International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8112/Y.1371

(10/2020)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Packet over Transport aspects – MPLS over Transport aspects

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Recommendation ITU-T G.8112/Y.1371

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Recommendation ITU-T G.8112/Y.1371

Interfaces for the MPLS transport profile layer network

Summary

Recommendation ITU-T G.8112/Y.1371 specifies the interfaces for the multi-protocol label switching transport profile (MPLS-TP) layer network. The interfaces for the MPLS-TP layer network use various server layer networks, like the plesiochronous digital hierarchy (PDH), synchronous digital hierarchy (SDH), optical transport hierarchy (OTH) and the Ethernet media access control (MAC) layer network (ETH).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8112/Y.1371	2006-10-07	15	11.1002/1000/8783
1.1	ITU-T G.8112/Y.1371 (2006) Cor. 1	2007-01-09	15	11.1002/1000/9006
2.0	ITU-T G.8112/Y.1371	2012-10-29	15	11.1002/1000/11772
2.1	ITU-T G.8112/Y.1371 (2012) Amd. 1	2014-04-04	15	11.1002/1000/12187
2.2	ITU-T G.8112/Y.1371 (2012) Cor. 1	2015-01-13	15	11.1002/1000/12385
3.0	ITU-T G.8112/Y.1371	2015-08-13	15	11.1002/1000/12547
3.1	ITU-T G.8112/Y.1371 (2015) Amd. 1	2017-08-13	15	11.1002/1000/13315
4.0	ITU-T G.8112/Y.1371	2020-10-29	15	11.1002/1000/14541

Keywords

Interface, MPLS-TP, NNI.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Interfaces for the MPLS transport profile layer network

1 Scope

This Recommendation specifies the interfaces for the multi-protocol label switching transport profile (MPLS-TP) layer network, in particular the:

- encapsulation of MPLS-TP client signals into the MPLS-TP characteristic information (MPLS-TP _CI) that will be present on MPLS-TP network-to-network interface (NNI) links in the transport network;
- encapsulation of MPLS-TP_CI into the MPLS-TP link frames that will be present on MPLS-TP NNI links in the transport network;
- MPLS-TP layer network within the transport network and associated MPLS-TP multiplexing;
- MPLS-TP nested connection monitoring per layer network level within the transport network;
- MPLS-TP operation, administration and maintenance (OAM) associated with nested connection monitoring in the transport network;
- encapsulation of MPLS-TP control plane information.

The MPLS-TP network uses various server layer networks like optical transport hierarchy (OTH), synchronous digital hierarchy (SDH), plesiochronous digital hierarchy (PDH) and Ethernet media access control (MAC) layer network (ETH). The detailed requirements are specified in a number of ITU-T Recommendations, ANSI Standards, IEEE Standards and IETF RFCs, which are cited.

This Recommendation specifies point-to-point label-switched paths (LSPs).

This Recommendation does not cover inter-operator control plane aspects of the MPLS-TP NNI.

This Recommendation provides a representation of the MPLS-TP technology using the methodologies that have been used for other transport technologies (e.g., SDH, optical transport network (OTN) and Ethernet).[1]

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.704] Recommendation ITU-T G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels*.

[ITU-T G.705] Recommendation ITU-T G.705 (2000), *Characteristics of plesiochronous digital hierarchy (PDH) equipment functional blocks*.

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[1] This Recommendation is intended to be aligned with the IETF MPLS RFCs normatively referenced by this Recommendation.

[ITU-T G.707] Recommendation ITU-T G.707/Y.1322 (2007), *Network node interface for the synchronous digital hierarchy (SDH)*.

[ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2020), *Interfaces for the optical transport network*.

[ITU-T G.832] Recommendation ITU-T G.832 (1998), *Transport of SDH elements on PDH networks – Frame and multiplexing structures*.

[ITU-T G.951] Recommendation ITU-T G.951 (1988), *Digital line systems based on the 1544 kbit/s hierarchy on symmetric pair cables*.

[ITU-T G.7041] Recommendation ITU-T G.7041/Y.1303 (2016), *Generic framing procedure*.

[ITU-T G.7043] Recommendation ITU-T G.7043/Y.1343 (2004), *Virtual concatenation of plesiochronous digital hierarchy (PDH) signals*.

[ITU-T G.7712] Recommendation ITU-T G.7712/Y.1703 (2019), *Architecture and specification of data communication network*.

[ITU-T G.8011] Recommendation G.8011/Y.1307 (2020), *Ethernet service characteristics*.

[ITU-T G.8012] Recommendation G.8012/Y.1308 (2004), *Ethernet UNI and Ethernet NNI*.

[ITU-T G.8040] Recommendation ITU-T G.8040/Y.1340 (2005), *GFP frame mapping into plesiochronous digital hierarchy (PDH)*.

[ITU-T G.8110.1] Recommendation ITU-T G.8110.1/Y.1370.1 (2011), *Architecture of the multi-protocol label switching transport profile layer network*.

[ITU-T G.8151] Recommendation ITU-T G.8151/Y.1374 (2020), *Management aspects of the MPLS-TP network element*.

[ITU-T Y.1415] Recommendation ITU-T Y.1415 (2005), *Ethernet-MPLS network interworking – User plane interworking*.

[ITU-Y Y.1711] Recommendation ITU-T Y.1711 (2004), *Operation & maintenance mechanism for MPLS networks*.

[ANSI T1.107] ANSI T1.107[2]-2002, *Digital hierarchy – Formats specifications*.

[IEEE 802.3] IEEE 802.3-2018, *IEEE Standard for Ethernet*.

[IETF RFC 3031] IETF RFC 3031 (2001), *Multiprotocol label switching architecture*.

[IETF RFC 3032] IETF RFC 3032 (2001), *MPLS label stack encoding*.

[IETF RFC 5586] IETF RFC 5586 (2009), *MPLS generic associated channel*.

[IETF RFC 5921] IETF RFC 5921 (2010), *A framework for MPLS in transport networks*.

[IETF RFC 5960] IETF RFC 5960 (2010), *MPLS transport profile data plane architecture*.

[IETF RFC 6215] IETF RFC 6215 (2011), *MPLS transport profile user-to-network and network-to-network interfaces*.

[IETF RFC 7213] IETF RFC 7213 (2014), *MPLS transport profile (MPLS-TP) next-hop Ethernet addressing*.

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[2] T1 standards have been maintained by the Alliance for Telecommunications Industry Solutions (ATIS) since November 2003.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 customer edge: [IETF RFC 5921]

3.1.2 MPLS-TP provider edge LSR (**MPLS-TP PE)**: See clauses 1.3.5 and 1.3.5.2 of [IETF RFC 5921].

3.1.3 network-to-network interface (NNI): [ITU-T G.8011]

3.1.4 user-to-network interface (UNI): [ITU-T G.8011]

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 inter-domain interface (IrDI): A physical interface that represents the boundary between the administrative domains of different network operators.

3.2.2 intra-domain interface (IaDI): A physical interface within the domain of a single network operator.

3.2.3 MPLS-TP characteristic information (MPLS-TP_CI) traffic unit: An instance of characteristic information and a unit of usage, which consists of an MPLS-TP_AI traffic unit or of an MPLS-TP operation, administration and maintenance (OAM) traffic unit, extended with an MPLS-TP_CI header containing the time-to-live (TTL) field of the MPLS shim header.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACH	Associated Channel Header
AI	Adapted Information
ATM	Asynchronous Transfer Mode
CE	Customer Edge
cHEC	core Header Error Check
CI	Characteristic Information
CII	Common Interworking Indicator
CLNS	Connectionless Network layer Service
CRC	Cyclic Redundancy Check
CW	Control Word
DA	Destination Address
DCN	Data Communication Network
ETH	Ethernet MAC layer network
ETY	Ethernet PHY layer
EXI	Extension header Identifier
FCS	Frame Check Sequence
FR	Full Reference

G-ACh	Generic Associated Channel
GAL	G-ACh Label
GFP	Generic Framing Procedure
GFP-F	Generic Framing Procedure – Frame mapped
HDLC	High-level Data Link Control
IaDI	Intra-Domain Interface
IP	Internet Protocol
IPG	Interpacket Gap
IrDI	Inter-Domain Interface
IS	Intermediate Service
LSB	Least Significant Bit
LSP	Label-Switched Path
LSR	Label Switching Router
MAC	Media Access Control
MoE	MPLS-TP over ETH
MoO	MPLS-TP over OTH
MoP	MPLS-TP over PDH
MoS	MPLS-TP over SDH
MPLS	Multi-Protocol Label Switching
MSB	Most Significant Bit
MT	MPLS Transport profile
MPLS-TP	MPLS Transport Profile
MPLS-TPP	MPLS-TP Path
MPLS-TPT	MPLS-TP Tandem connection monitoring
MSDU	MAC Service Data Unit
MUG	MPLS-TP Unit Group
NNI	Network-to-Network Interface
OAM	Operation, Administration and Maintenance
ODU	Optical channel Data Unit
ODUj	Optical channel Data Unit-order j
ODUk	Optical channel Data Unit-order k
OSI	Open Systems Interconnection
OSINL	Open Systems Interconnection Network Layer
OTH	Optical Transport Hierarchy
OTN	Optical Transport Network
PA	Preamble
PPP	Point-to-Point Protocol

P11s	1 544 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.704]
P12s	2 048 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.704]
P31e	34 368 kbit/s PDH path layer according to [ITU-T G.705]
P31s	34 368 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.832]
P32e	44 736 kbit/s PDH path layer according to [ITU-T G.705]
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
PE	Provider Edge
PFI	Payload Frame check sequence Indicator
PLI	Payload Length Indicator
PTI	Payload Type Identifier
PW	Pseudowire
SA	Source Address
SCC	Signalling Communication Channel
SCN	Signalling Communication Network
SDH	Synchronous Digital Hierarchy
SFD	Start of Frame Delimiter
SPME	Sub-Path Maintenance Element
Srv	Server
TC	Traffic Class
tHEC	type Header Error Check
TLV	Time, Length and Value
TTL	Time To Live
UNI	User-to-Network Interface
UNI-C	User-to-Network Interface, Client side
UNI-N	User-to-Network Interface, Network side
UPI	User Payload Identifier
VC	Virtual Container
VC-m	lower order VC – order m
VC-n	higher order VC-order n
VC-n-Xc	contiguous concatenated VC – order n
VC-n-Xv	virtual concatenated VC-order n
VLAN	Virtual Local Area Network

5 Conventions

None.

6 MPLS transport profile layer network interface structure

The MPLS-TP layer network as specified in [ITU-T G.8110.1] implies two interface classes:

- MPLS-TP layer network interface as specified in [IETF RFC 5921] and [IETF RFC 6215];
- client layer network interface as specified in [IETF RFC 5921] and [IETF RFC 6215].

The MPLS-TP layer interface can be deployed as a network-to-network interface (NNI) and within the transport network.

As described in [IETF RFC 5921], the MPLS-TP layer network consists of the transport service layer and the transport path layer.

The MPLS-TP NNI provides the interface between two MPLS-TP PEs and could be used for the support of client layer connection services, i.e., the transport service layer and the connection within transport, i.e., transport path layer.

The user-to-network interface (UNI) provides the interface for client services that are carried by MPLS-TP layers. UNIs are used for such a service. The location of the UNI and NNI is illustrated in Figure 6-1.

UNI functions are located at the customer edge (CE) and provider edge (PE). The user-to-network interface, client side (UNI-C) is located and terminated at the CE and the user-to-network interface, network side (UNI-N) is located and terminated at the PE. The functions for UNI-C and UNI-N are described in [IETF RFC 5921] and [IETF RFC 6215].

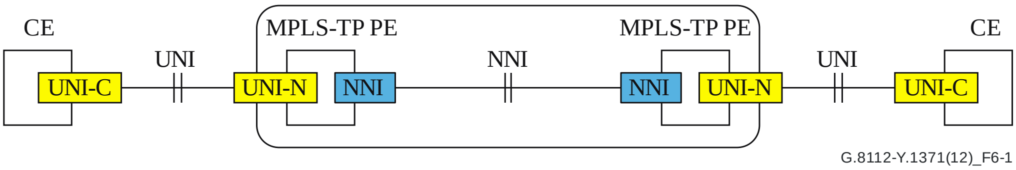

Figure 6-1 – Locations of UNI and MPLS-TP NNI

The MPLS-TP-NNI may be deployed as an intra-domain interface (IaDI) within a single administrative domain and as an inter-domain interface (IrDI) between two administrative domains as illustrated in Figure 6-2.

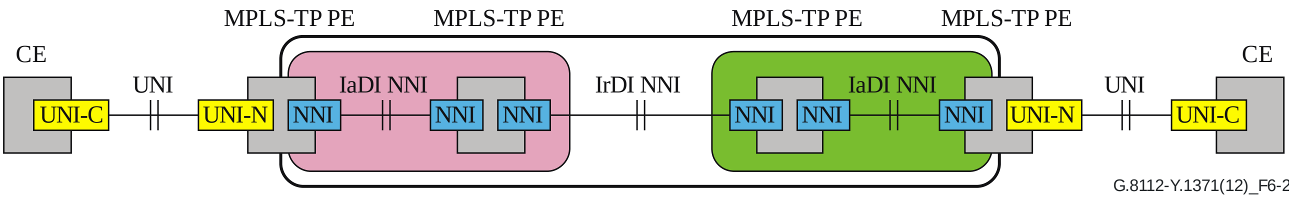

Figure 6-2 – Locations of client-UNI and MPLS-TP NNI

UNI and MPLS-TP NNI can encompass multiple layer networks. Appendix I describes an example of the Ethernet as the client service.

The MPLS-TP NNI can be used to carry informational elements of three planes (Figure 6-3):

– data (or user) plane, optionally including a data communication network (DCN) supporting management plane and control plane communications;

– control plane (e.g., signalling and routing);
– management plane.

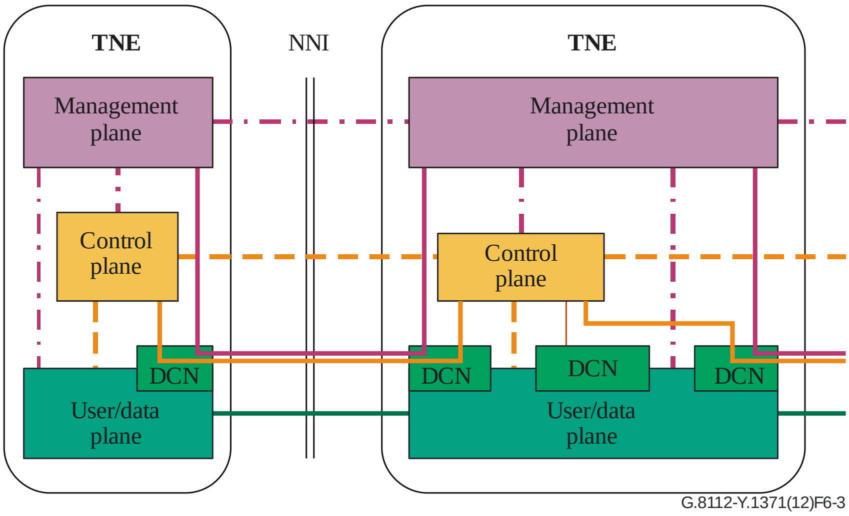

Figure 6-3 – Three planes of MPLS-TP NNI

Each NNI is divided into three plane-specific NNIs:

– NNI_D for the data plane informational elements, including OAM, which is terminated in the layer's termination, adaptation and connection/flow forwarding functions;
– NNI_C for the control plane informational elements;
– NNI_M for the management plane informational elements.

This Recommendation specifies NNI_D and NNI_C as defined in [IETF RFC 6215]. In [IETF RFC 6215], NNI_D and NNI_C are represented as NNI (network-to-network interface) functions. An NNI function is defined at the interface of an MPLS-TE PE node as described in Figure 2 of [IETF RFC 6215].

NNI_C and NNI_M realized via the DCN interface are described in [ITU-T G.7712] and [ITU-T G.8151], respectively.

6.1 NNI basic signal structure

The basic structure is shown in Figure 6-4. The relationship between clients and MPLS-TP is described in [IETF RFC 5921] and the example of the clients for pseudowire (PW) is described in [IETF RFC 5960]. Note that this Recommendation only describes Ethernet as a client.

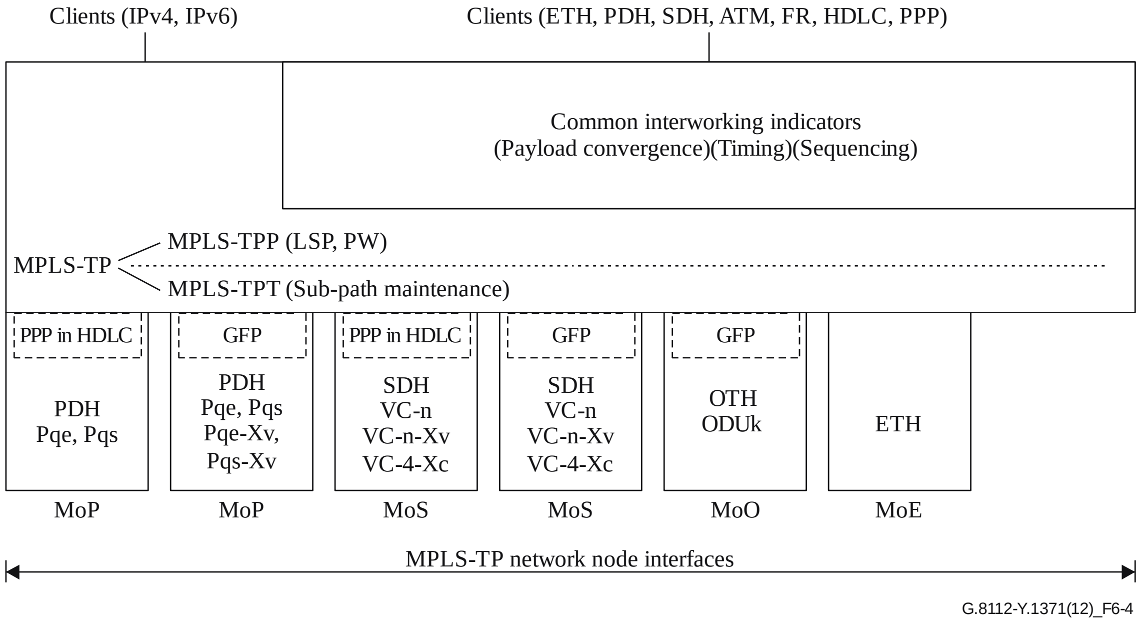

Figure 6-4 – Structure of the MPLS-TP network-to-node interfaces

6.1.1 MPLS-TP substructure

The MPLS-TP layer as described in [ITU-T G.8110.1] is further structured in sublayers in order to support the tunnelling (aggregation of lower level MPLS characteristic information MPLS_CI), network management and supervision functionalities defined in [ITU-T G.8110.1]:

– tunnelling;

– end-to-end MPLS-TP path (MPLS-TPP) supervision;

– MPLS-TP tandem connection monitoring (MPLS-TPT);

– optional adaptation of client signals via control word (CW), also known as common interworking indicator (CII), headers.

As described in [ITU-T G.8110.1], a tunnel is associated with one or more LSPs. The tunnel is one of the primary constructs that is identified and it is used to identify the LSPs that are associated with it.

6.1.2 MPLS-TP transport network structure

As described in [IETF RFC 5960], the MPLS-TP network has no awareness of the internals of the server layer of which it is a client; it requires only that the server layer be capable of delivering the type of service required by the MPLS-TP transport entities that make use of it.

As described in [ITU-T G.8110.1], MPLS-TP may also be used to add a connection-oriented packet transport capability to an existing transport network, regardless of whether it is a circuit switched or packet switched transport network.

The MPLS-TP transport network interface consists of the multiple layers, of which only the first one is illustrated in Figure 6-4. The next layers lie outside the scope of this Recommendation; the reader is referred to the appropriate technology Recommendations (e.g., [ITU-T G.707] for SDH).

There are a number of such MPLS-TP interfaces specified in this Recommendation as depicted in Figure 6-4:

• MPLS-TP over ETH (MoE);

• MPLS-TP over SDH (MoS);

• MPLS-TP over OTH (MoO);

• MPLS-TP over PDH (MoP).

In the case of circuit-switched transport, the payload bandwidths available are shown in Table 6-1for PDH, in clauses 6 and 11 of [ITU-T G.707] for SDH and in clause 7 of [ITU-T G.709] for OTH.

Table 6-1 – Bandwidth of the payload of PDH path signals

PDH type	PDH payload (kbit/s)	In steps of (kbit/s)
P11s	1 536 – (64/24) ≈ 1 533	
P12s	1 980	
P31s	33 856	
P32e	(4 696/4 760) × 44 736 ≈ 44 134	
P11s-Xv, X = 1 to 16	~1 533 to ~24 528	~1 533
P12s-Xv, X = 1 to 16	1 980 to 31 680	1 980
P31s-Xv, X = 1 to 8	33 856 to 270 848	33 856
P32e-Xv, X = 1 to 8	~44 134 to ~353 072	~44 134

6.2 Information structure for the MPLS-TP network node interfaces

The information structure for the MPLS-TP network node interfaces is represented by information containment relationships and flows. The principal information containment relationships are described in Figure 6-5.

6.2.1 MPLS-TP principal information containment relationships

As specified in [b-ITU-T G.8110.1], the MPLS-TP characteristic information (MPLS-TP_CI) consists of a stream of MPLS-TP_CI traffic units and OAM units. MPLS-TP_CI traffic units consist of an MPLS-TP adapted information (MPLS-TP_AI) traffic unit extended with an MPLS-TP_CI header containing the time-to-live (TTL) field of the MPLS-TP shim header (see clause 6.4). The MPLS-TP_AI traffic unit consists of an MPLS-TP_AI header containing the S field of the MPLS-TP shim header and an MPLS-TP payload field. The MPLS-TP payload field carries adapted client information or a label stack entry. A client signal of the MPLS-TP layer network is mapped into the MPLS-TP payload field via one of two different encapsulations (see Figure 6-5 and Table 6-2):

– direct encapsulation (IPv4, IPv6);

– CW-based encapsulation (ETH).

MPLS-TP OAM signal and encapsulation is described in clause 6.2.1.1.

An example of an information flow relationship is shown in Figure 6-6.

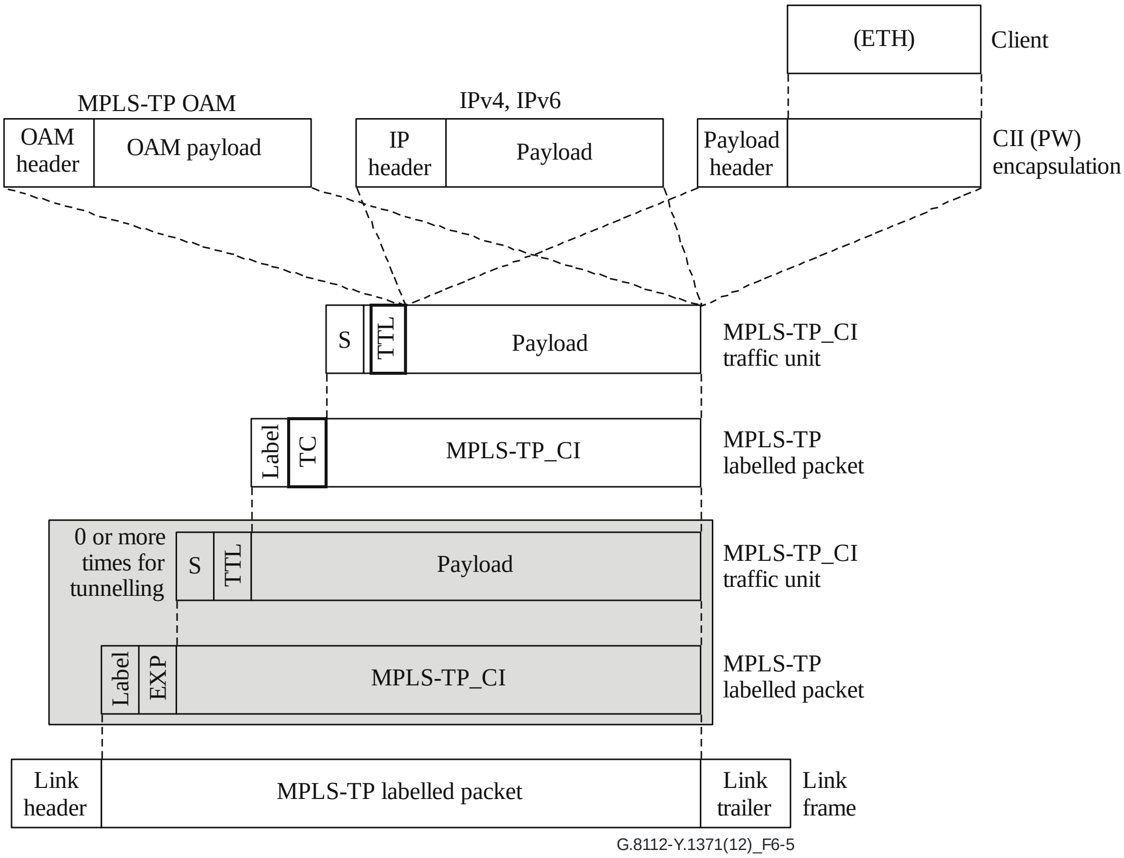

Figure 6-5 – MPLS-TP principal information containment relationships

Table 6-2 – Overview of encapsulated units

Encapsulation type	Reference
Internet protocol (IP) client encapsulation	(IPv4), clauses 2 and 3 of [IETF RFC 3032] (IPv6), clauses 2 and 3 of [IETF RFC 3032]
ETH client encapsulation	[ITU-T G.8110.1]
OAM encapsulation	[IETF RFC 5586] and [ITU-T G.8110.1]

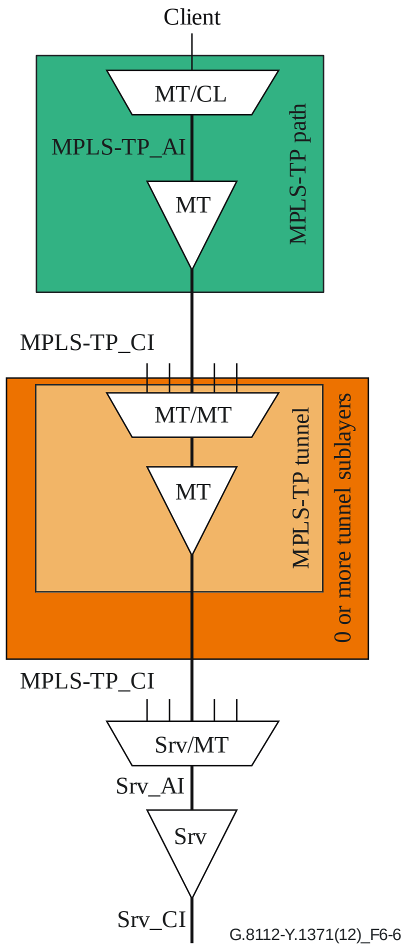

Figure 6-6 – Example of information flow relationship
Srv: server

6.2.1.1 MPLS-TP OAM

Figure 6-7 illustrates the generic format for MPLS-TP OAM.

The MPLS-TP OAM header consists of an MPLS-TP generic associated channel label (GAL) as specified in [IETF RFC 5586]. The MPLS-TP OAM payload consists of a generic associated channel (G-ACh) header, the associated channel header time, length and value (ACH TLV; optional), and G-ACh message. MPLS-TP OAM packets are distinguished from user data packets using the OAM header. Specific formats for MPLS-TP OAM lie outside the scope of this Recommendation.

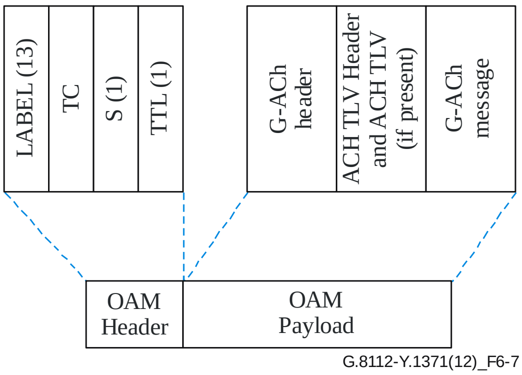

Figure 6-7 – Generic format for MPLS-TP OAM

6.2.1.2 Payload headers

6.2.1.2.1 ETH payload header

The mapping ETH payload header is described in clause 7.1 of [ITU-T G.8110.1].

6.2.2 MPLS-TP link frames

6.2.2.1 ETH link frame

The MPLS-TP_CI traffic unit (see [ITU-T G.8110.1]) is extended with a 3-bit traffic class (TC) field, a 20-bit label to complete the shim header. The resulting MPLS-TP labelled packet is then mapped as specified in [IETF RFC 3032], clauses 5 and 6.1 of [ITU-T G.8012] into the ETH payload information field using type encapsulation.

With the type encapsulation, the MAC destination address (DA), MAC source address (SA) and type fields are prepended. The MAC DA can be the MAC address of the MPLS-TP interface of the next hop or the broadcast MAC address (see [IETF RFC 7213]). The MAC SA is the MAC address of the sending interface. The type has value 0x8847. The frame check sequence (FCS) field specified in section 3 of [IEEE 802.3] with a 32-bit cyclic redundancy check (CRC) is appended. See Figure 6-8.

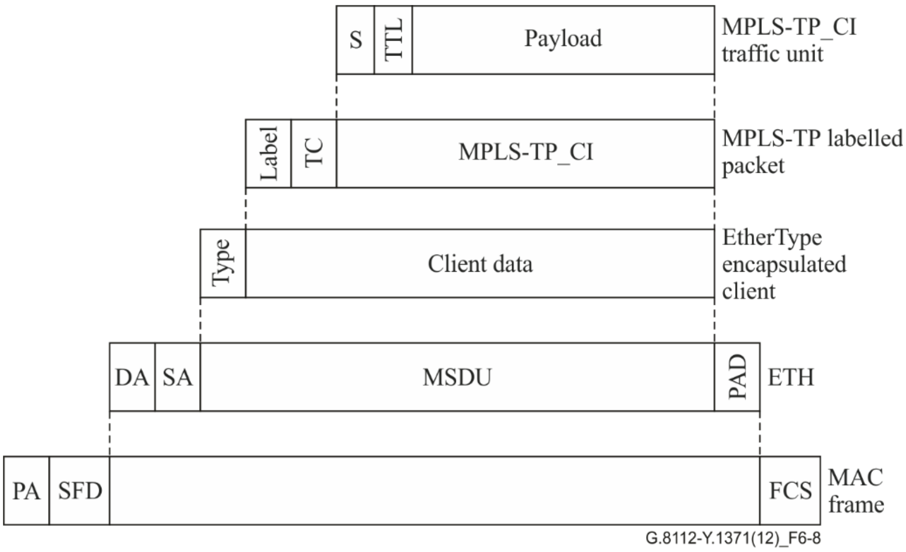

Figure 6-8 – Type encapsulation ETH link frame

6.2.2.2 GFP-F link frame

The MPLS-TP_CI traffic unit (see [ITU-T G.8110.1]) is extended with a 3-bit TC field, a 20-bit label to complete the shim header. The resulting MPLS-TP labelled packet is then mapped as specified in clause 7.6 of [ITU-T G.7041] in the generic framing procedure (GFP) payload information field. A core header with payload length indicator (PLI) and core header error check (cHEC) fields and a payload header field with payload type identifier (PTI), payload frame check sequence indicator (PFI), extension header identifier (EXI), user payload identifier (UPI) and type header error check (tHEC) subfields are prepended. The PTI subfield has value 000, the PFI subfield has value 1, the EXI subfield has value 0000 and the UPI subfield has value 0x0D. A payload FCS field with a 32-bit CRC is appended. See Figure 6-9. The maximum size of the GFP payload information field is specified in clause 6.1.2 of [ITU-T G.7041].

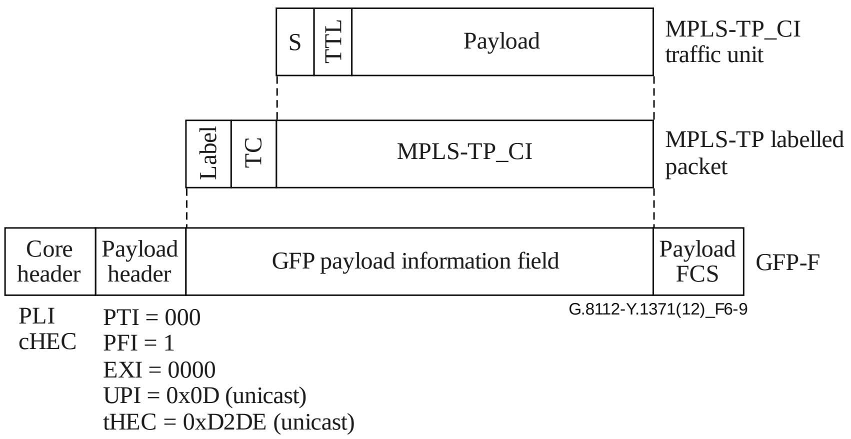

Figure 6-9 – GFP-F link frame

Figure 6-10 illustrates the mapping of the bits in the MPLS-TP labelled packet into the GFP payload information field within the generic framing procedure – frame-mapped (GFP-F) frame.

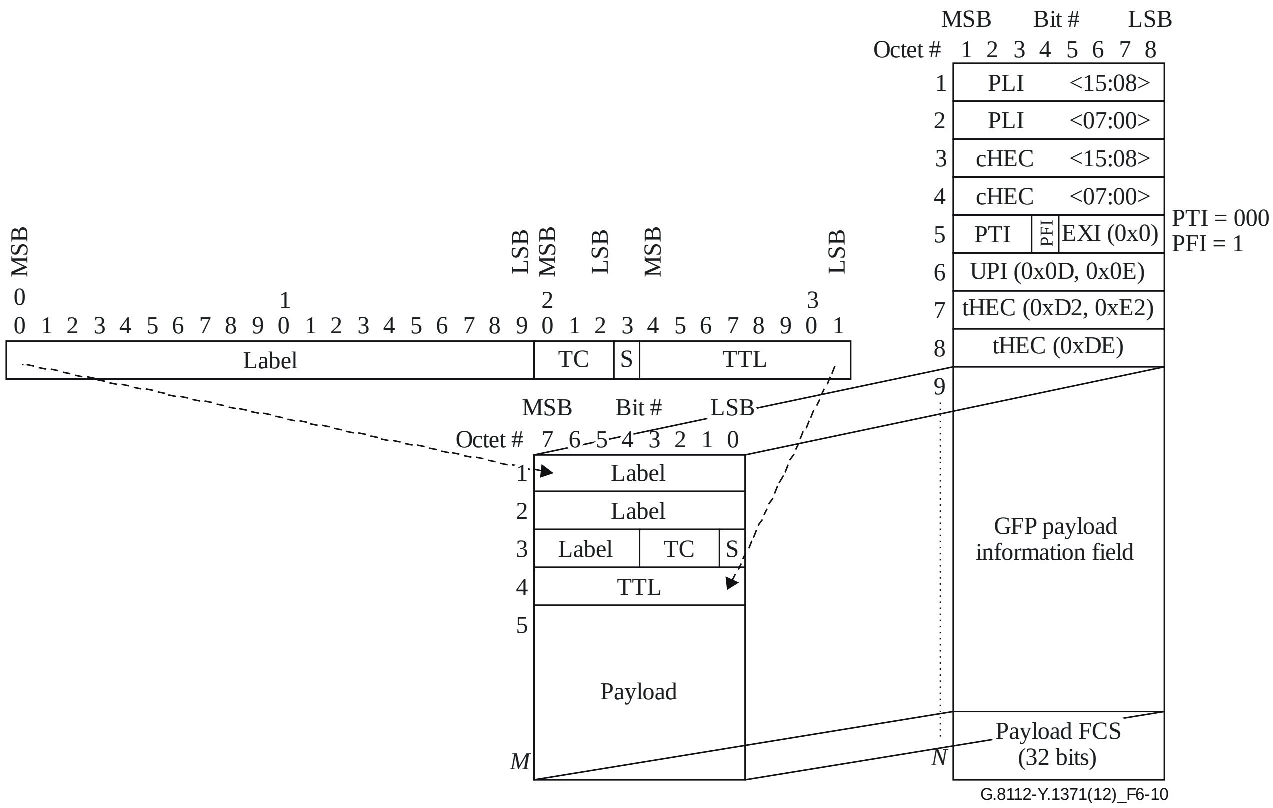

Figure 6-10 – Mapping MPLS-TP labelled packet into GFP-F link frame

6.2.3 MPLS-TP control frames

MPLS-TP control plane communication (NNI_C) for signalling and routing purposes is used for signalling communication network (SCN) links.

Four alternatives for SCN links are specified in [ITU-T G.7712]:

- SCN link sharing a server layer trail with MPLS-TP user traffic;
- SCN link utilizing the MPLS-TP signalling communication channel (SCC);
- SCN link utilizing a dedicated MPLS-TP LSP;
- Separate and independent SCN link.

When an SCN link shares a server layer trail, MPLS-TP control frames are encapsulated either in IPv4 or in IPv6 or in open systems interconnection (OSI) network layer packets and sent natively on the MPLS-TP NNI. See Figure 6-11.

NOTE – The encapsulation of the MPLS-TP control frames into IPv4, IPv6 or OSI network layer (OSINL) packets lies outside the scope of this Recommendation.

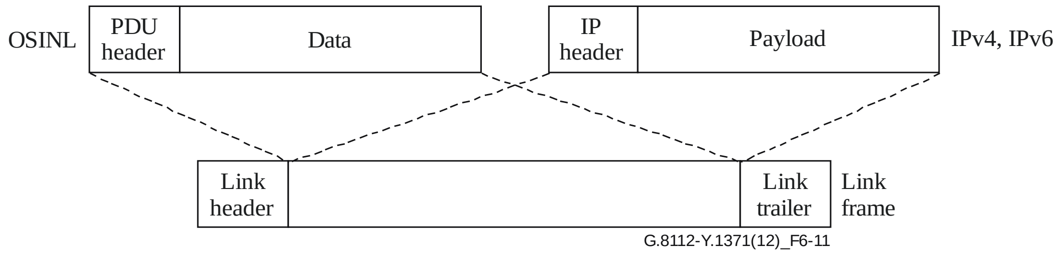

Figure 6-11 – MPLS-TP control frame over shared trail SCN links

Additional control frames can be required by the specific encapsulation method used for sending MPLS-TP link frames.

MPLS-TP control frames are distinguished from MPLS-TP data frames because they are not MPLS-TP link frames: the multiplexing of MPLS-TP and non-MPLS-TP link frames is required on all the MPLS-TP NNIs.

The encapsulation method used for MPLS-TP control frames is the same as that used for MPLS-TP link frames.

6.2.3.1 GFP-F link frame

The signalling and routing message is encapsulated into either IPv4 or IPv6 or OSI connectionless network layer service (CLNS) (intermediate service-intermediate service; IS-IS) packet as described in [ITU-T G.7712].

When the MPLS-TP NNI uses the GFP-F encapsulation, there are no other control protocols defined.

Control packets are encapsulated as specified in the standard references of Table 6-5 in the GFP payload information field. A core header with PLI and cHEC fields and a payload header field with PTI, PFI, EXI, UPI and tHEC subfields are prepended. The PTI subfield has value 000, the PFI subfield has value 1, the EXI subfield has value 0000 and the UPI subfield has the values defined in Table 6-3. A payload FCS field with a 32-bit CRC is appended.

Table 6-3 – Overview of GFP-F encapsulated control packets

Encapsulation type	Reference	UPI value
IP control packets	(IPv4) clause 7.7 of [ITU-T G.7041]	0x10
	(IPv6) clause 7.7 of [ITU-T G.7041]	0x11
OSI network layer control packets	(OSINL) clause 7.7 of [ITU-T G.7041]	0x0F

6.2.4 MPLS-TP NNI

The MPLS-TP NNI is supported by the interfaces listed in clauses 6.2.4.1 to 6.2.4.4.

6.2.4.1 MoE NNI

The MoE NNI deploys the type encapsulation-based ETH link frame as specified in clause 6.2.2.1.

6.2.4.2 MoS NNI

The MoS NNI deploys the GFP-F link frame as specified in clause 6.2.2.2. The mapping of the GFP-F link frames into VC-11/VC-11-Xv, VC-12/VC-12-Xv, VC-3/VC-3-Xv and VC-4/VC-4-Xv) and a virtual concatenated virtual container-order 4 (VC-4-Xc) is specified in clause 10.6 of [ITU-T G.707].

Path overhead and virtual concatenation of the virtual containers (VCs) is specified in [ITU-T G.707].

The components of the MoS NNI using the default encapsulation are illustrated in Figure 6-12.

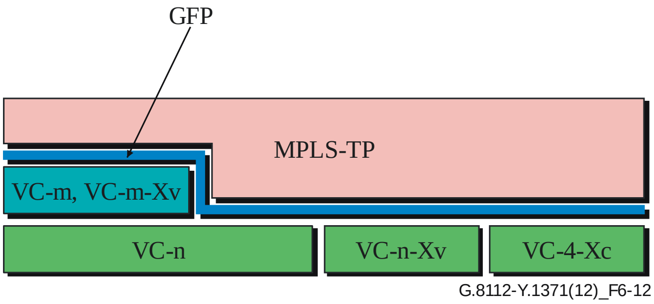

Figure 6-12 – Components of the MoS NNI using GFP-F encapsulation

6.2.4.3 MoO NNI

The MoO NNI deploys the GFP-F link frame as specified in clause 6.2.2.2 and its components are illustrated in Figure 6-13. The mapping of the GFP-F link frame into optical channel data unit-order j/optical channel data unit-order k (ODUj/ODUk) is specified in clause 17.4 of [ITU-T G.709].

Path overhead of the optical channel data units (ODUs) is specified in [ITU-T G.709].

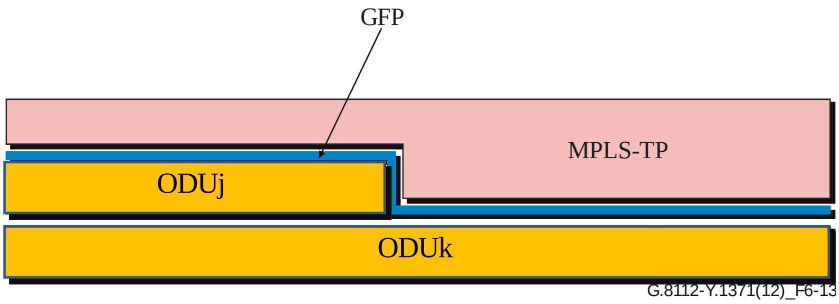

Figure 6-13 – Components of the MoO NNI

6.2.4.4 MoP NNI

The MoP NNI deploys the GFP-F link frame as specified in clause 6.2.2.2.

The mapping of the GFP-F link frames into P11s/P11s-Xv, P12s/P12s-Xv, P31s/P31s-Xv and P32e/P32e-Xv is specified in [ITU-T G.8040].

The frame structure of P11s, P12s and P32e is specified in [ITU-T G.704], the frame structure of P31e, the 34 368 kbit/s PDH path layer according to [ITU-T G.705], is specified in [ITU-T G.951] and the frame structure of P31s is specified in [ITU-T G.832]. Virtual concatenation of the P11s, P12s, P31s and P32e signals is specified in [ITU-T G.7043].

For the channelized P32e, the direct multiplexing of P11s into P32e is specified in clause 9.3 of [ANSI T1.107].

Figure 6-14 illustrates the relation of the components of MoP NNI using GFP-F.

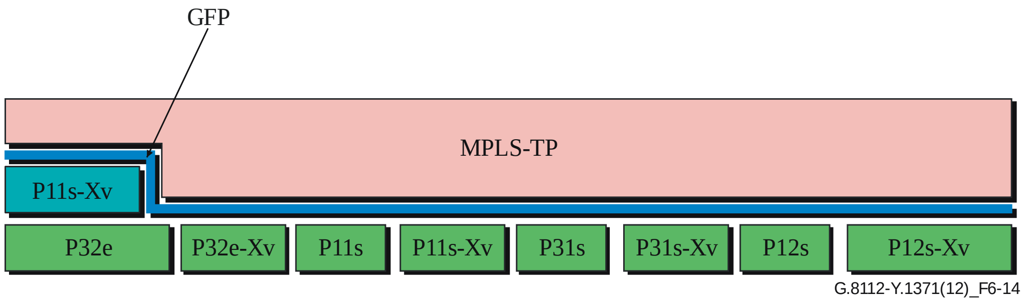

Figure 6-14 – Components of the MoP NNI using GFP-F

6.3 MPLS-TP labels

In the label field of the shim header for MPLS-TP connection identification, 20 bits are available. Some of these values are pre-assigned. The interpretation of these values is as described in Table 6-4.

Table 6-4 – MPLS-TP label value interpretation

MPLS-TP label value	Interpretation
0-3	Defined in [IETF RFC 3032]; not used in MPLS-TP
4-12	Reserved for future standardization (Note)
13	Defined in [IETF RFC 5586]
14	Defined in [ITU-T Y.1711]; not used in MPLS-TP
15	Reserved for future standardization (Note)
16-1 048 575	MPLS-TP connection identifier range (values assigned as per [IETF RFC 3031])
NOTE – The Internet Assigned Numbers Authority (IANA) allocates these values through the Internet Engineering Task Force (IETF) consensus action process.	

6.4 MPLS-TP shim header

The MPLS-TP traffic unit includes one or more MPLS shim headers as defined in [IETF RFC 3031] and specified as label stack entry in section 2 of [IETF RFC 3032].

7 Multiplexing/mapping principles

Figure 7-1 shows the relationship between various information structure elements and illustrates the multiplexing structure and mappings for the MPLS-TP from client signal to link frames. It illustrates an n-level multiplexing of MPLS-TP signals into MPLS-TP LSP. The MPLS transport profile characteristic information (MT_CI) traffic is multiplexed into an MPLS-TP unit group level 1 (MUG1). The MUG1 is extended with a second level MPLS shim header and then multiplexed into a higher MUG level.

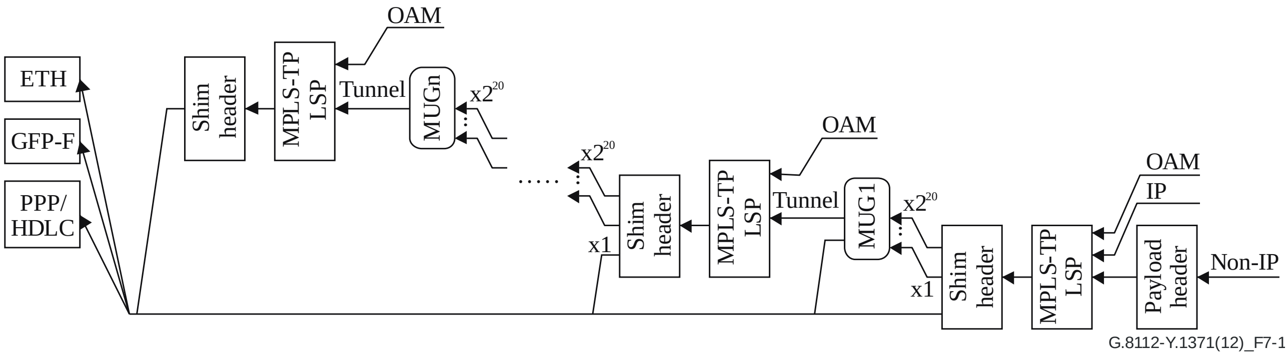

Figure 7-1 – MPLS-TP mapping, multiplexing and segment monitoring

7.1 Mapping

The client signal is mapped into the MPLS-TP LSP directly (like IP clients). For non-IP clients like Ethernet, a CW is optionally used as referred to in [ITU-T G.8110.1]. The CW is also known as the CII in [ITU-T Y.1415].

MPLS-TP OAM (see clause 6.2.1.1) may be added and both data and OAM packets are extended with a shim header (see clause 6.4).

The MPLS-TP packets are then mapped into the applicable link frames as specified in clause 6.2.2 and those link frames are transported over an MPLS-TP topological link.

7.2 MPLS-TP multiplex

The label-stacking mechanism in MPLS-TP provides an n-level MPLS-TP LSP multiplexing capability. The 20-bit label in the shim header identifies the individual MPLS-TP tributaries within the aggregate (MPLS-TP tunnel) signal. Up to 2^{20} MPLS-TP tributaries can be supported in the aggregate signal.

7.3 MPLS-TP tandem connection monitoring

Multiplexing may not be performed in all stacking steps to support one or more levels of MPLS-TPT [sub-path maintenance element (SPME)] as described in [ITU-T G.8110.1].

8 Physical specification of the MPLS-TP interfaces

There are no dedicated MPLS-TP physical interfaces. MPLS-TP interfaces are supported by physical interfaces specified in the following transport technologies: PDH, SDH, OTH and Ethernet.

Appendix I

Example of layer networks in ETH UNI and MPLS-TP NNI

(This appendix does not form an integral part of this Recommendation.)

[ITU-T G.8110.1] defines Ethernet as the client of MPLS-TP. Ethernet UNI and NNI are defined in [ITU-T G.8012]. The ETH UNI, ETH NNI and MPLS-TP NNI encompass multiple layer networks, each with its dedicated UNI and NNI (Figure I.1). The Ethernet PHY layer (ETY) UNI is defined in [ITU-T G.8012].

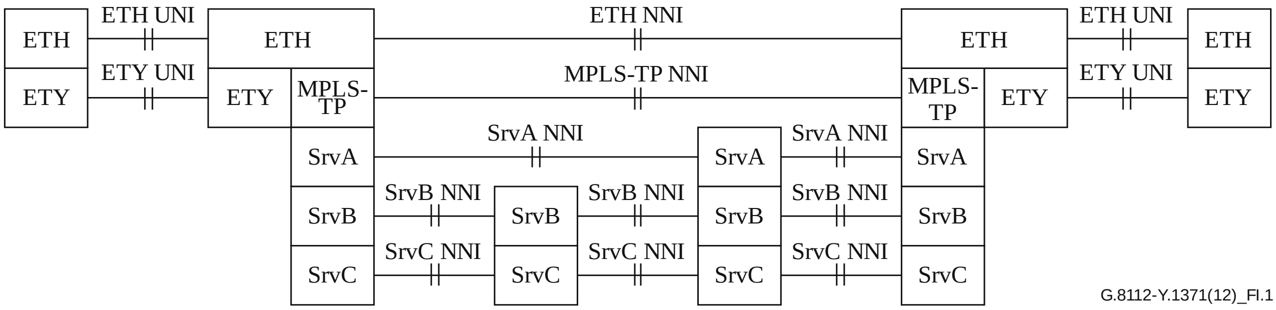

Figure I.1 – Example of layer networks in ETH UNI and MPLS-TP NNI

Appendix II

Bandwidth requirements for MPLS-TP transport

(This appendix does not form an integral part of this Recommendation.)

This appendix shows the transport bandwidth requirements for ETH client encapsulation over MPLS-TP over ETH link as a function of the Ethernet MAC rate, the client payload field length, whether or not the network has inserted a virtual local area network (VLAN) tag. This is shown in Tables II.1 and II.2.

NOTE – The MAC bit rate in Table II.1 is the actual bit rate of the Ethernet MAC frames after the removal of the 12 byte inter-packet gap plus 7 byte preamble + 1 byte start of frame delimiter (SFD). In other words, MAC bit rate = (Ethernet interface rate) (number of bits in the MAC frame)/(number of bits in the MAC frame 12 byte inter-packet gap + 7 byte preamble + 1 byte SFD). The calculations in Table II.2 are the same except that 10 Gbit Ethernet uses a 5 byte minimum inter-packet gap instead of 12 bytes.

Table II.1 – Maximum (un)tagged MAC bit rate per "1 Gbit/s" MAC server signal

		Payload bit rate (bit/s, nominal bit rate for Ethernet)					
		1 000 000 000	**1 000 000 000**		**1 000 000 000**	**1 000 000 000**	
		MAC bit rate (kbit/s), throughput (%) relative to maximum MAC bit rate			**Packets per second (pps), throughput (%) relative to maximum packet per second**		
VLAN tag	**MAC-size (Bytes)**	**1000Base-X**	**MPLS-TP over 1000Base-X**	**Throughput, %**	**1000Base-X**	**MPLS-TP over 1000Base-X**	**Throughput, %**
0	64	761.905	581.818	76.36	1.488.095	1.136.364	76.36
0	128	864.865	735.632	85.06	844.595	718.391	85.06
0	256	927.536	847.682	91.39	452.899	413.907	91.39
0	512	962.406	917.563	95.34	234.962	224.014	95.34
0	1 024	980.843	957.009	97.57	119.732	116.822	97.57
0	1 518	986.996	970.588	98.34	81.274	79.923	98.34
0	9 618	997.925	995.240	99.73	12.969	12.935	99.73
1	64	772.727	596.491	77.19	1.420.455	1.096491	77.19
1	128	868.421	741.573	85.39	822.368	702.247	85.39
1	256	928.571	849.673	91.50	446.429	408.497	91.50
1	512	962.687	918.149	95.37	233.209	222.420	95.37
1	1 024	980.916	957.169	97.58	119.275	116.387	97.58
1	1 518	987.030	970.663	98.34	81.064	79.719	98.34
1	9 618	997.926	995.242	99.73	12.964	12.929	99.73

NOTE 1 – VLAN tag; value gives the number of VLAN tags (no VLAN tag = 0).

NOTE 2 – Encapsulation overhead; 20 bytes for physical Ethernet interface [7 byte preamble, 1 byte SFD and 12 byte minimum interpacket gap (IPG)]. 26 byte encapsulation overhead for ETH client over MPLS-TP with CW.

Table II.2 – Maximum (un)tagged MAC bit rate per "10 Gbit/s" MAC server signal

		Payload bit rate (nominal bit rate for Ethernet)					
		10 000 000 000	10 000 000 000		1 000 000 000	1 000 000 000	
		MAC bit rate (kbit/s), throughput (%) relative to maximum MAC bit rate			Packets per second (pps), throughput (%) relative to maximum packet per second		
VLAN tag	**MAC-size (Bytes)**	**10GBase-R**	**MPLS-TP over 10GBase-R**	**Throughput, %**	**10GBase-R**	**MPLS-TP over 10GBase-R**	**Throughput, %**
0	64	7.619.048	5.818.182	76.36	14.880.952	11.363.636	76.36
0	128	8.648.649	7.356.322	85.06	8.445.946	7.183.908	85.06
0	256	9.275.362	8.476.821	91.39	4.528.986	4.139.073	91.39
0	512	9.624.060	9.175.627	95.34	2.349.624	2.240.143	95.34
0	1 024	9.808.429	9.570.093	97.57	1.197.318	1.168.224	97.57
0	1 518	9.869.961	9.705.882	98.34	812.744	799.233	98.34
0	9 618	9.979.249	9.952.401	99.73	129.695	129.346	99.73
1	64	7.727.273	5.964.912	77.19	14.204.545	10.964.912	77.19
1	128	8.684.211	7.415.730	85.39	8.223.684	7.022.472	85.39
1	256	9.285.714	8.496.732	91.50	4.464.286	4.084.967	91.50
1	512	9.626.866	9.181.495	95.37	2.332.090	2.224.199	95.37
1	1 024	9.809.160	9.571.695	97.58	1.192.748	1.163.873	97.58
1	1 518	9.870.298	9.706.633	98.34	810.636	797.194	98.34
1	9 618	9.979.257	9.952.420	99.73	129.641	129.293	99.73

NOTE 1 – VLAN tag; value gives the number of VLAN tags (no VLAN tag = 0).

NOTE 2 – Encapsulation overhead; 20 bytes for physical Ethernet interface (7 byte preamble, 1 byte SFD and 12 byte minimum IPG). 26-byte Encapsulation overhead for ETH client over MPLS-TP with CW.

Bibliography

[b-ITU-T G.8110.1] Recommendation ITU-T G.8110.1/Y.1370.1 (2011), *Architecture of the multi-protocol label switching transport profile layer network.*

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