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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

Architecture of Transport MPLS (T-MPLS) layer network

ITU-T Recommendation G.8110.1/Y.1370.1

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ITU-T Recommendation G.8110.1/Y.1370.1

Architecture of Transport MPLS (T-MPLS) layer network

Summary

This Recommendation describes the functional architecture of Transport MPLS (T-MPLS) layer networks using components of the MPLS network architecture described in ITU-T Rec. G.8110/Y.1370. The T-MPLS network functionality is described from a network-level viewpoint, taking into account T-MPLS network layering, definition of characteristic information, client/server associations, networking topology and layer network functionality. The functional architecture of the server networks used by the T-MPLS network is not within the scope of this Recommendation. Such architectures are described in other ITU-T Recommendations or IETF RFCs.

Source

ITU-T Recommendation G.8110.1/Y.1370.1 was approved on 10 November 2006 by ITU-T Study Group 15 (2005-2008) 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.

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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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/.

CONTENTS

ITU-T Recommendation G.8110.1/Y.1370.1

Architecture of Transport MPLS (T-MPLS) layer network [1] [2]

1 Scope

This Recommendation describes the functional architecture of Transport MPLS (T-MPLS) bearer plane networks using a subset of the components described in the MPLS layer network architecture of [ITU-T G.8110]. The T-MPLS network functionality is described from a network-level viewpoint, taking into account a T-MPLS network layered structure, client characteristic information, client/server associations, networking topology, and layer network functionality providing T-MPLS signal transmission, multiplexing, supervision, performance and survivability.

This Recommendation describes the bearer plane architecture of T-MPLS networks. Control plane and management plane aspects are outside its scope.

The T-MPLS is a connection-oriented packet-switched transport layer network technology based on the MPLS bearer plane modelled in [ITU-T G.8110]. T-MPLS is a technology focused on packet transport applications that adhere to ITU-T layer network architecture principles. A T-MPLS layer network can operate independently of its clients and its associated control networks (i.e., MCN and SCN). This independence affords network operators the freedom necessary to design robust packet transport networks for their own use and to transport customer traffic. T-MPLS trails can carry a variety of client traffic types. This Recommendation does not specify control or management protocols, but neither does it limit the application of such protocols to T-MPLS transport networks. Finally, transport connections can have very long holding times and thus T-MPLS includes features traditionally associated with transport networks, such as protection switching and operation and maintenance (OAM) functions.

Further, a T-MPLS network will not peer directly with an IP/MPLS network. This means that an LSP initiated from an IP/MPLS network element will be encapsulated before it transits a T-MPLS network. Similarly if IP/MPLS is used as a server layer for T-MPLS then an LSP initiated from a T-MPLS network element will be encapsulated before it transits an IP/MPLS network. This also implies that the control planes for T-MPLS and IP/MPLS are independent.

This Recommendation supports point-to-point Ethernet services as specified in ITU-T G.8011.x-series Recommendations over the T-MPLS layer network.

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1 Cisco Systems has expressed reservations concerning the work on ITU-T Rec. G.8110.1/Y.1370.1 since it does not take into account adequately the related work on transport of Ethernet pseudowire over MPLS network in the IETF PWE3 Working Group and in [ITU-T Y.1415], "Ethernet-MPLS network interworking – User plane interworking". Furthermore, at the time of approval of this Recommendation, the T-MPLS OAM requirements and mechanisms were still being worked on in ITU-T Study Group 13. Thus it is premature to approve G.8110.1.

2 Juniper Networks has expressed reservation concerning the approval of draft ITU-T Rec. G.8110.1 "Architecture of Transport MPLS (T-MPLS) layer network" at the November 2006 ITU-T Study Group 15 meeting. The only specified Ethernet adaptation in ITU-T Rec. G.8110.1/Y.1370.1 may not interoperate with other implementations of this Recommendation, due to inadequate specification of detail.

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.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.805] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

[ITU-T G.8010] ITU-T Recommendation G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks*.

[ITU-T G.8110] ITU-T Recommendation G.8110/Y.1370 (2005), *MPLS layer network architecture*.

[ITU-T G.8112] ITU-T Recommendation G.8112/Y.1371 (2006), *Interfaces for the Transport MPLS (T-MPLS) hierarchy*.

[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 and maintenance mechanism for MPLS networks*.

[ITU-T Y.1720] ITU-T Recommendation Y.1720 (2006), *Protection switching for MPLS networks*.

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

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

[IETF RFC 3270] IETF RFC 3270 (2002), *Multi-Protocol Label Switching (MPLS) Support of Differentiated Services*.

[IETF RFC 3443] IETF RFC 3443 (2003), *Time To Live (TTL) Processing in Multi-Protocol Label Switching (MPLS) Networks*.

3 Definitions

This Recommendation uses the following terms defined in [ITU-T G.805]:

3.1 access point

3.2 adapted information

3.3 characteristic information

3.4 client/server relationship

3.5 connection

3.6 connection point

3.7 layer network

3.8 link

3.9 link connection

3.10 matrix

3.11 network

3.12 network connection

3.13 port

3.14 reference point

3.15 subnetwork

3.16 subnetwork connection

3.17 termination connection point

3.18 trail

3.19 trail termination

3.20 transport

3.21 transport entity

3.22 transport processing function

3.23 unidirectional connection

3.24 unidirectional trail

This Recommendation uses the following terms defined in [IETF RFC 3031]:

3.25 label

3.26 label merging

3.27 label stack

3.28 label switched path

3.29 MPLS label stack

This Recommendation uses the following terms defined in [IETF RFC 3032]:

3.30 bottom of stack

3.31 time to live

3.32 experimental use

3.33 label value

This Recommendation uses the following terms defined in [IETF RFC 3270]:

3.34 per hop behaviour

3.35 EXP inferred PHB scheduling class LSP

3.36 label inferred PHB scheduling class LSP

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Adapted Information
AP	Access Point
CI	Characteristic Information
CII	Common Interworking Indicators
CO-PS	Connection-Oriented Packet Switched
CP	Connection Point
ECMP	Equal Cost Multi-Path
E-LSP	EXP-Inferred-PSC LSP
EXP	Experimental Use
IP	Internet Protocol
L-LSP	Label-Only-Inferred PSC LSP
LSP	Label Switched Path
MPLS	Multi-Protocol Label Switching
OAM	Operation, Administration and Maintenance
OSINL	OSI Network Layer
PE	Provider Edge
PHB	Per Hop Behaviour
PHP	Penultimate Hop Popping
PSC	PHB Scheduling Class
S	Bottom of Stack
SCN	Signalling Communication Network
TCP	Termination Connection Point
TDM	Time Division Multiplexing
TM	Transport Multi-Protocol Label Switching
T-MPLS	Transport Multi-Protocol Label Switching
TTL	Time-To-Live

5 Conventions

The diagrammatic convention for connection-oriented layer networks described in this Recommendation is that of [ITU-T G.805].

All transport entities within this Recommendation are unidirectional unless explicitly specified otherwise.

6 Functional architecture of T-MPLS networks

6.1 General

The functional architecture of T-MPLS transport networks is described using a subset of the MPLS architecture described in [ITU-T G.8110]. The specific aspects regarding the characteristic information, client/server associations, the topology and partitioning of T-MPLS transport networks are provided in this Recommendation. This Recommendation uses the terminology, functional architecture and diagrammatic conventions defined in [ITU-T G.805].

T-MPLS is intended to be a separate layer network with respect to MPLS. However, T-MPLS will use the same data-link protocol ID (e.g., EtherType), frame format and forwarding semantics as defined for MPLS frames. The semantics used within a label space are defined in [IETF RFC 3031], the implications of this for T-MPLS are described in clause 6.5.

The essential features of T-MPLS are:

- It is a CO-PS technology and therefore its architecture is based on [ITU-T G.805].
- T-MPLS LSPs do not use PHP.
- Bidirectional T-MPLS LSPs are supported by pairing the forward and backward directions to follow the same path (i.e., the same nodes and links). The pairing relationship between the forward and the backward directions is known in each node traversed by the bidirectional LSP.
- TTL in T-MPLS is supported according to [IETF RFC 3443] for only the pipe and short-pipe models.
- Both E-LSP and L-LSP are supported as defined in [IETF RFC 3270].
- EXP in T-MPLS is supported according to [IETF RFC 3270] for only the pipe and short-pipe models.
- In applications requiring packet loss probability comparable to TDM transport, a single drop precedence is supported by T-MPLS. In applications that require statistical multiplexing gain, two drop precedence values are supported by T-MPLS.
- The model used for TTL and EXP is consistent; either both use the pipe or both use the short-pipe model.
- Both per-platform and per-interface label space are supported.
- OAM is based on [ITU-T Y.1711].
- Protection switching and survivability are based on [ITU-T Y.1720].
- Merging is not supported (as defined in clause 8.3.2 of [ITU-T G.8110]).
- ECMP is not supported.
- Multicasting will be supported but currently it is for further study.
- Different options are supported for signalling communication network (SCN) links as described in clause 11:
  - Shared trail SCN links;
  - Shared hop SCN links;
  - Independent SCN links.
- Control and management plane requirements are outside the scope of this Recommendation.

6.2 T-MPLS network layered structure

One layer network is defined in the T-MPLS network architecture:

– T-MPLS layer network.

The T-MPLS layer network is a path layer network as defined in clause 6.2 of [ITU-T G.8110].

6.2.1 T-MPLS adapted information

The T-MPLS layer network adapted information is a (non-) continuous flow of TM_AI traffic units (TM_AI_D) equivalent to the MPLS_AI traffic units defined in clause 6.2.1 of [ITU-T G.8110].

The TM_AI traffic units (TM_AI_D) are complemented with the TM_AI_PHB and TM_AI_TSF signals.

6.2.2 T-MPLS characteristic information

The T-MPLS layer network characteristic information is a (non-) continuous flow of TM_CI traffic units (TM_CI_D).

The TM_CI traffic unit (TM_CI_D) consists either of a TM_AI traffic unit (TM_AI_D) or of a T-MPLS OAM traffic unit, extended with an MPLS_CI header defined in clause 6.2.2 of [ITU-T G.8110].

The T-MPLS OAM traffic unit is composed by a shim header with a label value "14", EXP field "000", the S bit set to "1" and the TTL field set to "1" followed by the T-MPLS OAM payload defined in [ITU-T Y.1711].

The TM_CI traffic units (TM_CI_D) are complemented with the TM_CI_iPHB, TM_CI_oPHB and TM_CI_SSF signals.

6.3 T-MPLS layer network

The T-MPLS layer network provides the transport of adapted information through a T-MPLS trail between T-MPLS access points.

The T-MPLS layer network characteristic information is transported over a T-MPLS network connection. The T-MPLS layer network contains the following transport processing functions, transport entities and topological components as defined in clause 8.1 of [ITU-T G.8110]:

– T-MPLS trail;
– T-MPLS trail termination source (TM_TT_So);
– T-MPLS trail termination sink (TM_TT_Sk);
– T-MPLS network connection (NC);
– T-MPLS link connection (LC);
– T-MPLS subnetwork connection (SNC);
– T-MPLS subnetwork (SN);
– T-MPLS link.

6.3.1 T-MPLS topological components

The T-MPLS topological components are defined in clause 8.1.1 of [ITU-T G.8110]:

– T-MPLS layer network;
– T-MPLS subnetwork;
– T-MPLS link;
– T-MPLS access group.

6.3.1.1 T-MPLS layer network

The T-MPLS layer network is defined by the complete set of T-MPLS access groups that may be associated for the purpose of transferring information as defined in clause 8.1.1.1 of [ITU-T G.8110].

6.3.1.2 T-MPLS subnetwork

A T-MPLS subnetwork is defined by the set of T-MPLS connection points that are available for the purpose of transferring information as defined in clause 8.1.1.2 of [ITU-T G.8110].

6.3.1.3 T-MPLS link

A T-MPLS link consists of a subset of the T-MPLS connection points at the edge of one T-MPLS subnetwork or T-MPLS access group that are associated with a corresponding subset of T-MPLS connection points at the edge of another T-MPLS subnetwork or T-MPLS access group for the purpose of transferring T-MPLS characteristic information as defined in clause 8.1.1.3 of [ITU-T G.8110].

6.3.1.4 T-MPLS access group

A T-MPLS access group is a group of collocated T-MPLS trail termination functions that are connected to the same T-MPLS subnetwork or T-MPLS link.

6.3.2 T-MPLS transport entities

The T-MPLS transport entities are:

– T-MPLS link connection;

– T-MPLS network connection;

– T-MPLS subnetwork connection;

– T-MPLS trail.

6.3.3 T-MPLS transport processing functions

The T-MPLS transport processing functions are:

– T-MPLS trail termination function;

– T-MPLS/client layer network adaptation functions.

6.3.3.1 T-MPLS trail termination

The bidirectional T-MPLS trail termination (TM_TT) function is performed by a collocated pair of associated unidirectional T-MPLS trail termination source (TM_TT_So) and sink (TM_TT_Sk) functions.

The T-MPLS trail termination source (TM_TT_So) performs the processes defined in clause 8.1.3.1 of [ITU-T G.8110] between its input and output.

The T-MPLS trail termination sink (TM_TT_Sk) performs the functions defined in clause 8.1.3.1 of [ITU-T G.8110] between its input and output.

6.3.3.2 T-MPLS/client layer network adaptation functions

The T-MPLS/client adaptation functions are described in clause 7.

6.3.4 T-MPLS reference points

The T-MPLS reference points are defined in clause 8.1.4 of [ITU-T G.8110]:

– T-MPLS access point (AP);

– T-MPLS connection point (CP);

– T-MPLS termination connection point (TCP).

6.3.4.1 T-MPLS access point

A T-MPLS access point (T-MPLS AP) represents the binding between a T-MPLS trail termination function and one or more TM/client, or TM/TM, adaptation functions as defined in clause 8.1.4.1 of [ITU-T G.8110].

6.3.4.2 T-MPLS connection point

A T-MPLS link connects to a T-MPLS subnetwork or another T-MPLS link via a T-MPLS connection point as defined in clause 8.1.4.2 of [ITU-T G.8110].

6.3.4.3 T-MPLS termination connection

A T-MPLS termination connection point (T-MPLS TCP) connects a T-MPLS trail termination (TM_TT) function with a T-MPLS link as defined in clause 8.1.4.3 of [ITU-T G.8110].

6.4 T-MPLS layer network partitioning

The description of T-MPLS layer network partitioning is the same as clause 8.2 of [ITU-T G.8110].

6.5 T-MPLS label behaviour

The allocation of the label space is described in clause 6.3 of [ITU-T G.8112]. The mechanisms for label allocation are outside the scope of this Recommendation.

Considerations regarding the implications of using the platform and interface label space, as defined in clauses 6.5.3 and 6.5.4, are described in Appendix III.

6.5.1 Reserved labels

The reserved label space is described in clause 6.3 of [ITU-T G.8112].

6.5.2 Label merge

Merging is not supported in T-MPLS networks.

6.5.3 Platform label space

The platform label space is described in clause 8.3.3 of [ITU-T G.8110].

6.5.4 Interface label space

The interface label space is described in clause 8.3.4 of [ITU-T G.8110].

6.5.5 Support for multiple label spaces

Multiple label spaces may be supported as described in clause 8.3.5 of [ITU-T G.8110].

6.6 Penultimate hop popping (PHP)

T-MPLS networks do not use PHP.

6.7 LSP tunnels

LSP tunnels are described in clause 8.5 of [ITU-T G.8110].

6.8 T-MPLS hierarchies

T-MPLS hierarchies are described in clause 9.2 of [ITU-T G.8110] (G.805 MPLS hierarchies).

7 Server/client associations

Three forms of adaptation function are considered in this Recommendation:

– TM/client adaptation, where the client is not T-MPLS.

– TM/TM adaptation, where the client is T-MPLS and the server is T-MPLS.

– Server/TM adaptation, where the server is not T-MPLS.

7.1 TM/client adaptation

The TM/client adaptation (TM/Client_A) is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of client-specific processes is outside the scope of this Recommendation.

7.1.1 TM/IP adaptation

The TM/IP adaptation source (TM/IP_A_So) performs the server-specific processes defined in clause 10.1.1 of [ITU-T G.8110] between its input and output.

The TM/IP adaptation sink (TM/IP_A_Sk) performs the server-specific processes defined in clause 10.1.1 of [ITU-T G.8110] between its input and output.

7.1.2 TM/MPLS adaptation

For further study.

7.1.3 TM/ETH adaptation

The bidirectional TM/ETH adaptation (TM/ETH_A) function is performed by a collocated pair of associated unidirectional TM/ETH adaptation source (TM/ETH_A_So) and sink (TM/ETH_A_Sk) functions. The description of the client-specific processes is outside the scope of this Recommendation and is specified in [ITU-T G.8010]. The TM/ETH adaptation source (TM/ETH_A_So) performs the following server-specific processes between its input and output:

– Optionally insert the common interworking indicators (CII) as defined in [ITU-T Y.1415].

– Map the ETH_CI_P and ETH_CI_DE signals into the TM_AI_PHB signal.

– Insert a one-bit S field set to "1". This indicates that the client is not MPLS.

– Select the output TM_AP: Selection criterion is the packet's output PSC.

– Output the resulting TM_AI.

The TM/ETH adaptation sink (TM/ETH_A_Sk) performs the following server-specific processes between its input and output:

– Multiplex the TM_AI traffic units coming from all the TM_APs.

– Extract and process the one-bit S field.

– Map the TM_AI_PHB signal into the ETH_CI_P and ETH_CI_DE signals.

– Extract the common interworking indicators (CII), and process the sequence number field as defined in [ITU-T Y.1415].

7.1.4 TM/ATM adaptation

For further study.

7.2 TM/TM adaptation

The bidirectional TM/TM adaptation (TM/TM_A) function is performed by a collocated pair of associated unidirectional TM/TM adaptation source (TM/TM_A_So) and sink (TM/TM_A_Sk) functions.

Two associated unidirectional T-MPLS CPs that belongs to the same bidirectional LSP can have different labels associated with them.

The TM/TM adaptation source (TM/TM_A_So) performs the processes defined in clause 10.1.2 of [ITU-T G.8110] between its input and its output.

The selection criteria for the TM_AP are only the input TM_CP and the packet's output PSC (ECMP is not supported in T-MPLS networks).

The TM/TM adaptation sink (TM/TM_A_Sk) performs the processes defined in clause 10.1.2 of [ITU-T G.8110] between its input and output.

7.3 Server/TM adaptation

The server/TM adaptation function is considered to consist of two types of processes: client-specific processes and server-specific processes. The client-specific processes are associated with the TM_CI traffic units, which ingress/egress via the T-MPLS (T)CP. Server-specific processes are outside the scope of this Recommendation.

The bidirectional Srv/TM adaptation function is performed by a collocated pair of source and sink Srv/TM adaptation functions.

Two associated unidirectional T-MPLS CPs that belongs to the same bidirectional LSP can have different labels associated with them.

The Srv/TM adaptation source (Srv/TM_A_So) performs the processes defined in clause 10.2 of [ITU-T G.8110] between its input and output.

The Srv/TM adaptation sink (Srv/TM_A_Sk) performs one of the processes defined in clause 10.2 of [ITU-T G.8110] between its input and output.

7.3.1 SDH path/TM adaptation

The adaptation to the SDH VC-n and VC-n-Xc path layer networks is performed in the Sn/TM, Sn-Xc/TM and Sn-X/TM adaptation (S/TM_A) functions. The S/TM_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional S/TM adaptation function is performed by a collocated pair of source and sink S/TM adaptation functions.

The S/TM adaptation source (S/TM_A_So) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Map the TM_CI traffic unit into the T-MPLS link-specific frame as specified in [ITU-T G.8112].
– Map the stream of link-specific frames into the payload of the SDH VC signal (e.g., VC-n/VC-n-Xv/VC-n-Xc) as specified in [ITU-T G.707].

The S/TM adaptation sink (S/TM_A_Sk) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Extract the T-MPLS link-specific frame stream from the payload of the SDH VC signal (e.g., VC-n/VC-n-Xv/VC-n-Xc).
– Demap the TM_CI traffic unit from the link-specific frame as specified in [ITU-T G.8112].

7.3.2 OTN path/TM adaptation

The adaptation to the OTN ODUk path layer networks is performed in the ODUkP/TM and ODUkP-X/TM adaptation (ODU/TM_A) functions. The ODU/TM_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional ODU/TM adaptation functions are performed by a collocated pair of source and sink ODU/TM adaptation functions.

The ODU/TM adaptation source (ODU/TM_A_So) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Map the TM_CI traffic unit into the T-MPLS link-specific frame as specified in [ITU-T G.8112].

– Map the stream of link-specific frames into the payload of the OTN ODU signal (e.g., ODUk/ODUk-Xv) as specified in [ITU-T G.709].

The ODU/TM adaptation sink (ODU/TM_A_Sk) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Extract T-MPLS link-specific frame stream from the payload of the OTN ODU signal (e.g., ODUk/ODUk-Xv).

– Demap the TM_CI traffic unit from the link-specific frame as specified in [ITU-T G.8112].

7.3.3 ETH/T-MPLS adaptation

The adaptation to the Ethernet layer networks is performed in the ETH/TM adaptation function. The ETH/TM_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation and is specified in [ITU-T G.8010].

The bidirectional ETH/TM adaptation functions are performed by a collocated pair of source and sink ETH/TM adaptation functions.

The ETH/TM adaptation source (ETH/TM_A_So) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Map the TM_CI traffic unit into an ETH_AI traffic unit as specified in [ITU-T G.8112].

The ETH/TM adaptation sink (ETH/TM_A_Sk) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Demap the TM_CI traffic unit from the ETH_AI traffic unit as specified in [ITU-T G.8112].

7.3.4 PDH path/TM adaptation

The adaptation to the PDH path layer networks is performed in the Pq/TM_A adaptation function, where Pq = 11s, 12s, 31s, 32e, 11s-Xv, 12s-Xv, 31s-Xv, 32e-Xv. The Pq/TM_A is considered to consist of two types of processes: client-specific processes and server-specific processes. The description of the server-specific processes is outside the scope of this Recommendation.

The bidirectional Pq/TM adaptation function is performed by a collocated pair of source and sink Pq/TM adaptation functions.

The Pq/TM adaptation source (Pq/TM_A_So) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Map the TM_CI traffic unit into the T-MPLS link-specific frame as specified in [ITU-T G.8112].
– Map the stream of link-specific frames into the payload of the PDH signal (e.g., P11s/P11s-Xv, P12s/P12s-Xv, P31s/P31s-Xv, P32s/P32s-Xv) as specified in [ITU-T G.8112].

The Pq/TM adaptation sink (Pq/TM_A_Sk) functions perform (in addition to the server-layer non-specific processes as described in clause 7.3) the following server-layer related specific processes:

– Extract the T-MPLS link-specific frame stream from the payload of the PDH signal (e.g., P11s/P11s-Xv, P12s/P12s-Xv, P31s/P31s-Xv, P32s/P32s-Xv) as specified in [ITU-T G.8112].
– Demap the TM_CI traffic unit from the link-specific frame as specified in [ITU-T G.8112].

8 T-MPLS network management

For further study.

9 T-MPLS survivability techniques

9.1 Protection techniques

For further study.

9.2 Network restoration

For further study.

10 T-MPLS and support of the Diff-Serv Architecture

The use of T-MPLS for support of differentiated services (Diff-Serv) is described in [IETF RFC 3270] and in clause 13 of [ITU-T G.8110].

Two Diff-Serv tunnelling models (if and how PHB information is propagated between sublayers) are supported by T-MPLS:

– The pipe model, with no penultimate hop popping;
– The short-pipe model, with no penultimate hop popping.

These models are discussed in clause 13.3 of [ITU-T G.8110].

Two forms of LSP are defined within [IETF RFC 3270] and [ITU-T G.8110]:

– E-LSP: an EXP-inferred PHB scheduling class (PSC) LSP. The PSC and drop precedence are inferred directly from the EXP field in the MPLS shim header.
– L-LSP: a label-only-inferred PHB scheduling class (PSC) LSP. The scheduling treatment is inferred from the 20-bit label in the MPLS shim header. The drop precedence to be applied is carried in the EXP field contained in the MPLS header.

Both E-LSP and L-LSP are supported by T-MPLS.

10.1 T-MPLS TTL behaviour

The time-to-live (TTL) field can be processed in a number of ways depending on LSP type as described in [IETF RFC 3443] and clause 13.1 of [ITU-T G.8110].

Two LSP types are supported:

– The pipe model, with no penultimate hop popping;

– The short-pipe model, with no penultimate hop popping.

The TTL behaviour of both modes is the same as defined in clause 13.2.2 of [ITU-T G.8110]. This common behaviour is provided in this clause by means of diagrams that describe the TTL processing that occurs in each of the transport processing functions in the appropriate reference diagram.

The transport processing functions and processes are described in Figure 10-1.

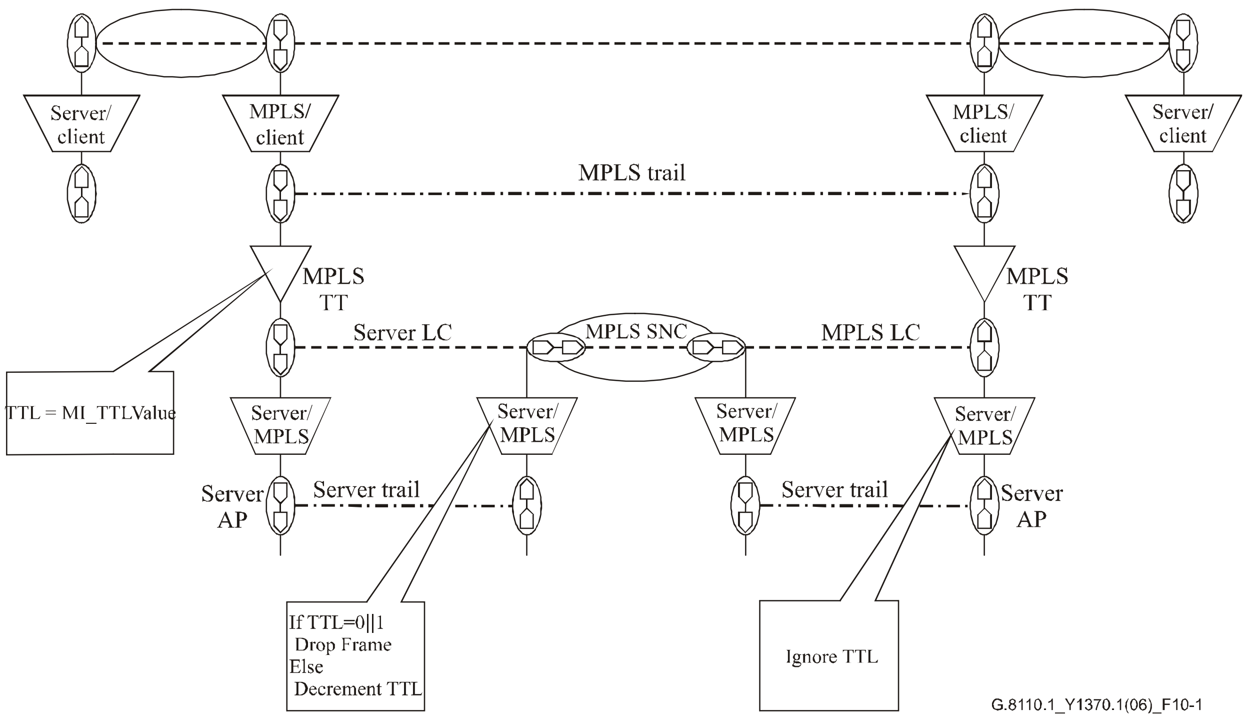

Figure 10-1 – Reference diagram for TTL behaviour

10.2 T-MPLS EXP behaviour

T-MPLS networks use the EXP field as described in [IETF RFC 3270] and in clause 13.3 of [ITU-T G.8110].

The EXP behaviour of both tunnelling models is provided in this clause by means of diagrams that describe the EXP processing that occurs in each of the transport processing functions in the appropriate reference diagram.

10.2.1 Pipe model

The transport processing functions and processes for the pipe model (without penultimate hop popping) are described in Figure 10-2.

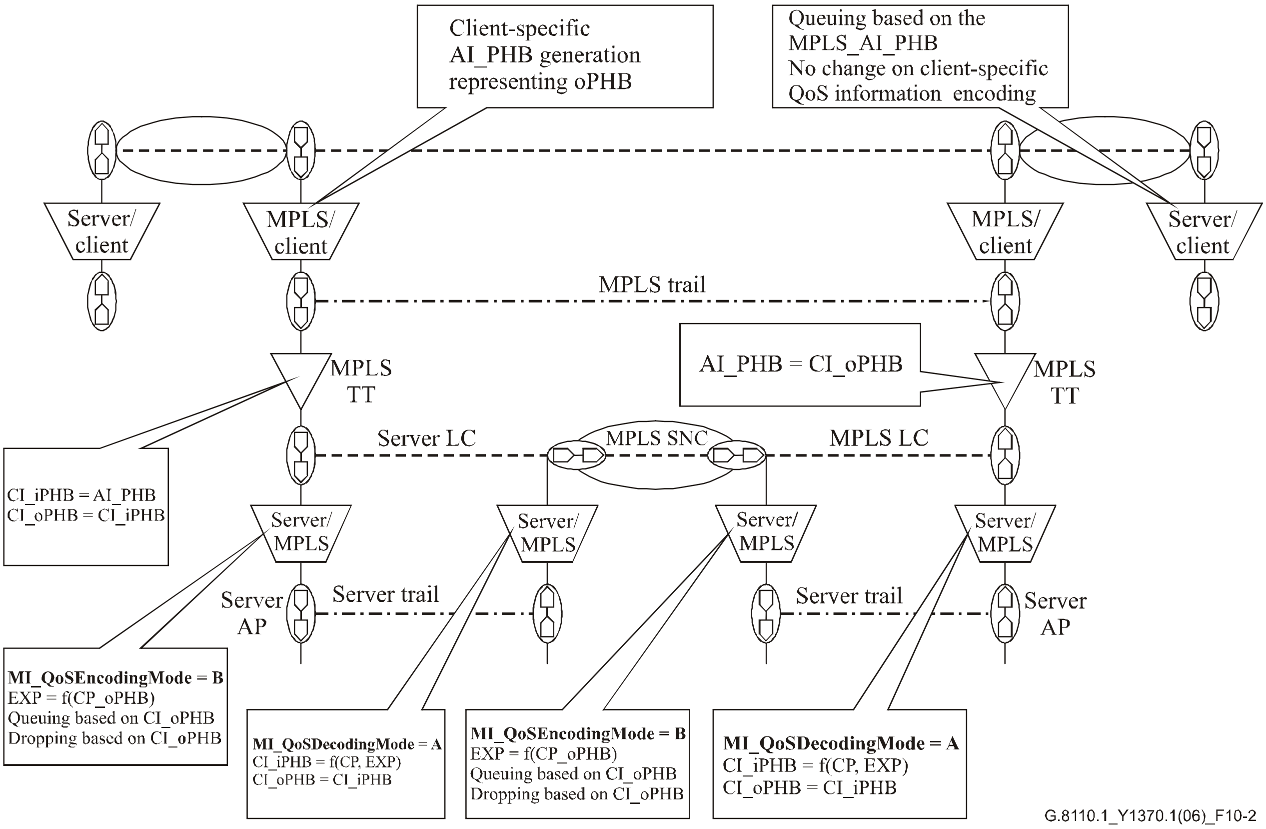

Figure 10-2 – Reference diagram for the pipe model

10.2.2 Short-pipe model

The transport processing functions and processes for the short-pipe model (without penultimate hop popping) are described in Figure 10-3.

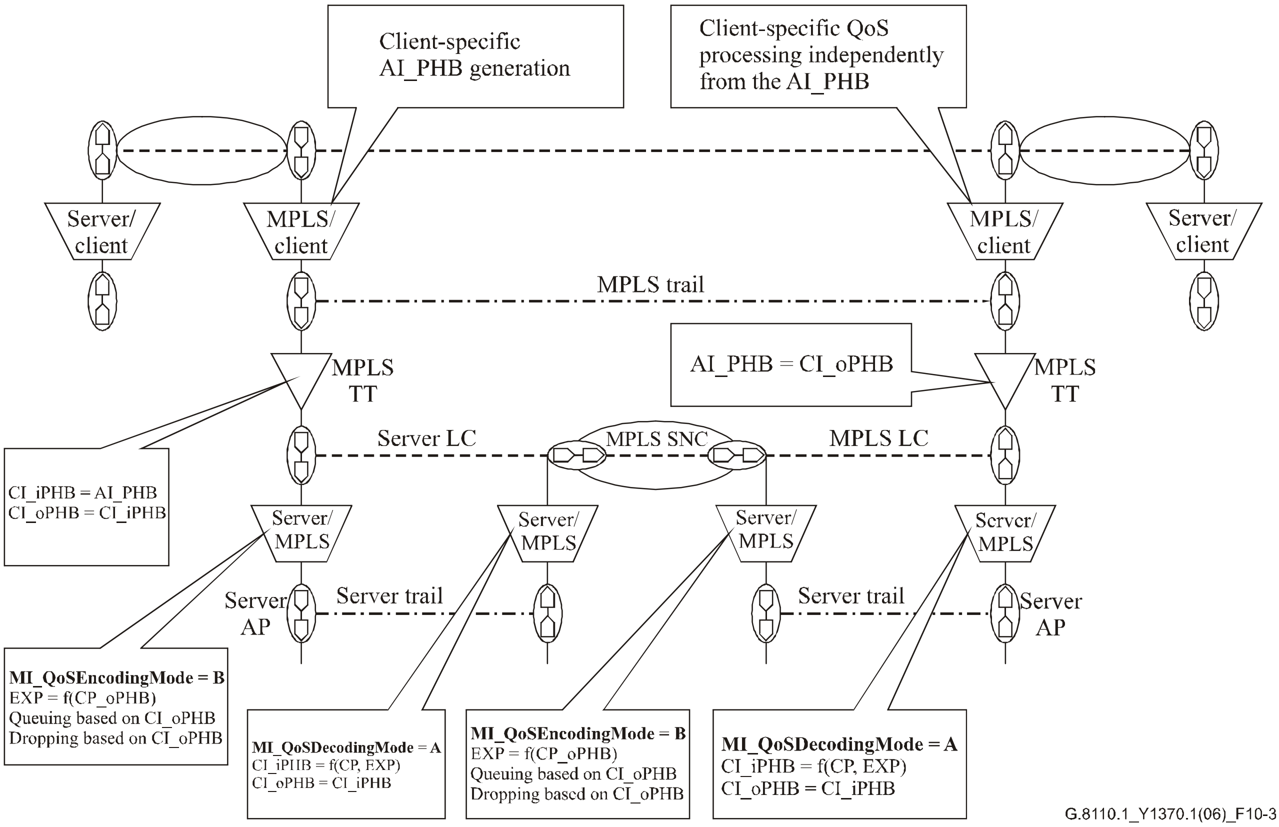

Figure 10-3 – Reference diagram for the short-pipe model

11 T-MPLS signalling communication network

Three options are defined for signalling communication network (SCN) links as follows:

– Shared trail SCN links.

– Shared hop SCN links.

– Independent SCN links.

SCN architecture (e.g., resiliency) is out of the scope of this Recommendation.

11.1 Shared trail SCN links

A shared trail SCN link is an SCN link supported by the same server trail as a T-MPLS link. In this case, the SCN link and T-MPLS link share the bandwidth provided by the common server trail.

There are two cases in which shared trail SCN links are useful.

The first is a case in which two T-MPLS network elements are connected by a server trail and there is no convenient or cost-effective alternative to provide out-of-band SCN connectivity between them as shown in Figure 11-1.

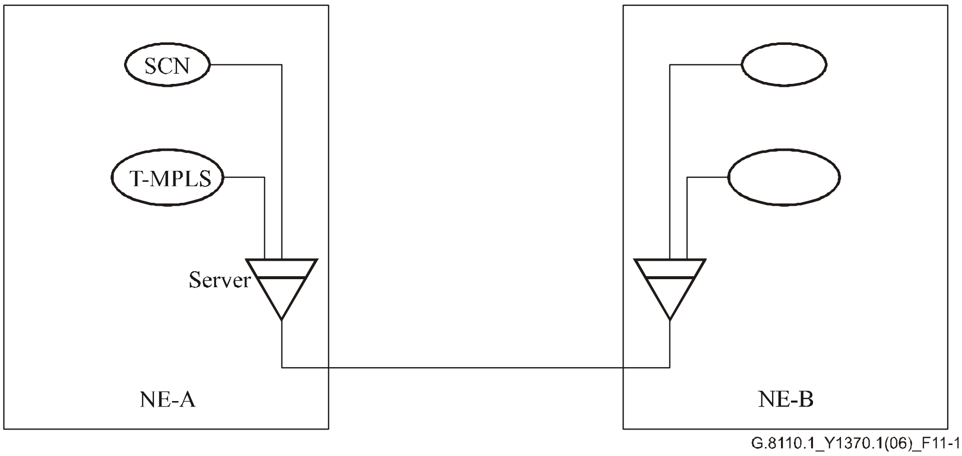

Figure 11-1 – T-MPLS NEs connected by a server trail shared with an SCN link

In this case the SCN native packets (e.g., IP or OSINL packets) are directly encapsulated into the server layer. The server adaptation function recognizes SCN packets as non-MPLS frames (e.g., by using the UPI when GFP encapsulation is used or by using the EtherType when Ethernet encapsulation is used).

The information on the shared trail SCN link can be associated to any T-MPLS connections that need to be signalled.

When a shared trail SCN link is used, T-MPLS cannot run in parallel with an IP (or other network layer network) user data plane over the same non-MPLS server layer trail.

The second case of interest is two T-MPLS NEs connected through a foreign T-MPLS network domain. This case is shown in Figure 11-2.

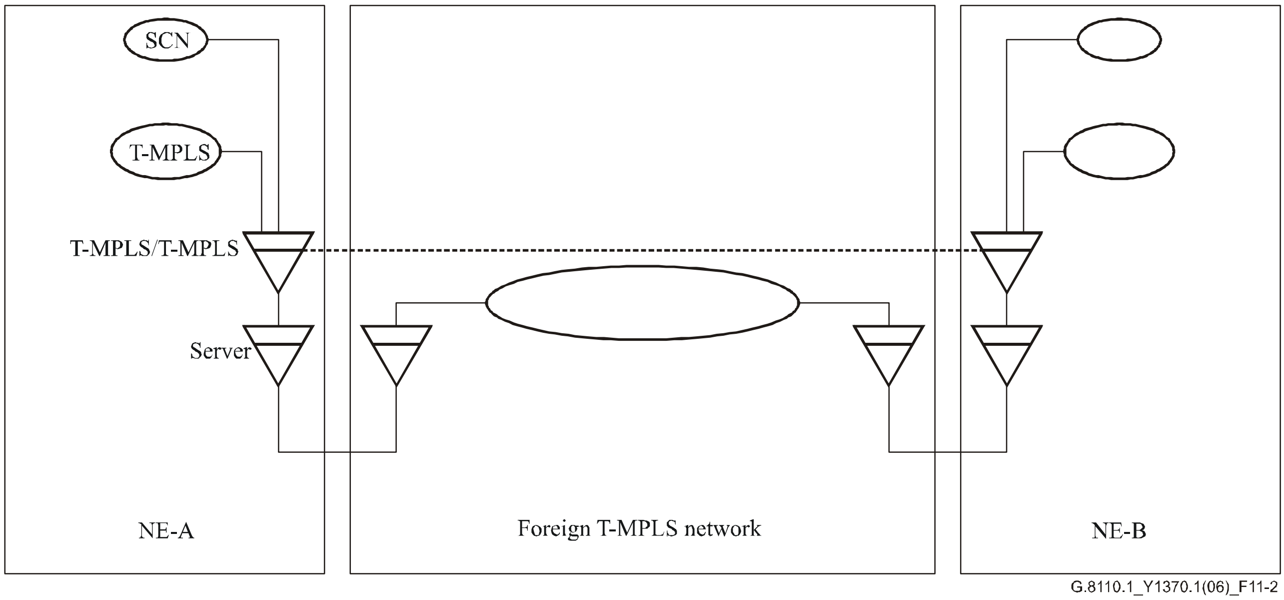

Figure 11-2 – T-MPLS NEs connected by a T-MPLS trail shared with an SCN link

In this case the SCN native packets (e.g., IP or OSINL packets) are directly encapsulated into the T-MPLS server layer trail. The TM/TM adaptation function recognizes SCN packets as non-MPLS frames by using the S bit in the label stack entry associated to the server layer T-MPLS trail.

The information on the shared trail SCN link can be associated to any other T-MPLS connection that needs to be signalled.

When a shared trail SCN link is used, T-MPLS cannot run in parallel with an IP (or other network layer network) user data plane over the same T-MPLS server layer trail.

11.2 Shared hop SCN links

A shared hop SCN link is an SCN link that shares the first hop with a T-MPLS link, but does not necessarily share other hops between the T-MPLS network elements connected by the T-MPLS link.

The shared hop SCN link can be supported by using a separate T-MPLS server trail in parallel with the T-MPLS server trail that provides a T-MPLS link for user traffic. This is shown in Figure 11-3.

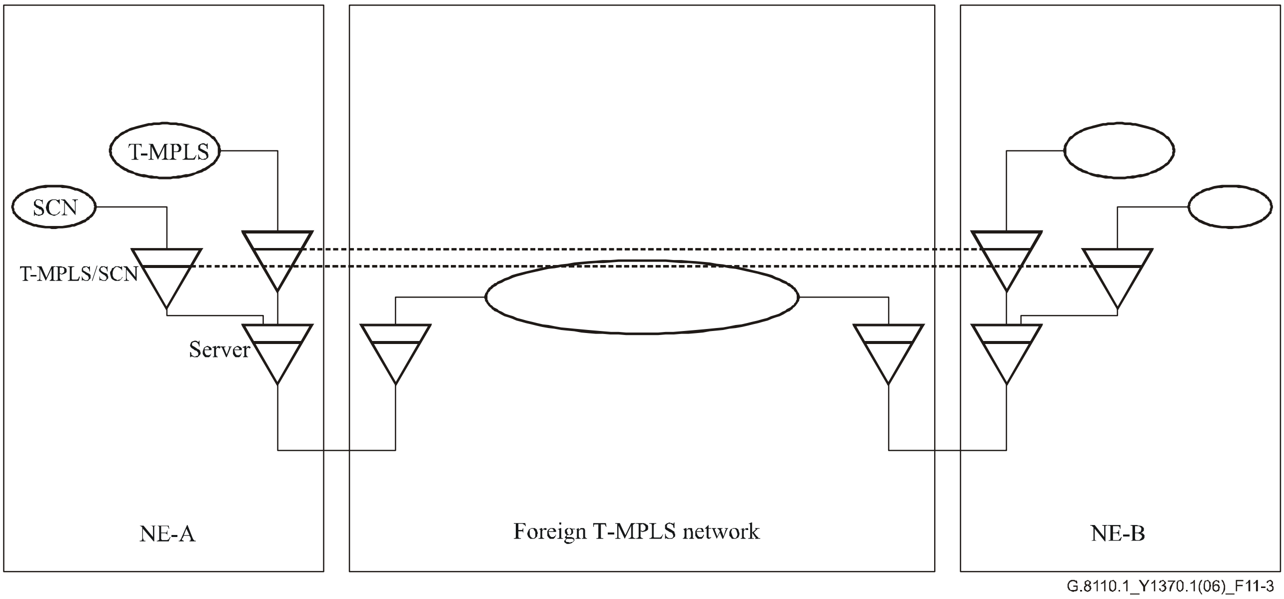

Figure 11-3 – T-MPLS NEs connected by a T-MPLS trail with an SCN link sharing a hop

In this case the SCN native packets (e.g., IP or OSINL packets) are encapsulated into a dedicated MPLS trail. This dedicated T-MPLS trail cannot be used for user plane traffic.

11.2.1 TM/SCN adaptation function

For further study.

11.3 Independent SCN links

T-MPLS can also support independent SCN links. These are SCN links that do not share server trail resources with T-MPLS links and are thus independent of the T-MPLS layer network topology.

The details of independent SCN links are out of the scope of this Recommendation.

12 T-MPLS management communication network

For further study.

Appendix I

Functional model for describing PWE3 and MPLS network interworking

The IETF PWE3 work group has developed methods of transporting services over many different PSNs, one of which is MPLS. Per [b-IETF RFC 3985], PWE3 architecture "PWE3 (pseudowire emulation edge to edge) is a mechanism that emulates the essential attributes of a telecommunications service (such as a T1 leased line or Frame Relay over a PSN (Packet Switched Network))".

An MPLS label is used as the pseudowire demultiplexer. The PSN can be implemented by utilizing a MPLS label switched network. The PSN transport trail is known as a PSN tunnel. The PSN tunnel can transport multiple pseudowires, each demultiplexed by a unique pseudowire MPLS label. A four-octet control word may be added to the MPLS payload field (whether the usage of the control word is required or optional depends on the payload type). The control word carries per-packet information. IETF has defined pseudowire encapsulations for different payload types (e.g., Ethernet, frame relay, ATM, PPP, PDH and SDH).

For a pseudowire server layer the client signal is an "attachment circuit" (AC). An AC may be an Ethernet port, an Ethernet VLAN, a frame relay DLCI, a frame relay port, etc. A pseudowire forwarder binds an AC to a particular pseudowire.

User plane services provided by pseudowires include:

1) Encapsulation of service-specific PDUs or PDH/SDH circuit data received from attachment circuits.
2) Carriage of encapsulated data over a PSN tunnel.
3) Managing the signalling, timing, order or other aspects of the service at the boundaries of the PW.

From an OAM perspective, T-MPLS pseudowires provide status and alarm management for each T-MPLS service instance.

In addition to a forwarder function, the pseudowire/client adaptation function requires certain client-specific processes. Per [b-IETF RFC 3985], these processes are called "native service processing (NSP)". The NSP may apply a transformation operation on the payloads as they pass between Attachment Circuits and pseudowires. Figure I.1 illustrates the pseudowire reference model.

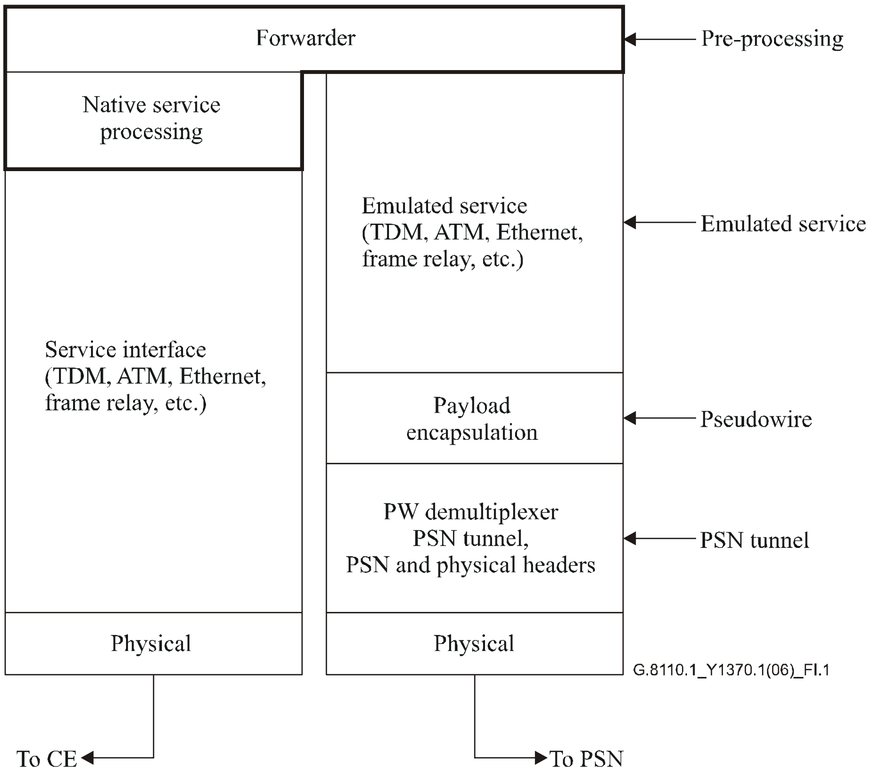

Figure I.1 – Pseudowire reference model

ITU-T Study Group 13 has developed a series of Recommendations for MPLS/client network interworking for different clients: e.g., Ethernet [ITU-T Y.1415], ATM cell mode [b-ITU-T Y.1411], ATM frame mode [b-ITU-T Y.1412], TDM [b-ITU-T Y.1413] and frame relay [b-ITU-T X.84]. These Recommendations are functionally equivalent to IETF PWE3, but use terminology specific to ITU-T. For a MPLS PSN, the encapsulation is the same as PWE3. The Y.1415 Ethernet-MPLS network interworking reference model is shown in Figure I.2.

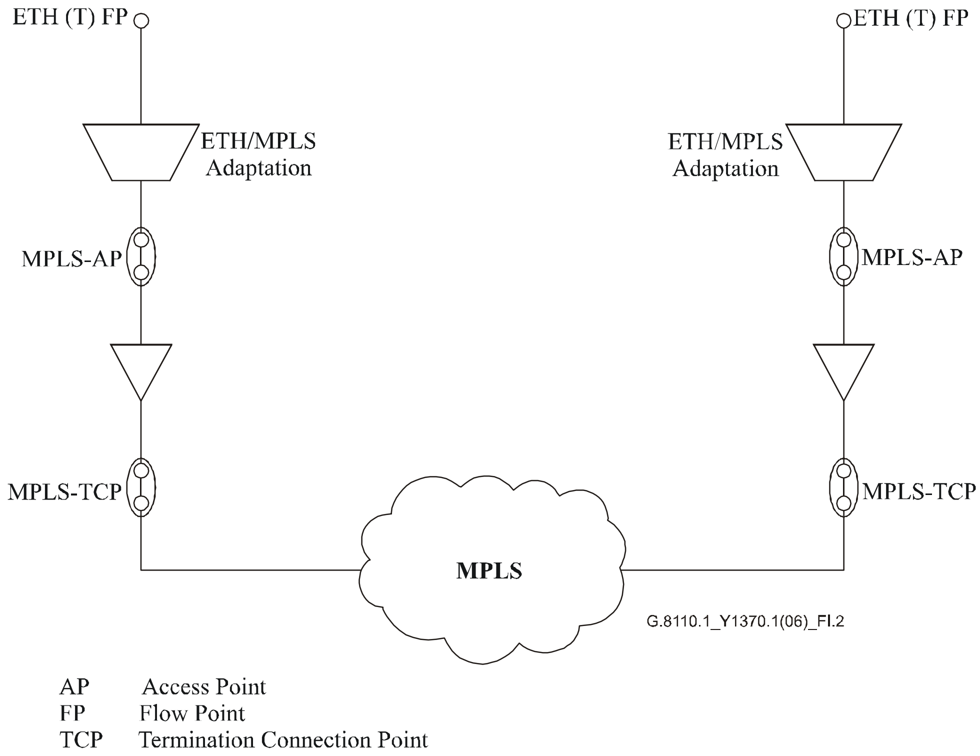

Figure I.2 – Y.1415 Ethernet-MPLS user plane interworking

The Y.1415 "Ethernet circuit" is the equivalent of the PWE3 Ethernet attachment circuit.

In a T-MPLS network, the PWE3/MPLS network interworking sublayer is in essence defined as a T-MPLS sublayer with a unique set of PWE3 MPLS/client adaptation functions. Figure I.3 illustrates how the PWE3 concept fits within the T-MPLS layer network model.

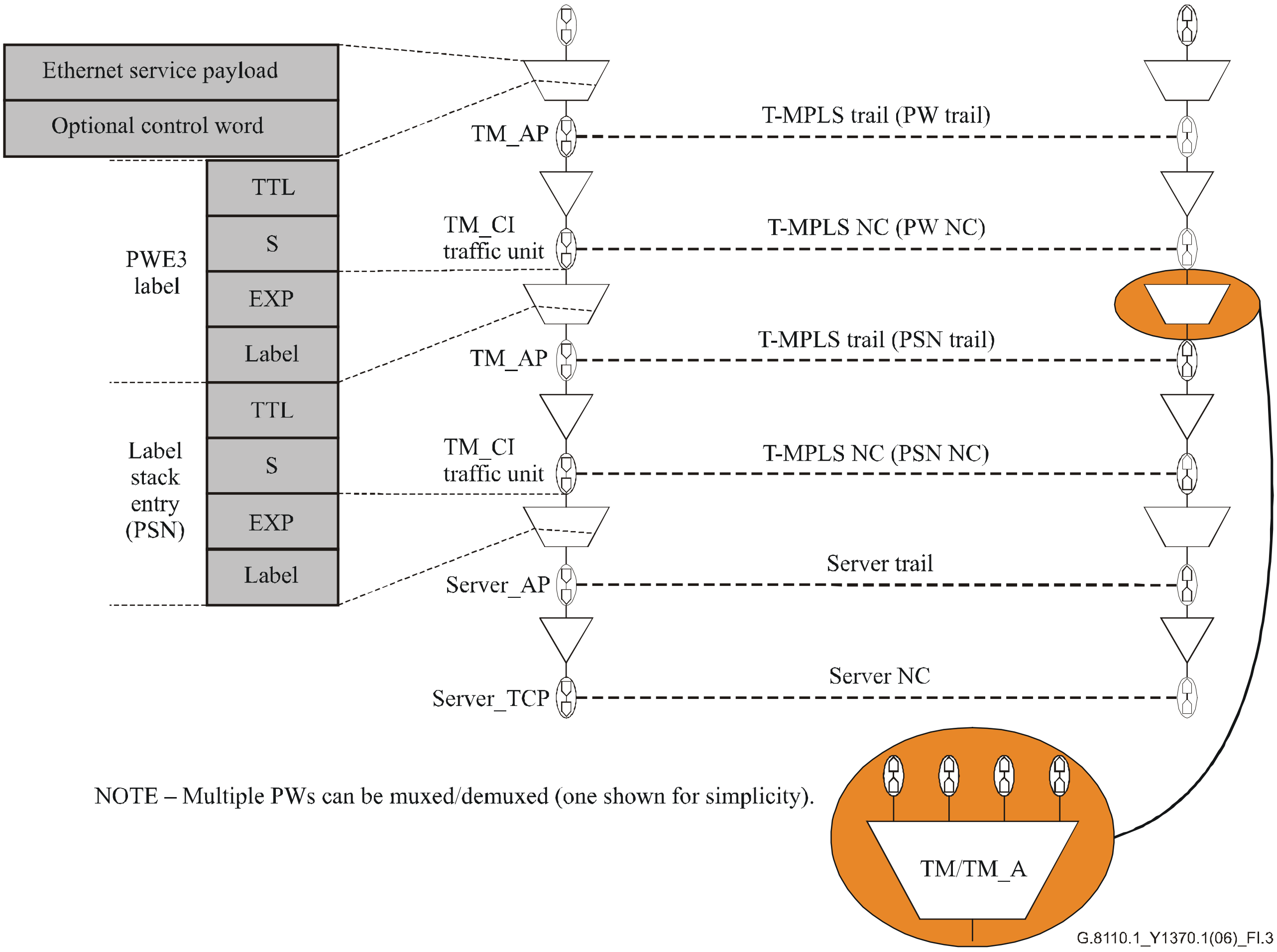

Figure I.3 – Pseudowire model

Note that in T-MPLS the T-MPLS trails use the subset of [ITU-T Y.1711] defined in [ITU-T G.8112] for OAM while the PW as defined by the IETF PWE3 working group is using VCCV [b-IETF VCCV].

Pseudowires can be switched by a subnetwork connection (SNC). This creates, in PWE3 terminology multi-segment pseudowires (MS-PW) as defined in [b-IETF MS PW Arch]. In T-MPLS networks, a pseudowire SNC is equivalent to a T-MPLS SNC. This is illustrated in Figure I.4.

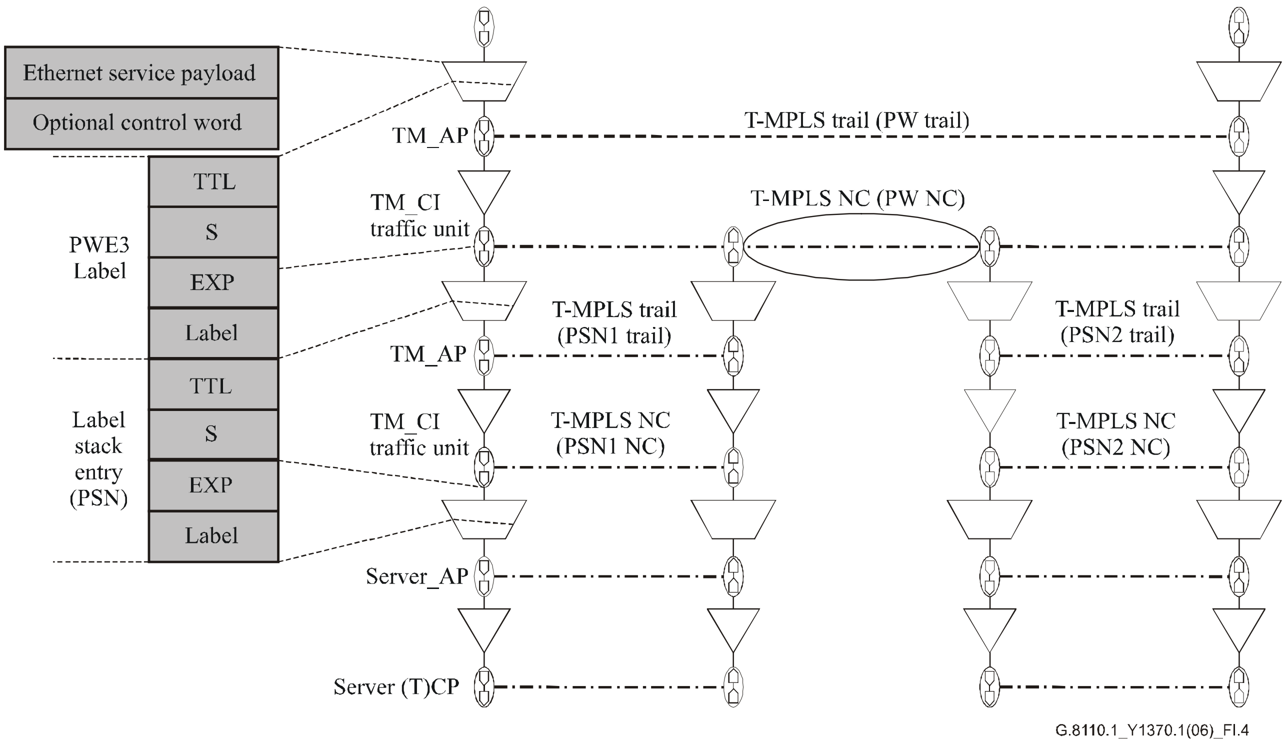

Figure I.4 – Pseudowire switching to create MS-PW

For the pseudowire at the switching point, the label and EXP bits are processed, the label TTL is decremented, but the control word and the service payload are passed across the SNC unchanged. The underlying T-MPLS network connection (pseudowire PSN tunnel) is terminated at the pseudowire switching point.

When the MPLS server layer is an SDH layer network, an SDH path layer may be used instead of the pseudowire PSN transport tunnel. This effectively saves a T-MPLS layer network connection and its associated control and management plane overhead. The SDH path that serves as the "pseudowire PSN tunnel" can be either individual VC or contiguous or virtual concatenated VCs. Figure I.5 illustrates this network model.

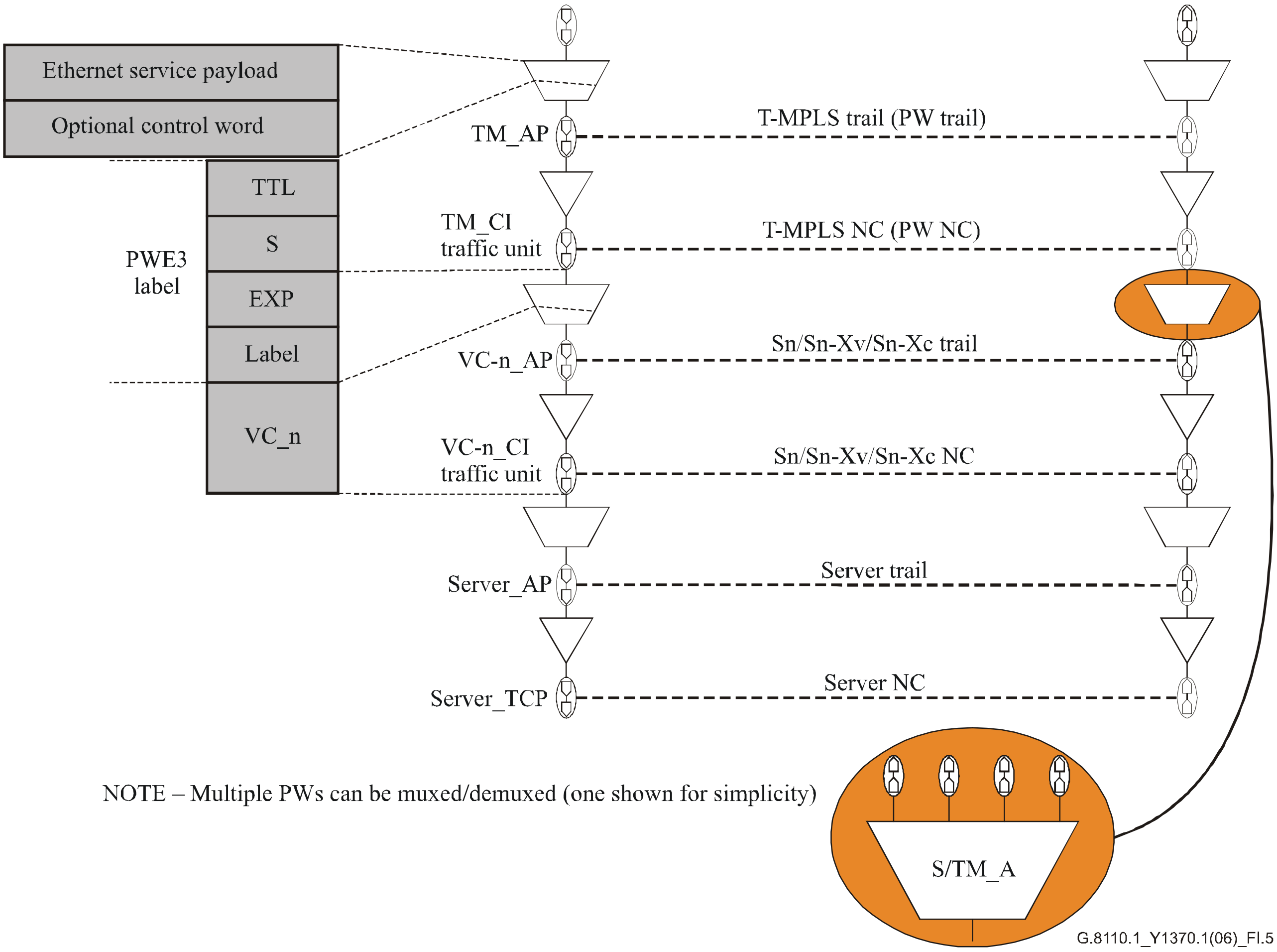

Figure I.5 – Pseudowires over SDH path

Pseudowires can be used as a packet transport mechanism for emulating LAN services over a T-MPLS network. Like in virtual private LAN service (VPLS) a full mesh of T-MPLS trails (PW trails) is used to interconnect split-horizon ETH flow domains as described in Appendix I to [ITU-T Y.1415].

Appendix II

Support of IP/MPLS LSR-based networks by T-MPLS networks supporting point-to-point Ethernet services

When two IP/MPLS LSRs are connected via e.g., 802.3 interfaces to a T-MPLS network, the T-MPLS network can provide an Ethernet service between these two LSRs (nodes LSR A and LSR B in Figure II.1) to establish an IP/MPLS link between these LSRs.

The IP/MPLS LSRs encapsulate their IP/MPLS packets into Ethernet frames with or without VLAN Tag. These Ethernet frames are then transported via 802.3 interfaces to the T-MPLS network edge (nodes X and Y). At the T-MPLS network edge the Ethernet signal is treated either as an all-to-one Ethernet service or as one or more EVC and/or bundled Ethernet services of which the frames are mapped into one or more T-MPLS (PW) trails and then transported through the T-MPLS network.

In this network scenario the IP/MPLS routing and control plane adjacency is between LSR A and LSR B. The T-MPLS network elements do not participate in the IP/MPLS routing and control plane. A signalling session that requests PHP is between LSR A and LSR B (T-MPLS nodes X and Y are not involved).

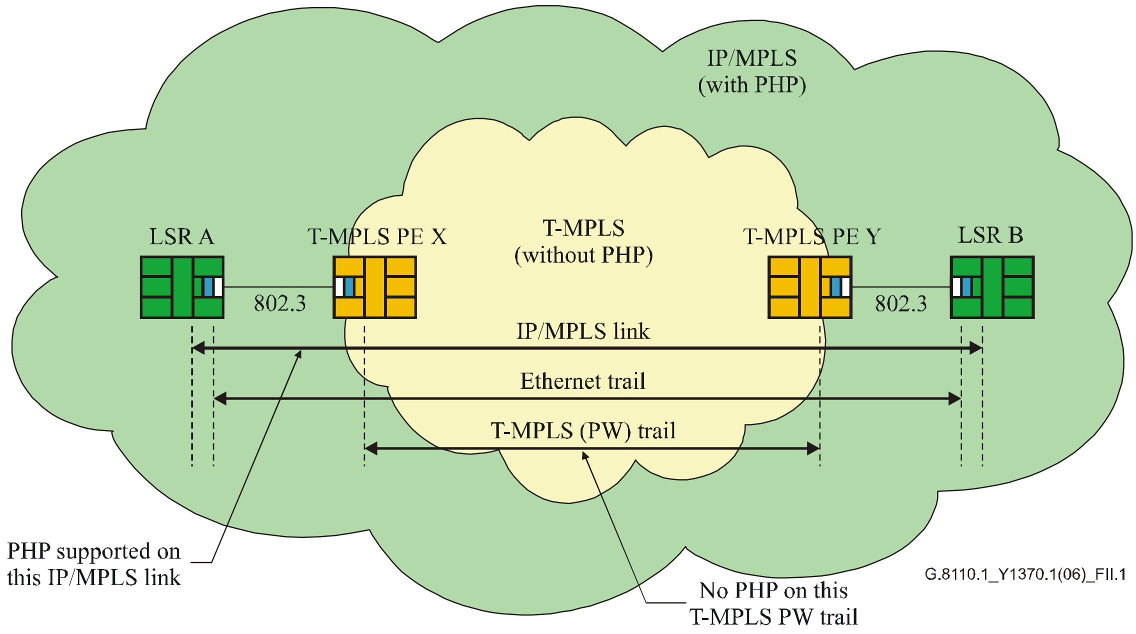

Figure II.1 – IP/MPLS via Ethernet over T-MPLS network

The functional model for this scenario is described in Figure II.2. The atomic functions in the figure are specified in [b-ITU-T G.8021] and [b-ITU-T G.8121]. The IP/MPLS signals are carried through an IP/MPLS link between LSR A and LSR B supported by an ETH trail between LSR A and LSR B. The ETH trail is carried through a serial-compound ETH link supported by an ETY trail interconnecting LSR A with T-MPLS PE X, a T-MPLS (PW) trail interconnecting T-MPLS PE X with T-MPLS PE Y and an ETY trail interconnecting T-MPLS PE Y with LSR B.

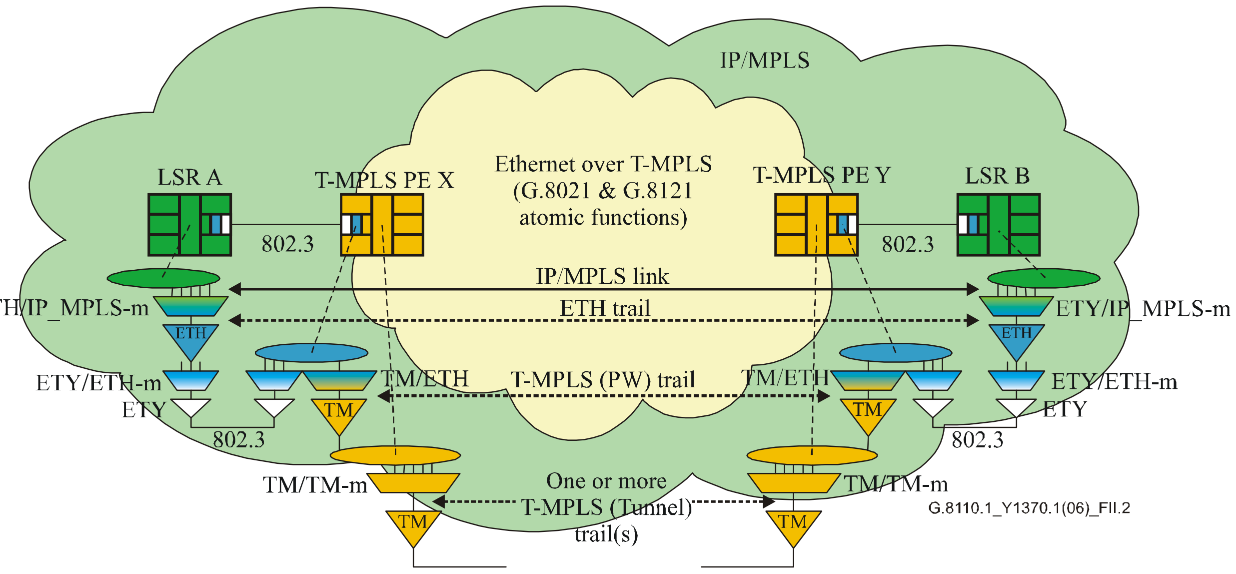

Figure II.2 – Functional model for IP/MPLS via Ethernet over T-MPLS network

Appendix III

Platform and interface label spaces

Each of the label spaces referenced in clauses 6.5.3 and 6.5.4 is provided by a label manager. This allows T-MPLS using the EtherType 0x8847 over Ethernet interfaces.

When a packet is received on an Ethernet interface with EtherType 0x8847, it is looked up in one particular label space as defined in clause 3.4 of [IETF RFC 3031].

The label manager is responsible for the allocation and reclamation of the labels that are used within an MPLS or T-MPLS adaptation function. All MPLS and/or T-MPLS applications interface to this manager to obtain labels.

When a request is made to a label manager for a label value there is no guarantee that a particular label value is assigned.

As a consequence, when a T-MPLS connection is set up by a network management system, the management plane does not own the label space but has to ask to a label manager the label value to use.

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