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

Packet over Transport aspects – MPLS over Transport aspects

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Transport

Interfaces for the Transport MPLS (T-MPLS) hierarchy

ITU-T Recommendation G.8112/Y.1371

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For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation G.8112/Y.1371

Interfaces for the Transport MPLS (T-MPLS) hierarchy

Summary

ITU-T Recommendation G.8112/Y.1371 specifies the interfaces for the Transport MPLS (T-MPLS) hierarchy. The interfaces for the Transport MPLS (T-MPLS) hierarchy uses various server layer networks like PDH, SDH, OTH, ETH and RPR.

Source

ITU-T Recommendation G.8112/Y.1371 was approved on 7 October 2006 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure. This file includes the modifications introduced by Corrigendum 1 that was approved on 9 January 2007 by ITU-T Study Group 15 under the ITU-T Recommendation A.8 procedure.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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ITU-T Recommendation G.8112/Y.1371

Interfaces for the Transport MPLS (T-MPLS) hierarchy

1 Scope

This Recommendation specifies the interfaces for the Transport MPLS (T-MPLS) hierarchy, in particular the:

- encapsulation of T-MPLS client signals into the T-MPLS characteristic information that will be present on T-MPLS NNI links in the transport network;
- encapsulation of T-MPLS characteristic information into the T-MPLS link frames that will be present on T-MPLS NNI links in the transport network;
- T-MPLS link frame format interworking when T-MPLS subnetworks with different link frame formats are interconnected;
- T-MPLS hierarchy within the transport network and associated T-MPLS multiplexing;
- T-MPLS nested connection monitoring per hierarchy level within the transport network;
- T-MPLS OAM associated with nested connection monitoring in the transport network;
- encapsulation of in-band T-MPLS control plane information into the T-MPLS link frames that will be present on T-MPLS NNI links in the transport network.

The T-MPLS network uses various server layer networks like OTH, SDH, PDH, ETH and RPR. The detailed requirements are specified in a number of ITU-T Recommendations, ANSI Standards, IEEE Standards and IETF RFC, which are referred to.

This Recommendation specifies unicast LSPs; multicast LSPs are for further study.

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

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

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

[ITU-T G.709] ITU-T Recommendation G.709/Y.1331 (2003), *Interfaces for the optical transport network (OTN).*

[ITU-T G.7041] ITU-T Recommendation G.7041/Y.1303 (2005), *Generic framing procedure (GFP).*

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

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

[ITU-T G.8110.1] ITU-T Recommendation G.8110.1/Y.1370.1 (2006), *Architecture of Transport MPLS (T-MPLS) layer networks.*

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

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

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

[IEEE 802.3] IEEE 802.3 AP-2007, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*.

[IETF RFC 3031] IETF RFC 3031 (2001), *Multiprotocol Label Switching Architecture*.

[IETF RFC 3032] IETF RFC 3032 (2001), *MPLS Label Stack Encoding*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 T-MPLS_CI traffic unit: See [ITU-T G.8110.1].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 NNI: An interface that is used for the interconnection of network elements within a transport network.

3.2.2 TMH-NNI: An NNI for the transfer of T-MPLS_CI traffic unit over a transport layer network referred to in this Recommendation.

3.2.3 network bit order: Presentation of the bits in the order those are transmitted; bits on the left are transmitted before bits shown on the right.

3.2.4 most significant bit to least significant bit order: Presentation of the bits in binary order; from left to right 2^n 2^{n-1} 2^{n-2} ... 2^1 2^0.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CI Characteristic Information

DA Destination Address

ETH Ethernet MAC layer network

ETH_CI Ethernet MAC Characteristic Information

FCS Frame Check Sequence

GFP Generic Framing Procedure

* T1 standards are maintained since November 2003 by ATIS.

GFP-F	Generic Framing Procedure – Frame Mapped
IaDI	Intra-Domain Interface
IrDI	Inter-Domain Interface
LAN	Local Area Network
LCAS	Link Capacity Adjustment Scheme
LLC	Logical Link Control
M_SDU	MAC Service Data Unit
MAC	Media Access Control
MoO	T-MPLS over OTH
MoP	T-MPLS over PDH
MoR	T-MPLS over RPR
MoS	T-MPLS over SDH
MPLS	Multi-Protocol Label Switching
NNI	Network Node Interface
ODU	Optical Channel Data Unit
ODUj	Optical Channel Data Unit – order j
ODUj-Xv	Virtual concatenated Optical Channel Data Unit – order j
ODUk	Optical Channel Data Unit – order k
ODUk-Xv	Virtual concatenated Optical Channel Data Unit – order k
OTH	Optical Transport Hierarchy
P11s	1544 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.704]
P12s	2048 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.704]
P31s	34 368 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.832]
P4s	139 264 kbit/s PDH path layer with synchronous 125 μs frame structure according to [ITU-T G.832]
PA	(Ethernet) Preamble
PDH	Plesiochronous Digital Hierarchy
PHY	Physical
RFC	Request for Comments
RPR	Resilient Packet Ring
SA	Source Address
SDH	Synchronous Digital Hierarchy
SFD	Start of Frame Delimiter
SNAP	Sub-Network Access Protocol
STM-N	Synchronous Transport Module – level N

TM	Transport MPLS
TMH	T-MPLS Hierarchy
TMH-NNI	T-MPLS Hierarchy Network Node Interface
TMP	T-MPLS path layer
T-MPLS	Transport MPLS
TNE	Transport Network Element
VC	Virtual Container (SDH)
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 ID	VLAN Identifier
VLAN	Virtual LAN

5 Conventions

None.

6 Transport MPLS hierarchy interface structure

The Transport MPLS hierarchy as specified in [ITU-T G.8110.1] implies one interface class:

- Transport MPLS hierarchy interface as specified in this Recommendation.

The TMH interface can be deployed as a network node interface (NNI) within the transport network. The TMH-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.

NOTE – The deployment of TMH interface as a T-MPLS user-to-network interface (UNI) is for further study.

The TMH-NNI could be used for the support of client layer connection services. Two or more client-UNIs are used for such a service as illustrated in Figure 6-1.

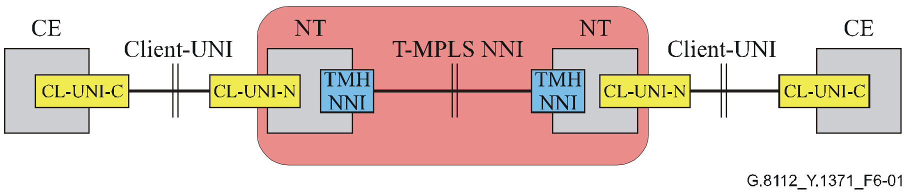

Figure 6-1 – Locations of Ethernet client-UNI and T-MPLS NNI

The client UNI and T-MPLS NNI encompass multiple layer networks, each with its dedicated UNI and NNI (Figure 6-2).

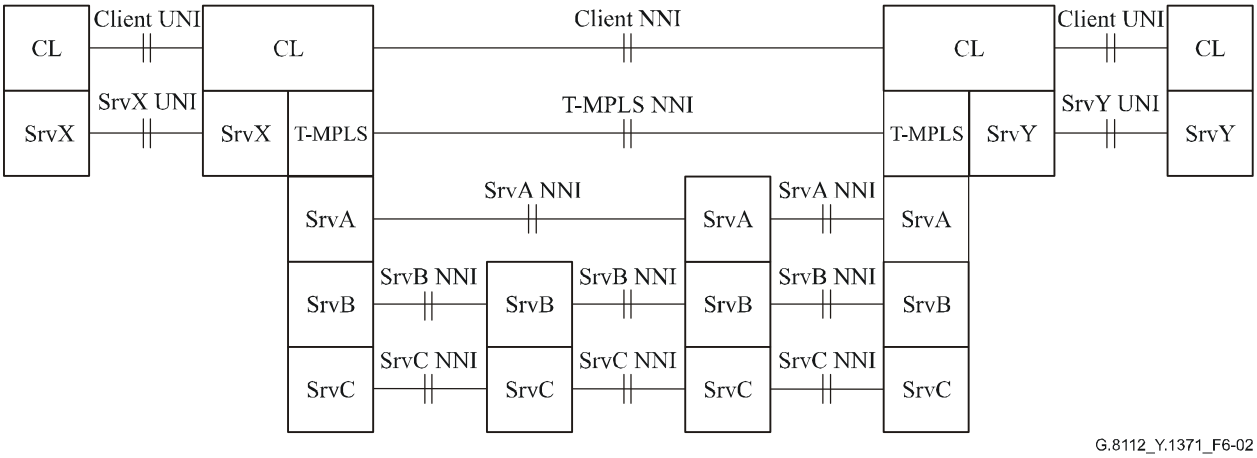

Figure 6-2 – Example of layer networks in client UNI and T-MPLS NNI in case of pt-pt T-MPLS layer connection

The client UNI could be used for the provision of an access link to a service node (SN), such as IP-router, ASON switch, etc. In this case, the CL-UNI-C is terminated at the customer edge (CE) and the CL-UNI-N is terminated at the NT. See Figure 6-3. It should be noted that a SN requires the support of SN specific protocols and may require the support of further layer networks. These SN related protocols and layer networks are not subject of this Recommendation and, therefore, not shown in the figure.

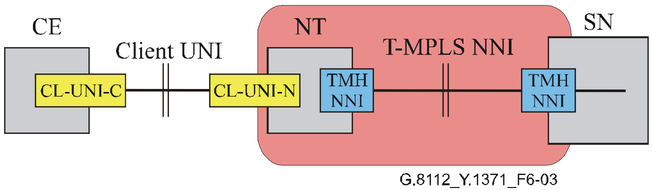

Figure 6-3 – Locations of client-UNI and T-MPLS NNI of an access link to an SN

The client UNI and T-MPLS NNI encompass multiple layer networks, each with its dedicated UNI and NNI (Figure 6-4).

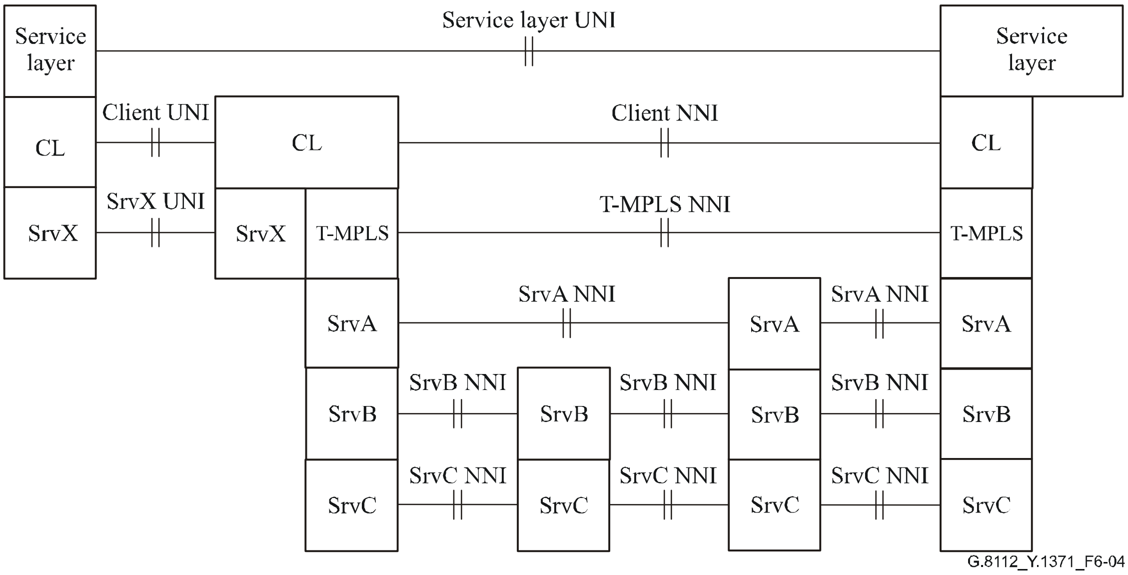

Figure 6-4 – Example of layer networks in client UNI and T-MPLS NNI in case of access link to a client's layer service node

An alternative configuration, in which the interface port on the service node has reduced complexity, is obtained when the client signal is terminated and the Service Layer's signal is extracted and forwarded via a direct encapsulation into T-MPLS_CI traffic units.

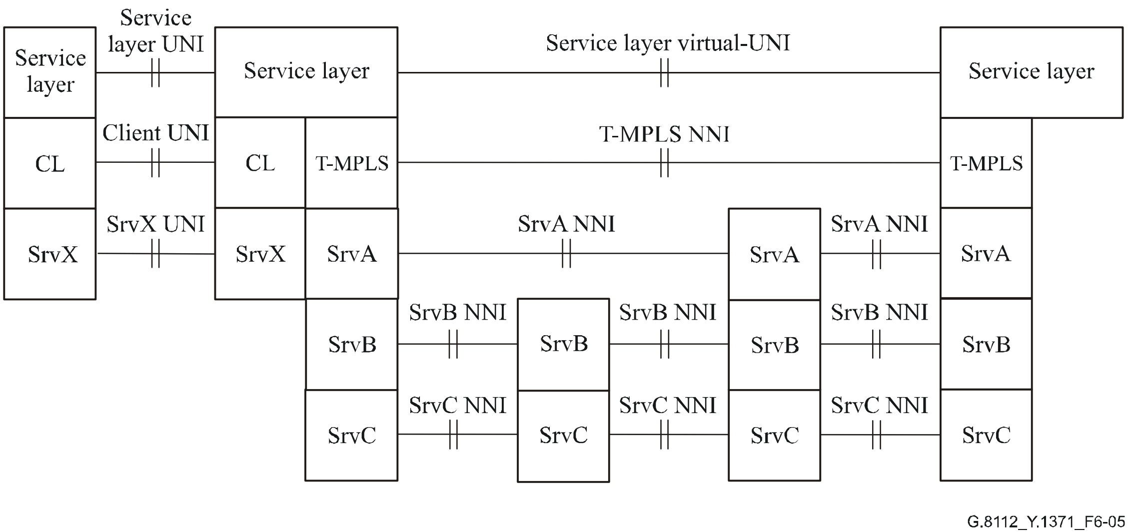

Figure 6-5 – Example of layer networks in service layer UNI and T-MPLS NNI supporting an extended service layer UNI (virtual UNI) to a service node

The T-MPLS connection may also be between two service nodes as shown in Figure 6-6.

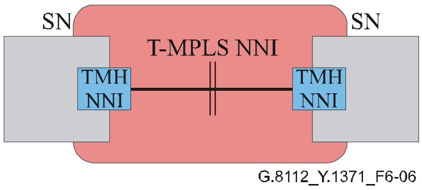

Figure 6-6 – T-MPLS NNI between service nodes

The T-MPLS NNI encompasses multiple layer networks, each with its dedicated NNI (Figure 6-7).

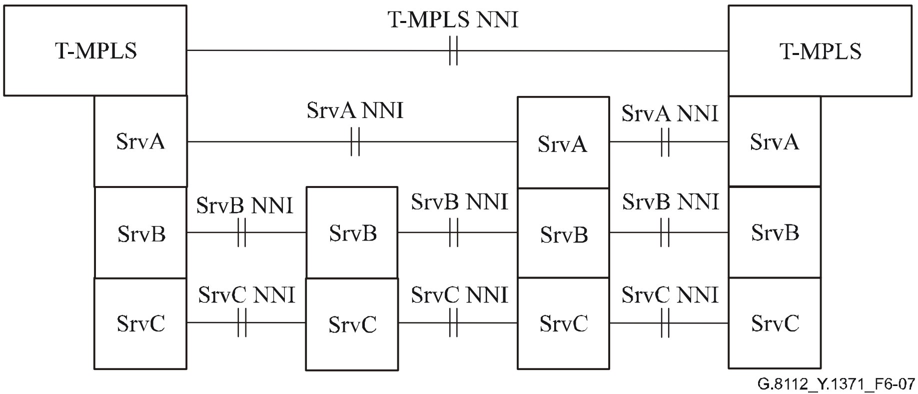

Figure 6-7 – Example of layer networks in T-MPLS NNI in case of interconnecting two T-MPLS layer service nodes

Figure 6-8 shows the use of the T-MPLS NNI as an IaDI and an IrDI.

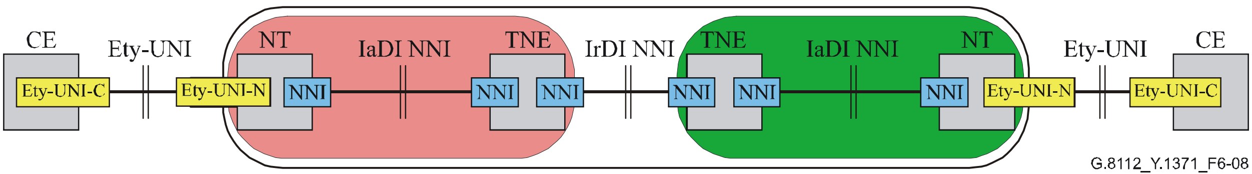

Figure 6-8 – Locations of T-MPLS NNI in a multi-operator network

This Recommendation specifies the T-MPLS NNI including the encapsulation into the T-MPLS's server layer (SrvA in Figures 6-2, 6-4 and 6-7).

The T-MPLS NNI may carry informational elements of three planes (Figure 6-9):

– 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.

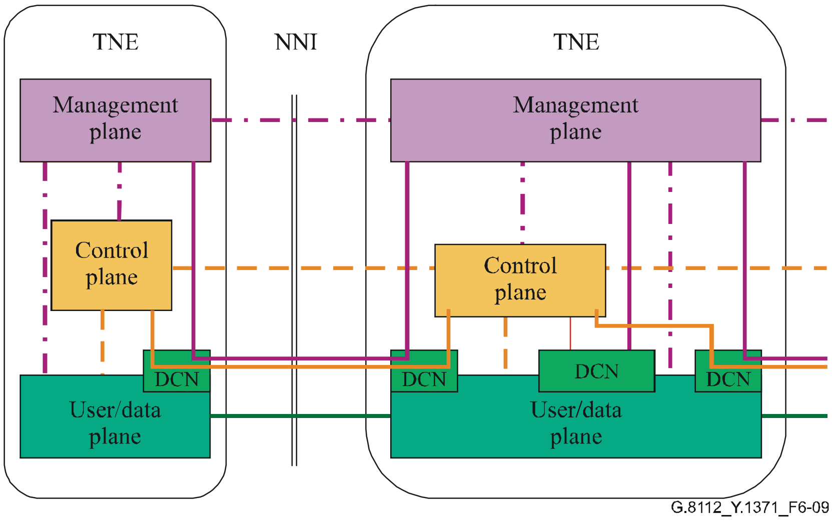

Figure 6-9 – Three planes of T-MPLS NNI

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.

NNI_C are optional elements within a NNI.

This Recommendation specifies the NNI_D and NNI_C.

6.1 NNI basic signal structure

The basic structure is shown in Figure 6-10.

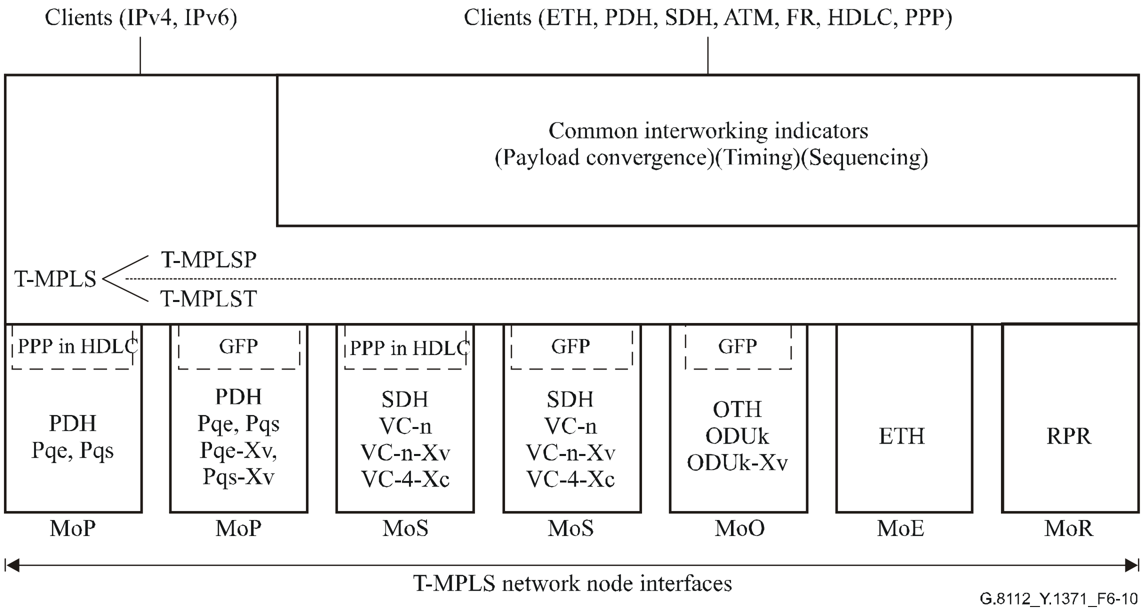

Figure 6-10 – Structure of the T-MPLS network node interfaces

6.1.1 T-MPLS substructure

The T-MPLS layer as defined in [ITU-T G.8110.1] is further structured in sublayers in order to support the tunnelling (aggregation of lower level MPLS_CI), network management and supervision functionalities defined in [ITU-T G.8110.1], [ITU-T Y.1710] and [ITU-T Y.1711]:

– tunnelling;

– end-to-end path supervision (T-MPLSP);

– tandem connection monitoring (T-MPLST);

– optional adaptation of client signals via common interworking indicator (also known as pseudowire) headers.

6.1.2 T-MPLS transport network structure

The T-MPLS transport network interface consists of the multiple layers, of which only the first one is illustrated in Figure 6-10. The next layers are outside the scope of this Recommendation; the reader is referred to the appropriate technology Recommendations (e.g., [ITU-T G.707] for SDH).

There is a number of such T-MPLS interfaces defined under this Recommendation as depicted in Figure 6-10:

• T-MPLS-over-ETH (MoE);

• T-MPLS-over-SDH (MoS);

• T-MPLS-over-OTH (MoO);

• T-MPLS-over-PDH (MoP);

• T-MPLS-over-RPR (MoR).

In the case of circuit-switched transport, the payload bandwidths available are shown in Tables 6-1, 6-2 and 6-3, respectively, for PDH, SDH and 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

Table 6-2 – Bandwidth of the payload of SDH VCs

VC type	VC payload (kbit/s)	In steps of (kbit/s)
VC-11	1 600	
VC-12	2 176	
VC-2	6 784	
VC-3	48 384	
VC-4	149 760	
VC-4-4c	599 040	
VC-4-16c	2 396 160	
VC-4-64c	9 584 640	
VC-4-256c	38 338 560	
VC-11-Xv, X = 1 to 64	1 600 to 102 400	1 600
VC-12-Xv, X = 1 to 64	2 176 to 139 264	2 176
VC-2-Xv, X = 1 to 64	6 784 to 434 176	6 784
VC-3-Xv, X = 1 to 256	48 384 to 12 386 304	48 384
VC-4-Xv, X = 1 to 256	149 760 to 38 338 560	149 760

Table 6-3 – Bandwidth of the OTH ODUs

ODU type	OPU payload (kbit/s)	In steps of (kbit/s)
ODU1	2 488 320	
ODU2	238/237 × 9 953 280 ≈ 9 995 277	
ODU3	238/236 × 39 813 120 ≈ 40 150 519	
ODU1-Xv, X = 1 to 256	2 488 320 to 637 009 920	2 488 320
ODU2-Xv, X = 1 to 256	≈ 9 995 277 to ≈ 2 558 709 902	≈ 9 995 277
ODU3-Xv, X = 1 to 256	≈ 40 150 519 to ≈ 10 278 532 946	≈ 40 150 519

6.2 Information structure for the T-MPLS network node interfaces

The information structure for the T-MPLS network node interfaces is represented by information containment relationships and flows. The principal information containment relationships are described in Figure 6-11.

6.2.1 T-MPLS principle information containment relationship

The T-MPLS_CI consists of a stream of T-MPLS_CI traffic units and OAM units. T-MPLS_CI traffic units consist of a T-MPLS_AI traffic unit extended with an T-MPLS_CI header containing the TTL field of the T-MPLS shim header (refer to clause 6.4). The T-MPLS_AI traffic unit consists of a T-MPLS_AI header containing the S field of the T-MPLS shim header and a T-MPLS payload field. The T-MPLS payload field carries adapted client information or a label stack entry. A client signal of the T-MPLS layer network is mapped into the T-MPLS payload field via one of two different encapsulations (see Figure 6-11):

– direct encapsulation (IPv4, IPv6);

– common interworking indicator (also known as pseudowire) based encapsulation (ETH).

Table 6-4 – Overview of encapsulated units

Encapsulation type	Reference
IP client encapsulation	(IPv4) [IETF RFC 3032], clauses 2 and 3 (IPv6) [IETF RFC 3032], clauses 2 and 3
ETH client encapsulation	[ITU-T Y.1415]
Other	For further study

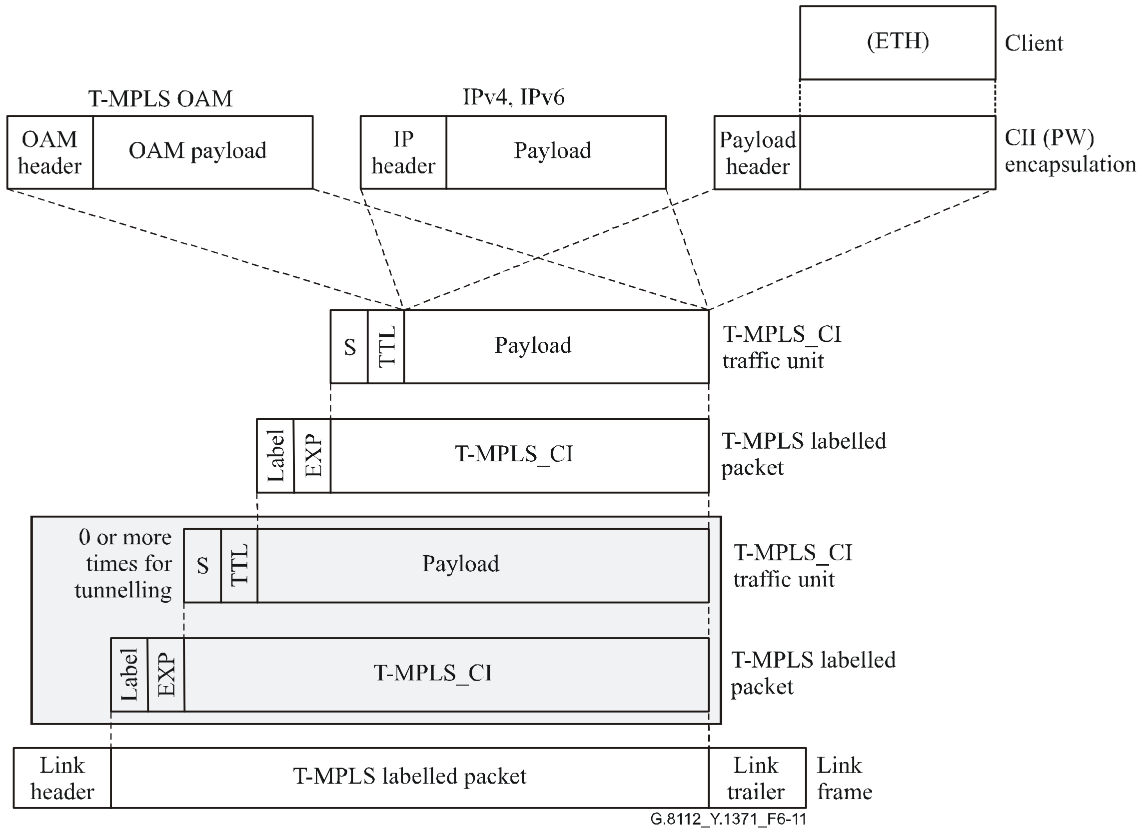

Figure 6-11 – T-MPLS principle information containment

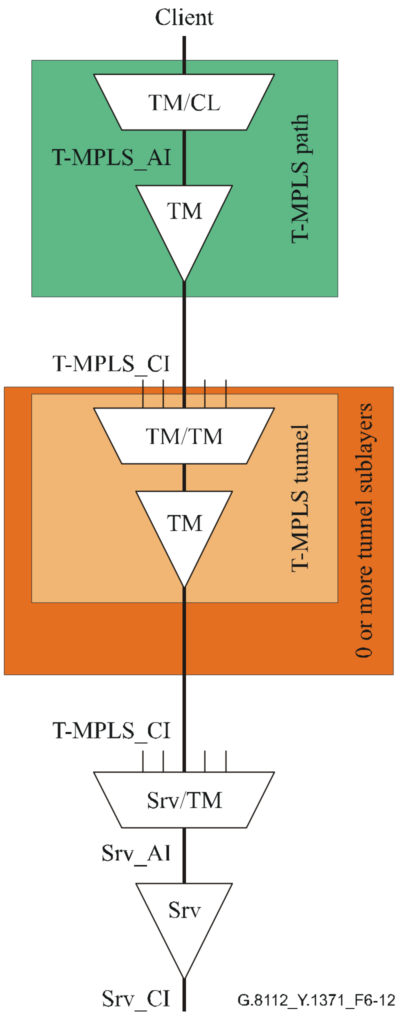

Figure 6-12 – Example of information flow relationship

6.2.1.1 T-MPLS OAM

T-MPLS OAM is specified in [ITU-T Y.1711]. Figure 6-13 illustrates the set of T-MPLS OAM and their format.

The T-MPLS OAM header consists of a T-MPLS shim header with a reserved label value of 14 (OAM Alert). The DL and DT fields in the FDI and BDI OAM packets are set to all-zeroes by the transmitter and are to be ignored by the receiver. The LSP TTSI fields in the FDI and BDI OAM packets are set to all-zeroes by the transmitter and are to be ignored by the receiver. The format of the LSP TTSI field in the FFD/CV OAM packets within the scope of T-MPLS is for further study.

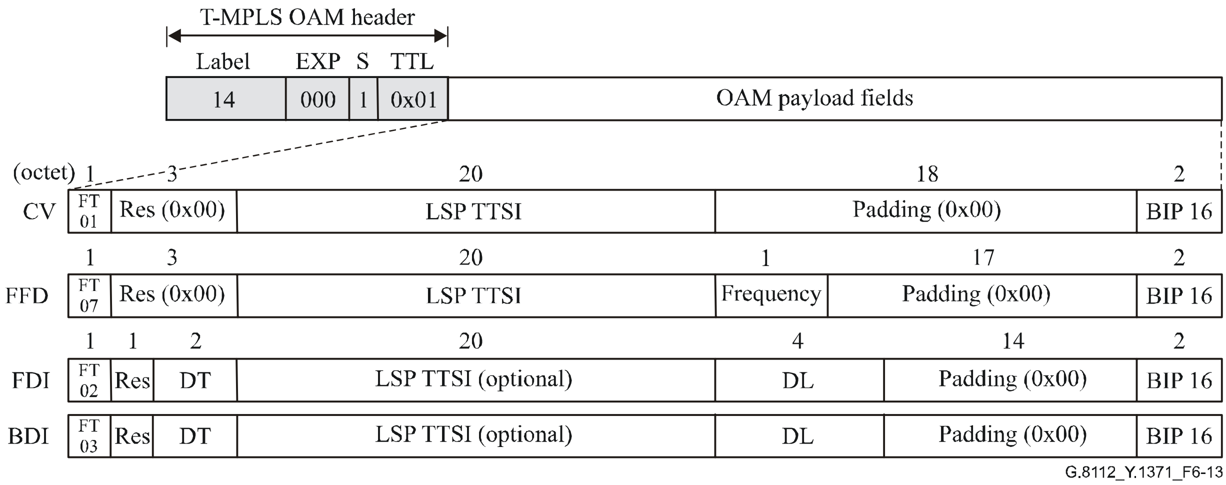

Figure 6-13 – Y.1711 defined T-MPLS OAM

6.2.1.2 Payload headers

6.2.1.2.1 ETH payload header

Refer to clause 6.2.1.6/G.8012/Y.1308.

6.2.2 T-MPLS link frames

6.2.2.1 ETH link frame

The T-MPLS_CI traffic unit (see [ITU-T G.8110.1]) is extended with a 3-bit EXP field, a 20-bit label to complete the shim header. The resulting T-MPLS labelled packet is then mapped as specified in [IETF RFC 3032], clause 5 and clause 6.1/G.8012/Y.1308 into the ETH payload information field using type encapsulation.

With the type encapsulation, the MAC DA, MAC SA and Type fields are prepended. The MAC DA is the MAC address of the T-MPLS next hop's interface or the broadcast MAC address. The MAC SA is the MAC address of the sending interface. The Type has value 0x8847 for case of unicast. The 802.3 FCS field with a 32-bit CRC is appended. See Figure 6-14.

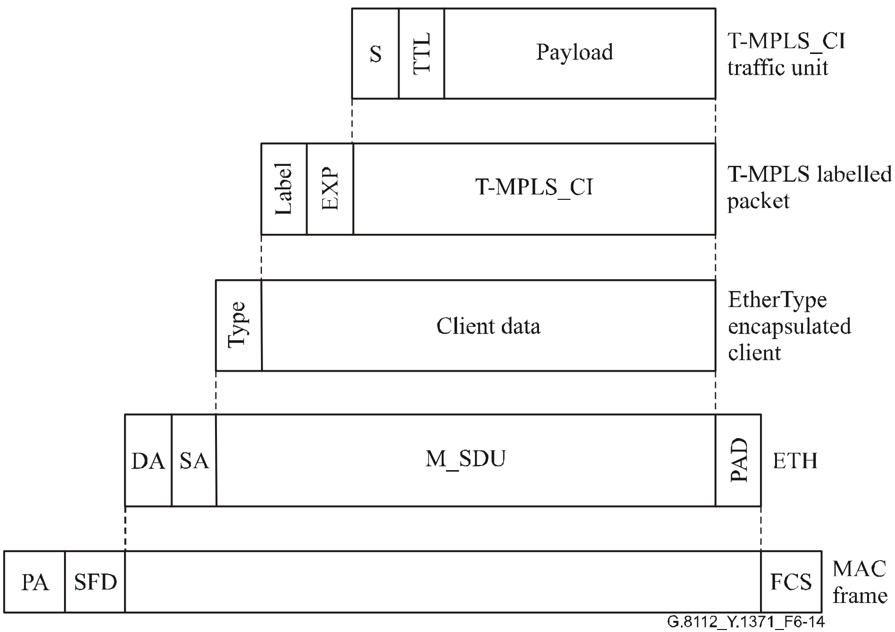

Figure 6-14 – Type encapsulation ETH link frame

6.2.2.2 GFP-F link frame

The T-MPLS_CI traffic unit (see [ITU-T G.8110.1]) is extended with a 3-bit EXP field, a 20-bit label to complete the shim header. The resulting T-MPLS labelled packet is then mapped as specified in clause 7.6 of [ITU-T G.7041] 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 value 0x0D (case of unicast). A payload FCS field with a 32-bit CRC is appended. See Figure 6-15. The maximum size of the GFP payload information field is specified in clause 6.1.2 of [ITU-T G.7041].

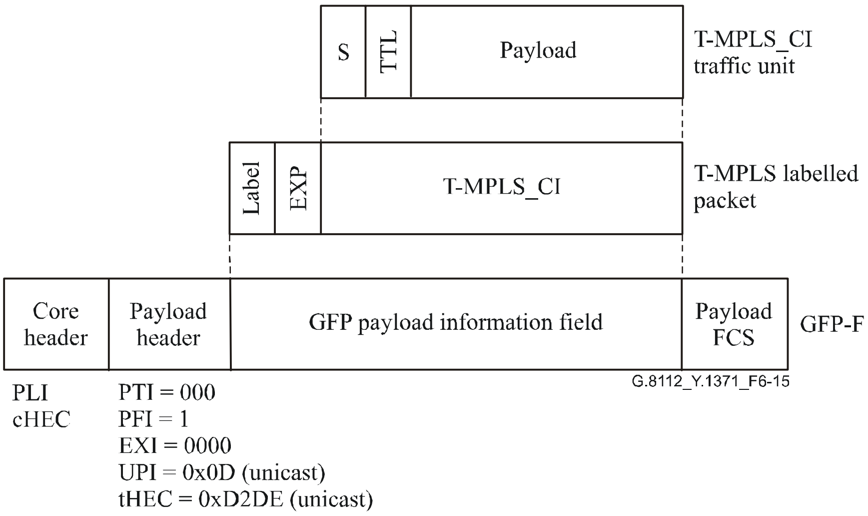

Figure 6-15 – GFP-F link frame

Figure 6-16 illustrates the mapping of the bits in the T-MPLS labelled packet into the GFP payload information field within the GFP-F frame.

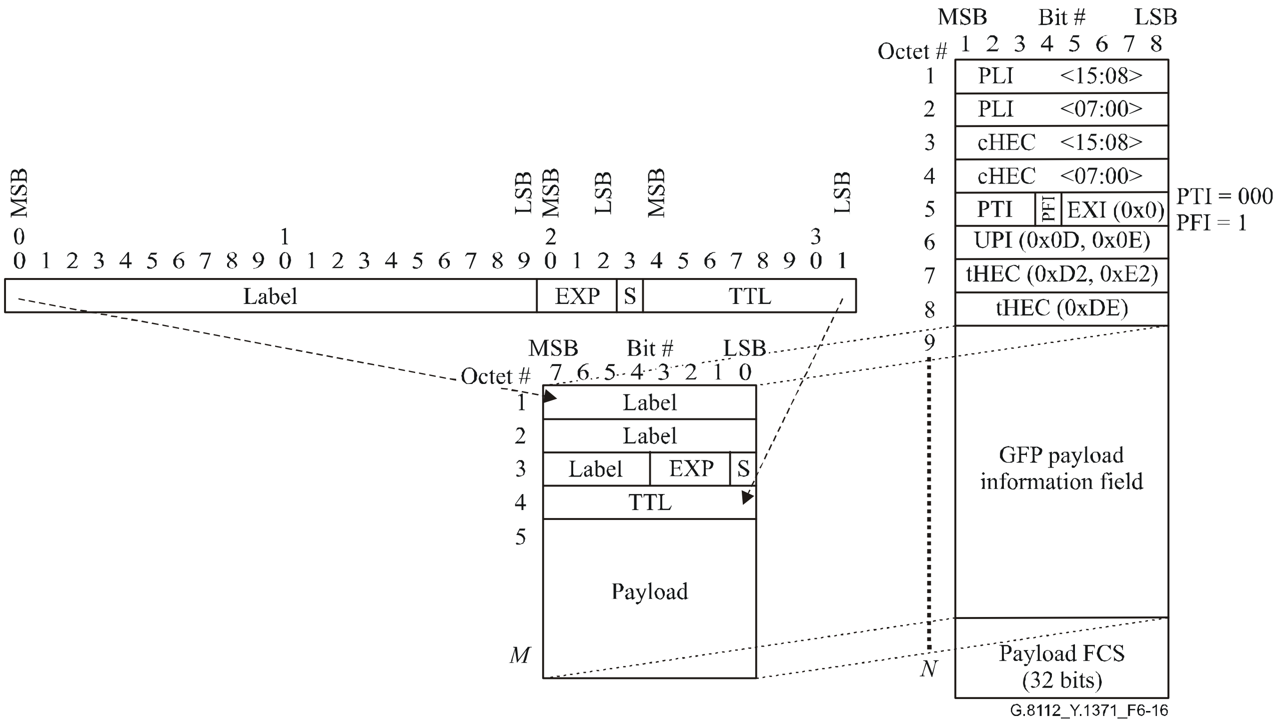

Figure 6-16 – Mapping T-MPLS labelled packet into GFP-F link frame

6.2.2.3 RPR link frame

For further study.

6.2.3 In-band T-MPLS control frames over shared trail SCN links

Three alternatives for SCN links are defined in [ITU-T G.8110.1]. T-MPLS control plane communication (NNI_C) for signalling and routing purposes are used for shared trail SCN links.

When shared trail SCN links are used, T-MPLS control frames are encapsulated either in IPv4 or in IPv6 or in OSI network layer packets and sent natively on the T-MPLS NNI interface (Figure 6-17).

NOTE – The encapsulation of the T-MPLS control frames into IPv4, IPv6 or OSINL packets is out of scope of this Recommendation.

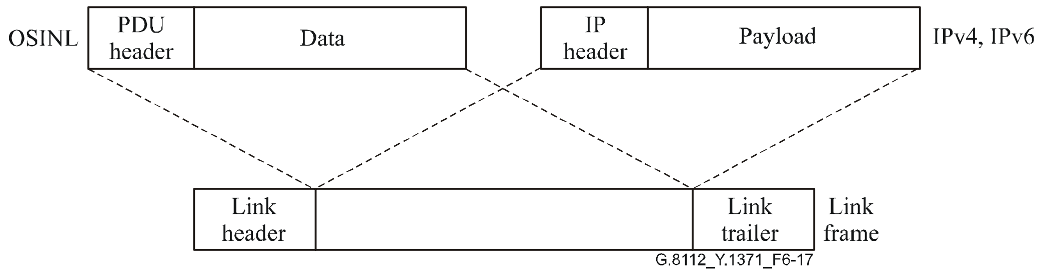

Figure 6-17 – T-MPLS control frame over shared trail SCN links

Additional control frames can be required by the specific encapsulation method used for sending T-MPLS link frames (e.g., the LCP and NCP control frames in PPP).

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

The encapsulation method used for T-MPLS control frames is the same as the one used for the T-MPLS link frames.

6.2.3.1 ETH link frame

The signalling and routing message is encapsulated into either IPv4 or IPv6 or OSI CNLS (IS-IS) packet.

With MoE NNI, the ARP control protocol can be implemented in the control plane. If implemented, the ARP control frames must be sent in-band.

Control packets are encapsulated as specified in the standard references of Table 6-5 in the ETH payload information field.

Table 6-5 – Overview of ETH encapsulated control packets

Encapsulation type	Reference	Type value
ARP	RFC 826	0x0806
IP control packets	(IPv4) RFC 894 and RFC 1042	0x0800
	(IPv6) RFC 2464	0x86DD
OSI network layer control packets	(OSINL)	

With the type encapsulation, the MAC DA, MAC SA and Type fields are prepended. The MAC DA is the MAC address of the next hop's interface or the broadcast MAC address (depending on the control packet). The MAC SA is the MAC address of the sending interface. The Type has the values defined in Table 6-5. The 802.3 FCS field with a 32-bit CRC is appended.

6.2.3.2 GFP-F link frame

The signalling and routing message is encapsulated into either IPv4 or IPv6 or OSI CNLS (IS-IS) packet.

When the T-MPLS 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 6-6 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 6-6. A payload FCS field with a 32-bit CRC is appended.

Table 6-6 – 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

6.2.3.3 RPR link frame

For further study.

6.2.4 T-MPLS UNI

For further study.

6.2.5 T-MPLS NNI

The T-MPLS NNI is supported by the interfaces listed below.

6.2.5.1 MoE NNI

The T-MPLS over ETH (MoE) NNI deploys the Type encapsulation based ETH link frame as specified in clause 6.2.2.1. The mapping of ETH link frame into an ETY link frame is specified in ITU-T Rec. G.8012/Y.1308.

6.2.5.2 MoS NNI

The T-MPLS over SDH (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, VC-4/VC-4-Xv and VC-4-Xc is specified in clause 10.6 of [ITU-T G.707].

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

The components of the T-MPLS over SDH NNI using the default encapsulation are illustrated in Figure 6-18.

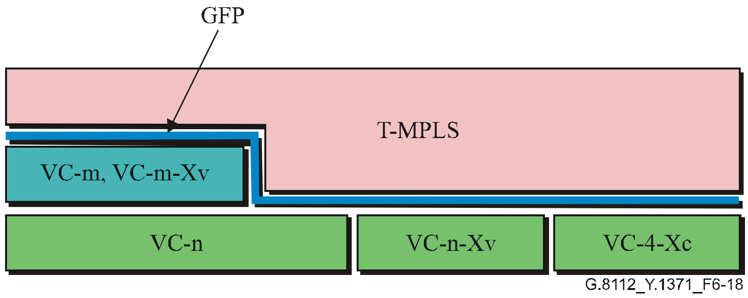

Figure 6-18 – Components of the T-MPLS over SDH NNI using GFP-F encapsulation

6.2.5.3 MoO NNI

The T-MPLS over OTH NNI deploys the GFP-F link frame as specified in clause 6.2.2.2 and its components are illustrated in Figure 6-19. The mapping of the GFP-F link frame into ODUj/ODUk and ODUj-Xv is specified in clauses 17.3 and 18.2.4 respectively of [ITU-T G.709].

Path overhead and virtual concatenation of the ODUs is specified in [ITU-T G.709].

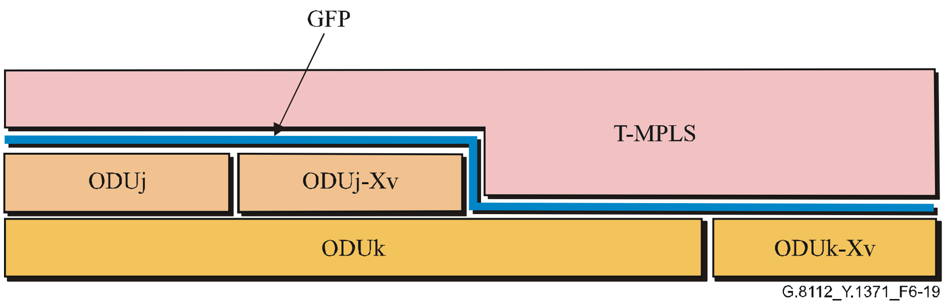

Figure 6-19 – Components of the T-MPLS over OTH NNI

6.2.5.4 MoP NNI

The T-MPLS over PDH 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 is specified in ITU-T Rec. G.951 and the frame structure of P31s is specified in ITU-T Rec. G.832. Virtual concatenation of the P11s, P12s, P32s 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 6-20 illustrates the relation of the components of T-MPLS over PDH NNI using GFP-F.

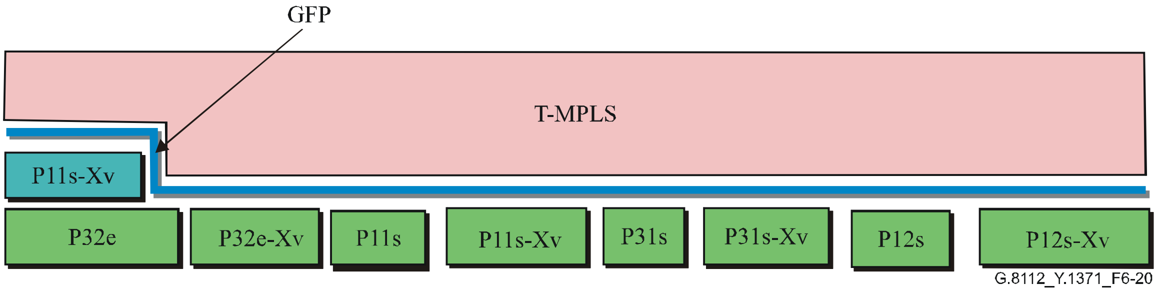

Figure 6-20 – Components of the T-MPLS over PDH NNI using GFP-F

6.2.5.5 MoR NNI

For further study.

6.3 T-MPLS labels

20 bits are available in the label field of the shim header for T-MPLS connection identification. Some of these values are pre-assigned. The interpretation of these values is as described in Table 6-7.

Table 6-7 – T-MPLS label value interpretation

T-MPLS label value	Interpretation
0-3	Defined in [IETF RFC 3032]; not used in T-MPLS
4-13	Reserved for future standardization (Note)
14	OAM Alert label (see [ITU-T Y.1711] and RFC 3429)
15	Reserved for future standardization (Note)
16-1'048'575	T-MPLS connection identifier range (values assigned as per [IETF RFC 3031])
NOTE – IANA allocates these values through the IETF consensus action process.	

6.4 T-MPLS shim header

The T-MPLS traffic unit includes one or more MPLS shim headers as defined in [IETF RFC 3031] and specified as label stack entry in clause 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 T-MPLS from client signal to link frames.

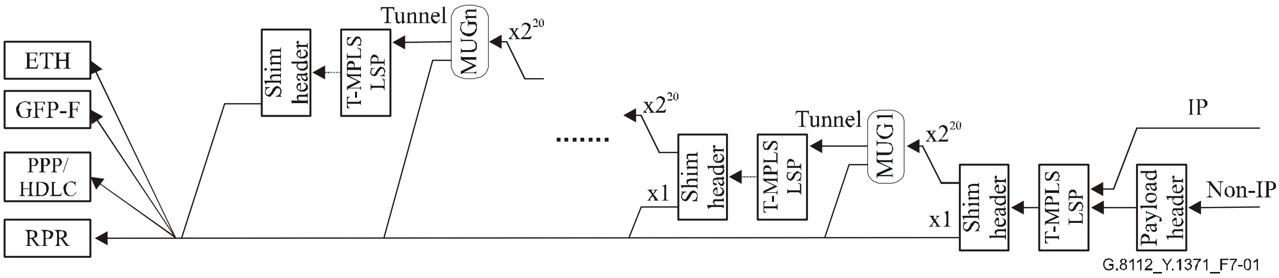

Figure 7-1 – T-MPLS mapping, multiplexing and segment monitoring

7.1 Mapping

The client signal is mapped into the T-MPLS LSP directly (IP clients), or indirectly via common interworking indicators (CII) based encapsulation (non-IP clients). With CCI based encapsulation one or more additional encapsulation steps may be present: a real time protocol, common interworking indicators. Refer to 6.2.1.2.

T-MPLS OAM (refer to 6.2.1.1) may be added and both data and OAM packets are extended with a shim header (refer to 6.4).

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

7.2 T-MPLS multiplex

The label stacking mechanism in T-MPLS provides an n-level T-MPLS LSP multiplexing capability. The 20-bit label in the shim header identifies the individual T-MPLS tributaries within the aggregate (T-MPLS tunnel) signal.

7.3 T-MPLS tandem connection monitoring

Multiplexing may not be performed in all stacking steps to support one or more levels of T-MPLS tandem connection monitoring. The mechanism is for further study.

8 Physical specification of the T-MPLS interfaces

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

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