000-3H3:
  - ITU-T G.693, November 2009: VSR2000-3H3
- VSR2000-3H5:
  - ITU-T G.693, November 2009: VSR2000-3H5

10 Imported Type Definitions

The list of data types imported from ONF TAPI Common model

10.1 DateAndTime

This primitive type defines the date and time according to the following structure: yyyyMMddhhmmss.s[Z|{+|-}HHMm] where: yyyy 0000..9999 year MM 01..12 month dd 01..31 day hh 00..23 hour mm 00..59 minute ss 00..59 second s .0...9 tenth of second (set to .0 if EMS or NE cannot support this granularity) Z Z indicates UTC (rather than local time) {+|-} + or - delta from UTC HH 00..23 time zone difference in hours Mm 00..59 time zone difference in minutes.

Attribute Name	Type	Mult.	Access	Stereotypes	Description
value	String	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY OpenInterfaceModelAttribute • AVC: NA	The specific value of the universal id

10.2 TimePeriod

Attribute Name	Type	Mult.	Access	Stereotypes	Description
value	Integer	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY OpenInterfaceModelAttribute • AVC: NA	
unit	TimeUnit	1	RW	OpenModelAttribute • isInvariant: false • valueRange: no range constraint • support: MANDATORY OpenInterfaceModelAttribute • AVC: NA	

11 References

[1] IETF RFC 2119, *Key words for use in RFCs to Indicate Requirement Levels*, March 1997

[2] IETF RFC 8174, *Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words*, May 2017

[3] MEF Technical Specification MEF 4, *Metro Ethernet Network Architecture Framework - Part 1: Generic Framework*, 2004

[4] MEF Technical Specification MEF 7.3, *Carrier Ethernet Services Management Information Model*, 2016

[5] MEF Service Operation Specification MEF 55, *Lifecycle Service Orchestration Reference Architecture and Framework*, 2016

[6] MEF Technical Specification MEF 59, *Network Resource Management - Information Model: Connectivity*

[7] MEF Specification MEF 60, *Network Resource Provisioning - Interface Profile Specification*

[8] MEF Specification MEF 63, *Subscriber Layer 1 Service Attributes – Technical Specification*

[9] MEF Info Model GitHub repository: **“**https://github.com/MEF-GIT/MEF-Common-Model”

[10] ITU-T G.7711/Y.1702 Generic protocol-neutral information model for transport resources, March 2018

[11] ONF TR-512 Core Information Model, Version 1.4, November 2018

[12] ONF TR-527 Functional Requirements for Transport API, June 10, 2016

[13] ONF Transport API (TAPI) Information Model, SDK 2.1 - “https://github.com/OpenNetworkingFoundation/TAPI”, October 2018

[14] Papyrus UML Tool - Version Neon “https://www.eclipse.org/papyrus/documentation.html” Copyright © 2015 The Eclipse Foundation. All Rights Reserved.

[15] TM Forum, Information Framework (SID), GB922, Release 17.0.0, June 2017.

[16] TM Forum MTNM 4.5, July 2015

[17] TM Forum MTOSI 4.0, July 2015

Appendix A Examples of Network Scenarios (Informative)

In the following are depicted some network scenarios.

1) UNI to UNI:

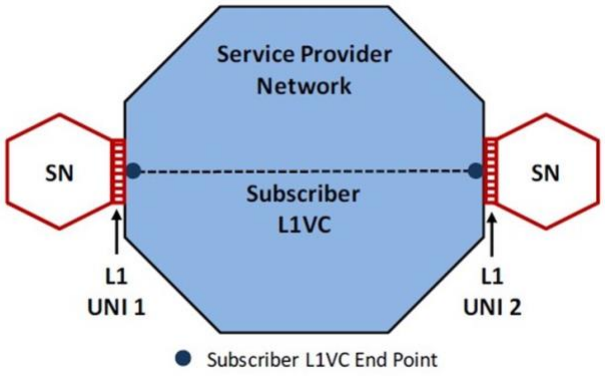

Figure 8 – Subscriber Layer 1 Virtual Connection (MEF 63)

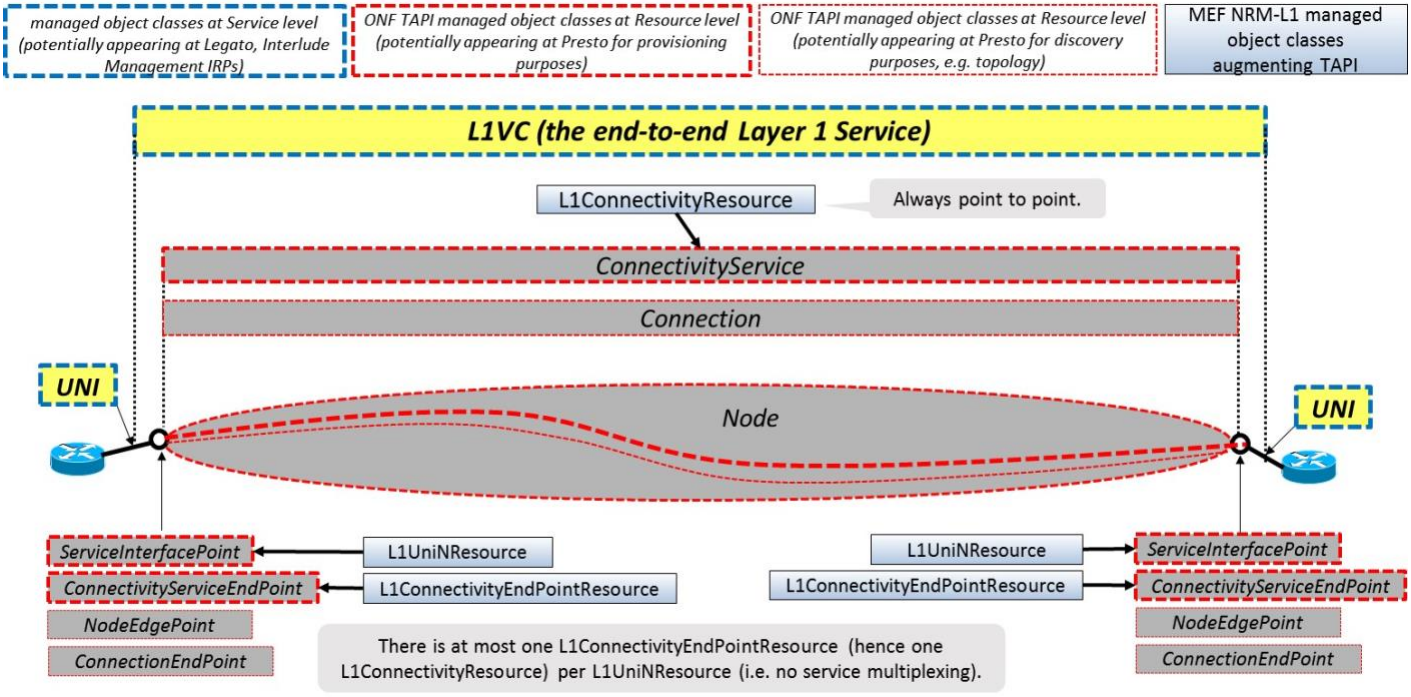

Figure 9 – Single Provider, single domain

2) UNI to INNI:

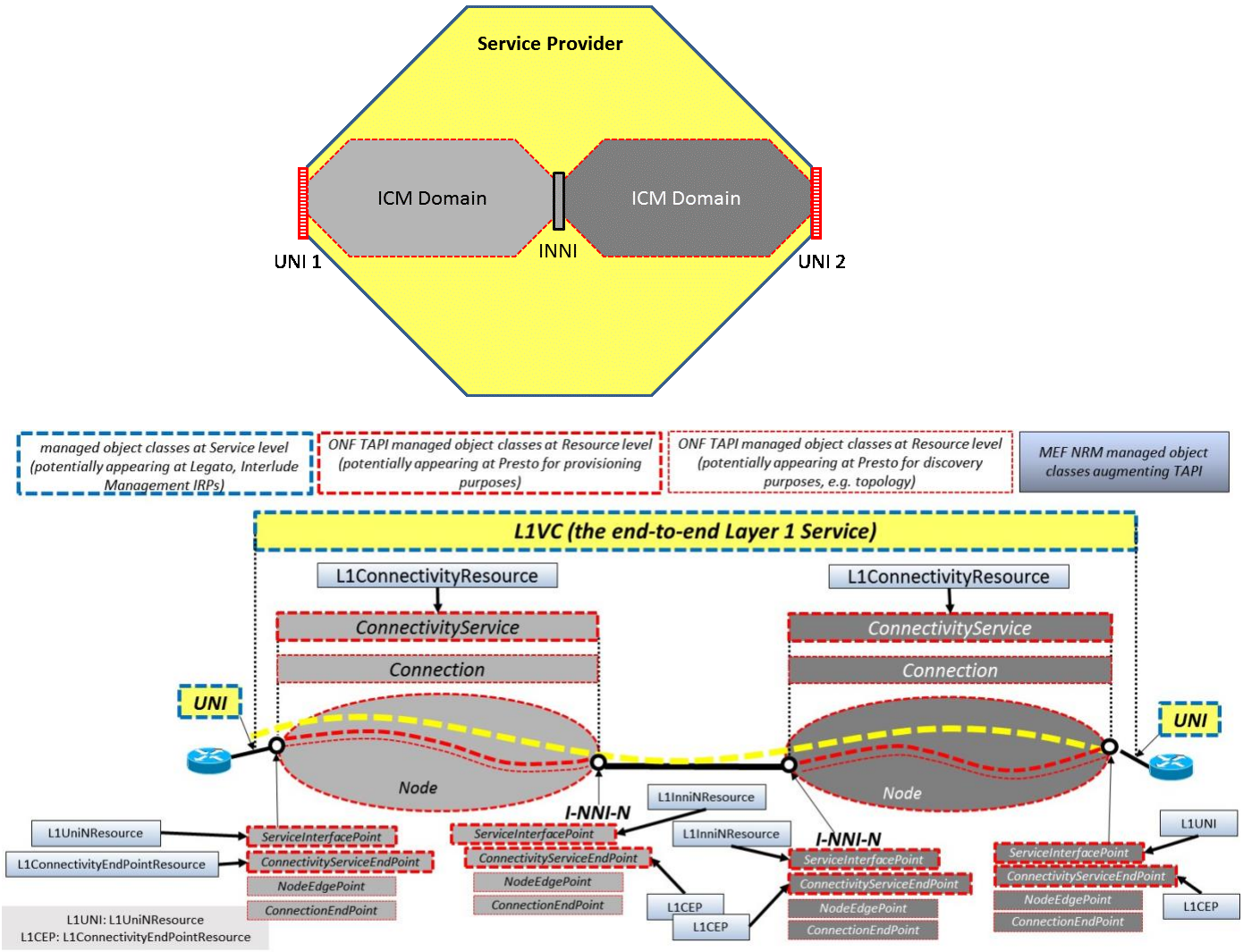

Figure 10 - Single Provider, separately managed domains