International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.8110.1/Y.1370.1

Amendment 1
(07/2007)

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

Amendment 1

ITU-T Recommendation G.8110.1/Y.1370.1 (2006) – Amendment 1

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TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

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ITU-T Recommendation G.8110.1/Y.1370.1

Architecture of Transport MPLS (T-MPLS) layer network

Amendment 1

Summary

This amendment contains additional material to be incorporated into ITU-T Recommendation G.8110.1/Y.1370.1. It presents the architectural aspects of T-MPLS unidirectional point-to-multipoint (p2mp) connections, T-MPLS OAM, T-MPLS survivability and security aspects.

The p2mp forwarding plane architecture is based on a profile of the ongoing work in IETF (see Appendix V).

Source

Amendment 1 to ITU-T Recommendation G.8110.1/Y.1370.1 (2006) was approved on 29 July 2007 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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Architecture of Transport MPLS (T-MPLS) layer network

Amendment 1

1) Scope

This amendment contains additional material to be incorporated into [ITU-T G.8110.1]. It presents the architectural aspects of T-MPLS unidirectional point-to-multipoint (p2mp) connections, T-MPLS OAM, T-MPLS survivability and security aspects.

The p2mp forwarding plane architecture is based on a profile of the ongoing work in IETF (see Appendix V).

2) References

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

3) Conventions

This amendment contains changes to [ITU-T G.8110.1].

Some of the material is new, while some represents modifications to existing material in the original Recommendation.

4) Changes to G.8110.1

The following clauses contain changes to be made to G.8110.1.

4.1) Changes to Summary

Change the Summary as follows:

This Recommendation describes the functional architecture of Transport MPLS (T-MPLS) layer networks and uses components described in the MPLS Layer Network Architecture of ITU-T Rec. G.8110/Y.1370.

The transport 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.

4.2) Changes to clause 1, Scope

Change clause 1 as follows:

This Recommendation describes the functional architecture of Transport MPLS (T-MPLS) layer networks and uses 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. The p2mp forwarding plane architecture is based on a profile of the ongoing work in IETF (see Appendix V).

This Recommendation describes the layer network 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 forwarding plane modelled in [ITU-T G.8110]. Transport 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 management and signalling communication networks. 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 & maintenance (OAM) functions.

This means that an LSP initiated from an IP/MPLS network element is encapsulated in Ethernet 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 is encapsulated in Ethernet before it transits an IP/MPLS network. This enforces the independence of the control planes for T-MPLS and IP/MPLS.

This Recommendation supports Ethernet as the client of the T-MPLS layer network.

Equipment developed prior to the production of this Recommendation is not expected to comply with this Recommendation.

4.3) Additions to clause 2, References

4.3.1) Additions to clause 2

Add the following references:

[ITU-T G.808.1] ITU-T Recommendation G.808.1 (2006), *Generic protection switching – Linear trail and subnetwork protection*.

[ITU-T G.8080] ITU-T Recommendation G.8080/Y.1304 (2006), *Architecture for the automatically switched optical network (ASON)*.

[ITU-T G.8121] ITU-T Recommendation G.8121/Y.1381 (2006), *Characteristics of Transport MPLS equipment functional blocks*.

[ITU-T M.20] ITU-T Recommendation M.20 (1992), *Maintenance philosophy for telecommunication networks*.

[ITU-T X.731] ITU-T Recommendation X.731 (1992), *Information technology – Open Systems Interconnection – Systems Management: State management function*.

[IEEE 802.3] IEEE Standard 802.3-2005, *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*.

[IEEE 802.1AE] IEEE Standard 802.1AE-2006, *Local and metropolitan area networks – Media Access Control (MAC) Security*.

4.3.2) Changes to clause 2

Replace the reference to Y.1720 with the following reference:

[ITU-T G.8131] ITU-T Recommendation G.8131/Y.1382 (2007), *Linear protection switching for Transport MPLS (T-MPLS) networks*.

4.4) Additions to clause 3, Definitions

4.4.1) Additions to clause 3

Add the following definition from [ITU-T G.805]:

3.3 administrative domain

3.8 connection supervision

3.12 management domain

3.17 sub-layer

3.21 tandem connection

4.4.2) Additions to clause 3

Add the following definitions at the end of clause 3:

This Recommendation uses the following terms defined in [ITU-T G.808.1]:

3.42 network survivability

3.43 protection

3.44 restoration

This Recommendation uses the following term defined in [ITU-T X.731]:

3.45 administrative state

This Recommendation uses the following terms defined in [ITU-T G.8010]:

3.46 maintenance entity group

3.47 maintenance entity

3.48 maintenance entity group end point compound sink function

3.49 maintenance entity group end point compound source function

3.50 maintenance entity group intermediate point compound function

3.51 pro-active monitoring

3.52 on-demand monitoring

This Recommendation defines the following term:

3.53 Transport MPLS (T-MPLS)

T-MPLS is a connection-oriented packet transport network technology. T-MPLS creates an application profile of the forwarding plane as defined in the relevant IETF RFCs for the use of MPLS frame format (MPLS header), the MPLS forwarding semantics (e.g., label swapping and stacking) and the client to MPLS mapping in transport networks. These basic functions are complemented with transport network functionality such as connection and performance monitoring, survivability including protection switching and restoration, management and control plane (ASON/GMPLS).

4.5) Additions to clause 4, Abbreviations

Add the following abbreviations to G.8110.1:

A	Adaptation
APS	Automatic Protection Switch
EMF	Equipment Management Function
LC	Link Connection
ME	Maintenance Entity
MEG	Maintenance Entity Group
MEP	Maintenance entity group End Point
MIP	Maintenance entity group Intermediate Point
NC	Network Connection
NE	Network Element
NMS	Network Management System
ODU	Optical channel data unit
OS	Operations System
OTH	Optical Transport Hierarchy
p2mp	point-to-multipoint
p2p	point-to-point
SDH	Synchronous Digital Hierarchy
Sk	Sink
SN	Sub-Network
SNC	Sub-Network Connection
SNC/S	SNCP with Sub-layer monitoring
SNCP	Sub-Network Connection Protection
So	Source
TMD	T-MPLS Diagnostic function
TMDe	T-MPLS Diagnostic function within TMx MEP
TMDi	T-MPLS Diagnostic function within TMx MIP
TMT	T-MPLS Tandem Connection
TT	Trail Termination
VC	Virtual Container

4.6) Additions to clause 5, Conventions

Add the following paragraph after the first paragraph in clause 5:

The diagrammatic conventions for MEG End Point (MEP) and MEG Intermediate Point (MIP) compound functions are those of [ITU-T G.8010].

4.7) Additions to clause 6, Functional architecture of Transport MPLS networks

4.7.1) Additions to clause 6.1

Add the following bullet in clause 6.1 (after the first bullet saying "It is a CO-PS technology therefore its architecture is based on [ITU-T G.805]"):

– T-MPLS connections are supported by traffic-engineered connections in the server layer.

4.7.2) Changes to clause 6.1

Replace the following bullet in clause 6.1:

– OAM is based on [ITU-T Y.1711].

With the following bullet:

– OAM is based on [ITU-T Y.1711] as profiled in [ITU-T G.8112].

4.7.3) Changes to clause 6.1

Replace the following bullet in clause 6.1:

– Protection switching and survivability are based on [ITU-T Y.1720].

With the following bullet:

– Protection switching and survivability are based on [ITU-T G.808.1] and [ITU-T G.8131].

4.7.4) Changes to clause 6.1

Replace the following bullet in clause 6.1:

– Multicasting will be supported but currently it is for further study.

With the following bullet:

– Unidirectional point-to-multipoint connections are supported as unidirectional p2mp LSPs (see Appendix V for additional details).

4.7.5) Changes to clause 6.2.2

Change the following paragraph in clause 6.2.2 as follows:

The T-MPLS OAM traffic unit is composed by the T-MPLS OAM PDU defined in [ITU-T G.8112] extended with the S field of the MPLS shim header.

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

4.7.6) Additions to clause 6.3

Add Figure 6-1 at the end of clause 6.3:

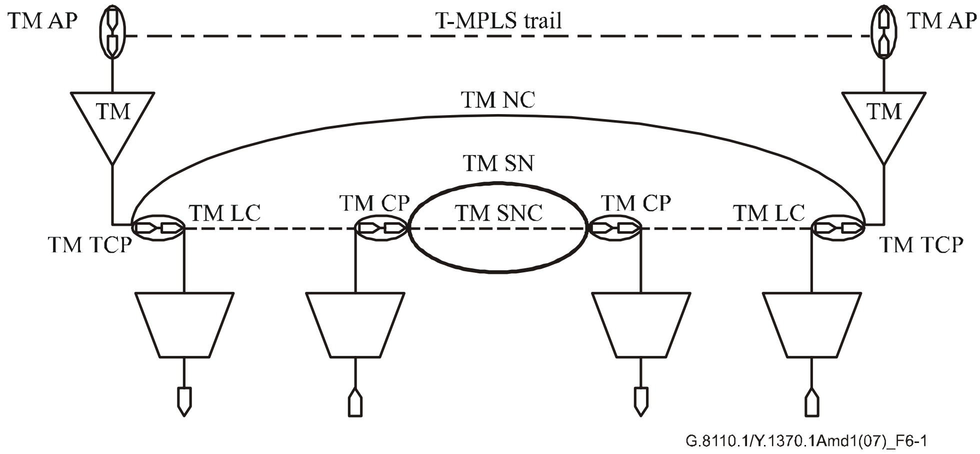

Figure 6-1 – T-MPLS layer network example

4.7.7) Changes to clause 6.3.3.1

Replace the text in clause 6.3.3.1, T-MPLS trail termination, as follows:

The bidirectional T-MPLS trail termination (TM_TT) function is performed by a colocated 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 following processes between its input and output:

– inserts the 8-bit TTL field;
– inserts network connection level T-MPLS OAM signals for pro-active monitoring;
– outputs the resulting TM_CI.

The T-MPLS trail termination sink (TM_TT_Sk) performs the following functions between its input and output:

– extracts and processes network connection level T-MPLS OAM signals for pro-active monitoring;
– extracts and terminates the 8-bit TTL field;
– outputs the resulting TM_AI.

4.7.8) New clause 6.9

Add a new clause 6.9, T-MPLS network topology, as follows:

6.9 T-MPLS network topology

A T-MPLS layer network contains zero or more TM links and zero or more TM sub-networks.

Transport MPLS layers can support unidirectional and bidirectional point-to-point connections, and unidirectional point-to-multipoint connections between two or more connection points and/or termination connection points at the edges of the T-MPLS layer network administrative domain.

6.9.1 Unidirectional and bidirectional connections and trails

A bidirectional connection in a server layer network may support either bidirectional or unidirectional client layer network connections, but a unidirectional server layer network may only support unidirectional client layer network connections.

6.9.2 Unidirectional point-to-multipoint connections and trails

A unidirectional point-to-multipoint network connection broadcasts the traffic from the root T-MPLS TCP to the leaf T-MPLS TCPs as illustrated in Figure 6-2.

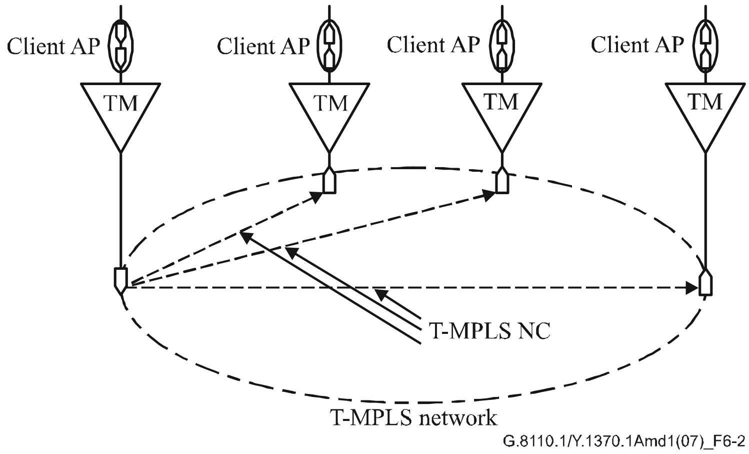

Figure 6-2 – Point-to-multipoint T-MPLS connection

A unidirectional point-to-multipoint sub-network connection broadcasts the traffic from the root T-MPLS CP to the leaf T-MPLS CPs as illustrated in Figure 6-3. The broadcast function provided by the point-to-multipoint sub-network connection is limited to the sub-network in which it exists. It may form part of a broadcast function within a larger (containing) sub-network or network connection.

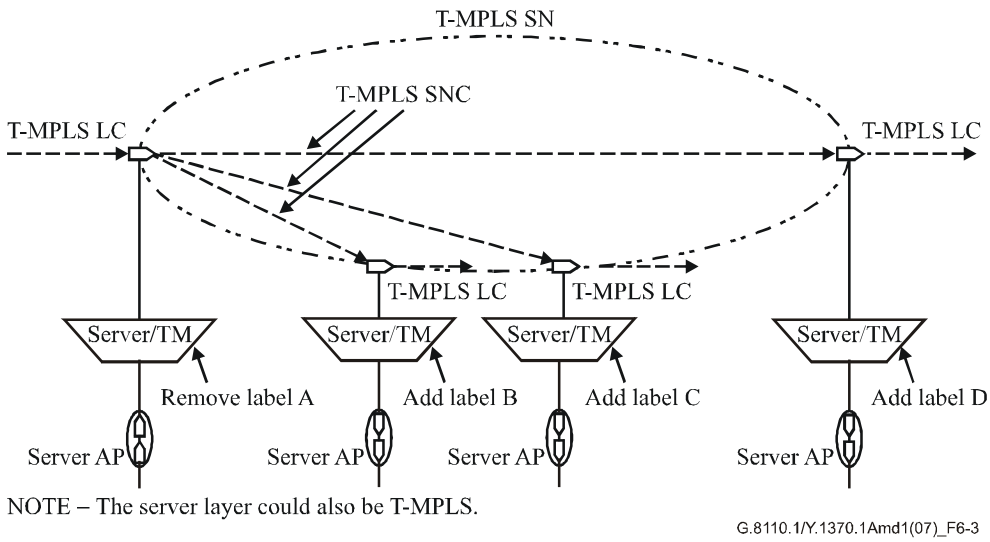

Figure 6-3 – Point-to-multipoint T-MPLS sub-network connection

4.8) Additions to clause 7, Server/client associations

4.8.1) Changes to clause 7.2

Change the following paragraph in clause 7.2, TM/TM adaptation as follows:

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

4.8.2) Additions to clause 7.3

Add the following text after the second paragraph in clause 7.3, Server/TM adaptation:

The Server/TM adaptation functions can work in two basic modes: in the mode 1, one or more TM connection points are allowed, while in the mode 2 only a single TM connection point is allowed.

NOTE – The support of mode 1 is mandatory while the support of mode 2 is optional.

4.8.3) Additions to clause 7.3

Replace the last two paragraphs is clause 7.3, Server/TM adaptation, as follows:

The Srv/TM adaptation source (Srv/TM_A_So) performs the following processes between its input and output.

– *For the case of mode 1*
  - Insert the same value 20-bit MPLS Label into each TM_CI traffic unit associated with a particular connection point;
  - Insert EXP field according to processes described in clause 10.2;
  - Multiplex the T-MPLS Labelled frames.
– *For the case of mode 2*
  - Remove the TTL and S fields.
– Server layer related specific processes.

The Srv/TM adaptation sink (Srv/TM_A_Sk) performs the following processes between its input and output:

– Server layer related specific processes.
– *For the case of mode 1*
  - Demultiplex the MPLS labelled Packets using the 20-bit label value;
  - Remove the 20-bit Label;
  - Process EXP according to clause 10.2;
  - Process TTL according to clause 10.1. When the TTL is decremented and has expired, the traffic unit is discarded.
– *For the case of mode 2*
  - Insert a TTL field equal to 254 and the S bit equal to 0.

4.9) Additions to clause 8, Transport MPLS network management

Replace the text in clause 8 with:

This clause describes network management for the T-MPLS transport network. In particular, it describes the maintenance entities, maintenance entity supervision techniques and layer network management requirements for fault, performance and configuration management, management communications and client/server interaction management.

8.1 Generic requirements

8.1.1 Generic fault, configuration and performance management

The T-MPLS layer network shall provide support for fault, configuration and performance management end-to-end and also within and between administrative boundaries.

It shall provide a means of detection and notification in the event of a misconnection.

The T-MPLS layer network shall provide facilities to:

– ensure interconnection of transport network entities that have compatible adapted or characteristic information;

– detect faults, isolate faults and initiate recovery actions where applicable. The T-MPLS layer network shall provide facilities for single-ended maintenance.

In the event of a signal within the server layer being interrupted, upstream and downstream network entities in the server layer shall be notified.

The T-MPLS layer network shall be able to detect performance degradations to avoid failures and verify quality of service.

8.1.2 Generic management communications

The T-MPLS layer network shall support communications between:

– OSs and remote NEs;

– craft terminals and local or remote NEs.

These forms of communication may also be supported externally to the T-MPLS layer network.

8.1.3 Generic client/server interaction management

The T-MPLS layer network shall detect and indicate when connectivity is not present between two T-MPLS CPs, regardless of the state of the server layer.

In order to avoid unnecessary, inefficient or conflicting survivability actions, escalation strategies (e.g., introduction of hold-off times and alarm suppression methods) are required:

– within a layer;

– between the server and client layer.

8.1.4 T-MPLS maintenance entity groups

The basic maintenance entities in the T-MPLS network are the T-MPLS connection-oriented trail (see Figure 6-1).

The T-MPLS trail monitors the T-MPLS network connection between a pair of termination connection points at the boundary of the T-MPLS layer network.

The T-MPLS layer network may contain multiple administrative domains: e.g., service provider and one or more network operator domains. Each of these administrative domains has an associated maintenance entity group located between a pair of T-MPLS connection points at the boundaries of that T-MPLS layer network administrative domain. Maintenance entity groups also exist between a pair of T-MPLS connection points at the boundary of two adjacent T-MPLS layer network administrative domains. Figures 8-1 and 8-2 illustrate such T-MPLS layer network administrative domain maintenance entity groups for the point-to-point and point-to-multipoint connection cases.

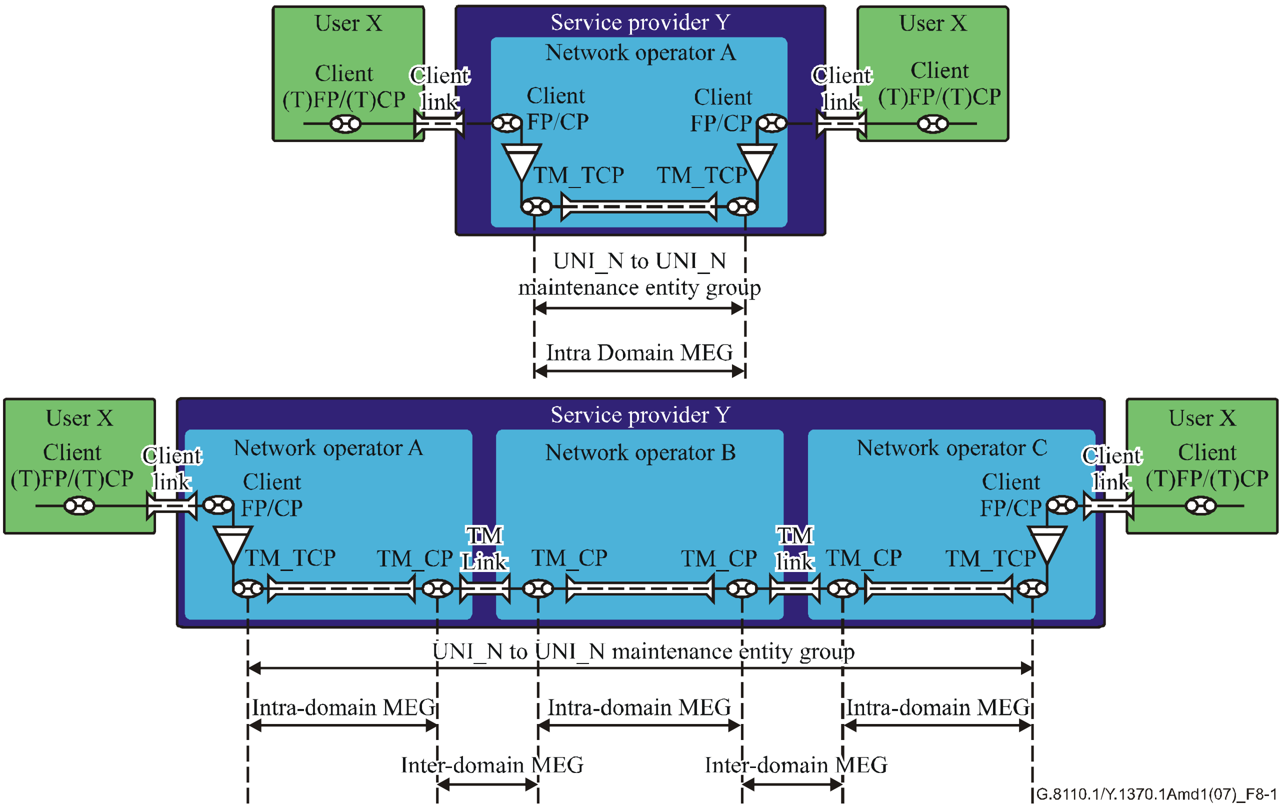

Figure 8-1 – Point-to-point T-MPLS connection administrative domain associated maintenance entity groups

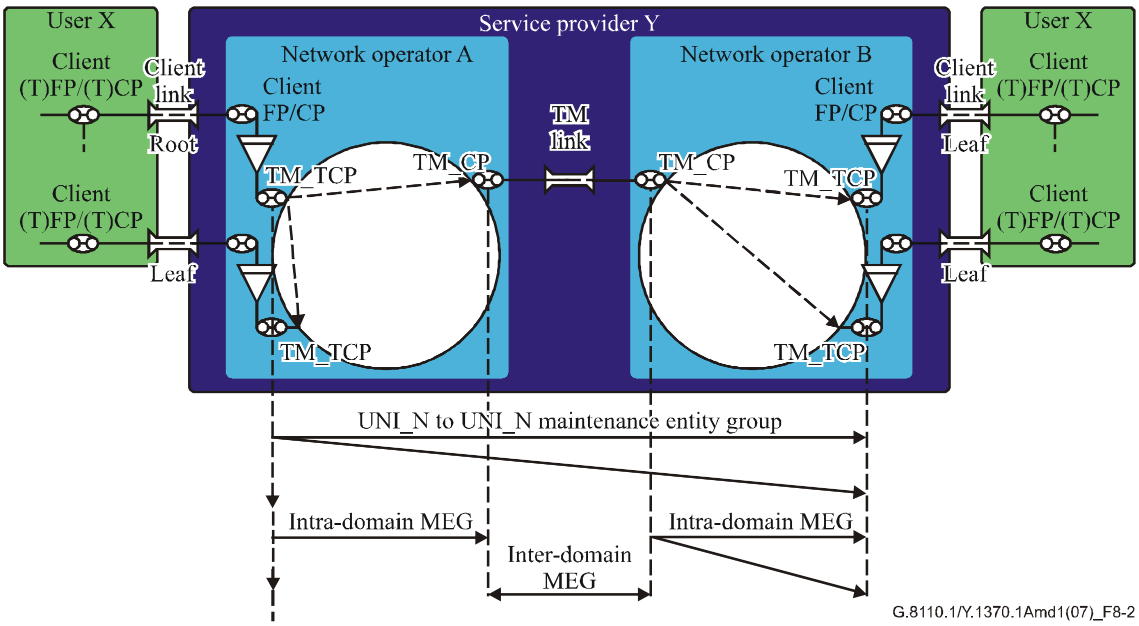

Figure 8-2 – Point-to-multipoint T-MPLS connection administrative domain associated maintenance entity groups

Protection switching/restoration applications as well as testing applications may require the presence of T-MPLS layer network maintenance entity groups for their operation. Such maintenance entity groups can be between any two T-MPLS connection points in the T-MPLS layer network.

8.2 T-MPLS connection supervision techniques

Connection supervision is the process of monitoring the integrity of a given maintenance entity group in the T-MPLS layer network. The integrity may be verified by means of detecting and reporting continuity, connectivity and transmission performance defects for a given maintenance entity group. [ITU-T G.805] defines four types of monitoring techniques for maintenance entity groups.

The maintenance entity group supervision process can be applied to network connections or tandem connections (an arbitrary series of sub-network connections and link connections).

8.2.1 Inherent monitoring

T-MPLS maintenance entity groups may be indirectly monitored by using the inherently available data from the server layers and computing the approximate state of the client connection from the available data.

T-MPLS layer network maintenance entity groups may be indirectly monitored by using the inherently available data from the T-MPLS server layers (e.g., SDH VC, OTH ODU, T-MPLS server trail) and computing the approximate state of the T-MPLS maintenance entity group from the available data.

8.2.2 Non-intrusive monitoring

This clause is for further study.

8.2.3 Intrusive monitoring

For the diagnostic tests of certain parameters (e.g., throughput), an intrusive measurement has to be performed that interrupts the user data traffic in the diagnosed entity. The diagnostic tests can be performed as uni- or bidirectional diagnostic tests. In case of unidirectional tests, the user data traffic in one direction is interrupted. In case of bidirectional tests, the user data traffic in both directions is interrupted. An OAM signal that carries the Lock indication is inserted for the immediate client ME at the egress of the interrupted entity.

This technique is restricted to the set-up, or intermittent testing.

8.2.4 Sub-layer monitoring

Additional OAM and trail overhead is added to the original characteristic information such that the maintenance entity group of interest can be directly monitored by a trail created in a sub-layer. With this technique, all parameters can be tested directly. This scheme can provide for nested sub-layer trail monitored maintenance entity groups.

The applications of sub-layer monitoring include monitoring a multi-domain T-MPLS connection; supporting sub-network protection mechanisms (e.g., SCN/S) and supporting fault location (for both unidirectional and bidirectional connections). The usage of sub-layer monitoring for fault localization is outside the scope of this Recommendation and it is described in [ITU-T M.20].

T-MPLS layer (network, tandem and link) maintenance entity groups may be directly monitored by means of insertion of tandem connection monitoring OAM at the ingress of the maintenance entity group and extraction and processing of this OAM at the egress of the maintenance entity group.

Insertion, extraction and processing of this tandem connection monitoring OAM is functionally performed in the T-MPLS tandem connection trail termination functions TMT_TT, which establish T-MPLS tandem connection trails. For this purpose, the TM_CP is expanded into a TM_CP, TMT/TM_A function, TMT_AP, TMT_TT and TM_TCP as illustrated in Figure 8-3.

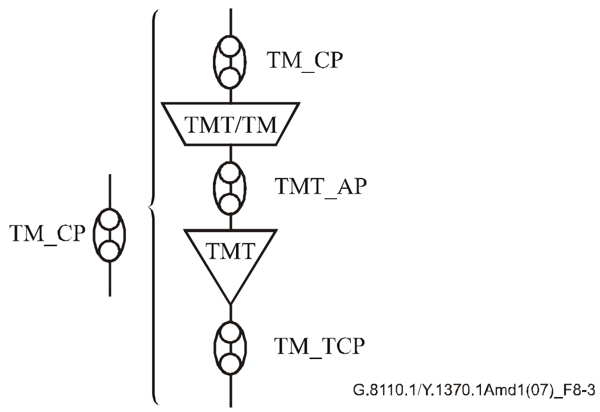

Figure 8-3 – Creating a T-MPLS sub-layer by expansion of a TM_CP

8.2.5 Layer monitoring

OAM is added to the adapted information such that the network connection's maintenance entity group can be directly monitored by the T-MPLS trail created in the T-MPLS layer network. With this technique, all parameters can be tested directly.

T-MPLS layer network maintenance entity groups may be directly monitored by means of insertion of connection monitoring OAM at the ingress of the T-MPLS trail and extraction and processing of this OAM at the egress of the T-MPLS trail.

Insertion, extraction and processing of this connection monitoring OAM is functionally performed in T-MPLS trail termination functions TM_TT, which establish T-MPLS connection-oriented trails.

8.2.6 Maintenance entity levels

T-MPLS OAM defines a single maintenance entity group (MEG) for network connection monitoring, up to six maintenance entity groups (MEGs) for tandem connection monitoring and one maintenance entity group (MEG) for link connection monitoring.

Tandem connections can be nested. Overlapping is not supported.

Tandem connection requires that the OAM frames at the network connection, link connection and tandem connection be distinguishable from each other.

Tandem connection nesting requires that the OAM frames at the client and server MEGs be distinguishable from each other.

Maintenance entity group end point source compound functions (MEP_So) add their connection monitoring T-MPLS OAM traffic units to the TM_CI. At T-MPLS tandem or link connection MEP_So compound functions, the incoming TM_CI may contain TM_CI traffic units carrying T-MPLS OAM for one or more client MEGs.

To ensure isolation of the operation of the local T-MPLS tandem or link connection MEG, the MEP source compound function increments the value of the MEG level (encoded in the MEG Level field inside the T-MPLS OAM PDU) of the incoming T-MPLS OAM traffic units and the MEP sink compound function decrements the value of the MEG level of the outgoing T-MPLS OAM traffic units. All the MEPs and MIPs inside an MEG will process and generate T-MPLS OAM traffic units with the MEG level equal to 0.

NOTE – The MEP source compound function must prevent any incoming T-MPLS OAM traffic unit received with MEG level 7 from entering its maintenance entity group.

8.2.7 T-MPLS maintenance entity group monitoring

8.2.7.1 Pro-active monitoring

T-MPLS maintenance entity groups may be pro-actively monitored by means of insertion of T-MPLS OAM at the ingress of the T-MPLS maintenance entity group and extraction and processing of this T-MPLS OAM at the egress of the T-MPLS maintenance entity group. A T-MPLS maintenance entity group may operate at the network or tandem connection level.

Insertion, extraction and processing of this T-MPLS OAM is functionally performed in a T-MPLS trail termination function TM_TT (refer to clause 6.3.3.1) or in a T-MPLS tandem connection trail termination function TMT_TT (refer to clause 8.3.1.1).

The TM_TT or TMT_TT function at the ingress/egress of a T-MPLS p2p maintenance entity group terminates the maintenance entity group and one point-to-point maintenance entity.

The TM_TT or TMT_TT function at the ingress/egress of an N point T-MPLS p2mp maintenance entity group terminates the maintenance entity group and N–1 point-to-point maintenance entities.

8.2.7.2 On-demand monitoring

On-demand T-MPLS MEG monitoring application complements the pro-active T-MPLS monitoring application. On-demand T-MPLS MEG monitoring application provides performance characterization and fault localization capabilities. The latter allow for discovering the node in which a T-MPLS continuity or connectivity fault is located. On-demand T-MPLS OAM can be inserted at the ingress of the T-MPLS maintenance entity, which is then replied to from intermediate and/or egress points of the T-MPLS maintenance entity group. Insertion, extraction and processing of this on-demand T-MPLS OAM is functionally performed in T-MPLS diagnostic trail termination functions TMD_TT. For this purpose, the TM_CP is expanded into a TM_CP, TMD/TM_A function, TMD_AP, TMD_TT and TM_TCP as illustrated in Figure 8-4.

A TMD_TT function has two modes: originator and responder (refer to clause 8.3.1.2). Both modes are enabled in the TMDe_TT function, which is part of a T-MPLS MEP compound function (see clause 8.2.7.3). The responder mode is enabled in the TMDi_TT function, which is part of a T-MPLS MIP compound function (see clause 8.2.7.4).

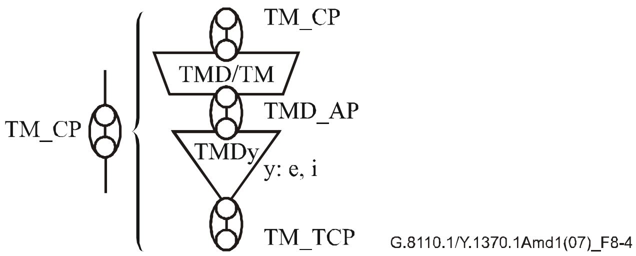

Figure 8-4 – Creating T-MPLS on-demand monitoring functions by expansion of a TM_CP

8.2.7.3 T-MPLS MEP compound functions

The T-MPLS MEP trail termination functions combine the following atomic functions (Figure 8-5):

– T-MPLS network/tandem connection to T-MPLS or client adaptation (TM/Client_A, TM/TM_A or TMT/TM_A);

– T-MPLS network/tandem connection trail termination (TM_TT or TMT_TT);

– T-MPLS diagnostic to T-MPLS adaptation (TMD/TM_A);

– T-MPLS diagnostic trail termination (TMDe_TT).

A T-MPLS MEP function is able to originate and terminate pro-active T-MPLS OAM signals and to originate, respond to and terminate diagnostic T-MPLS OAM signals.

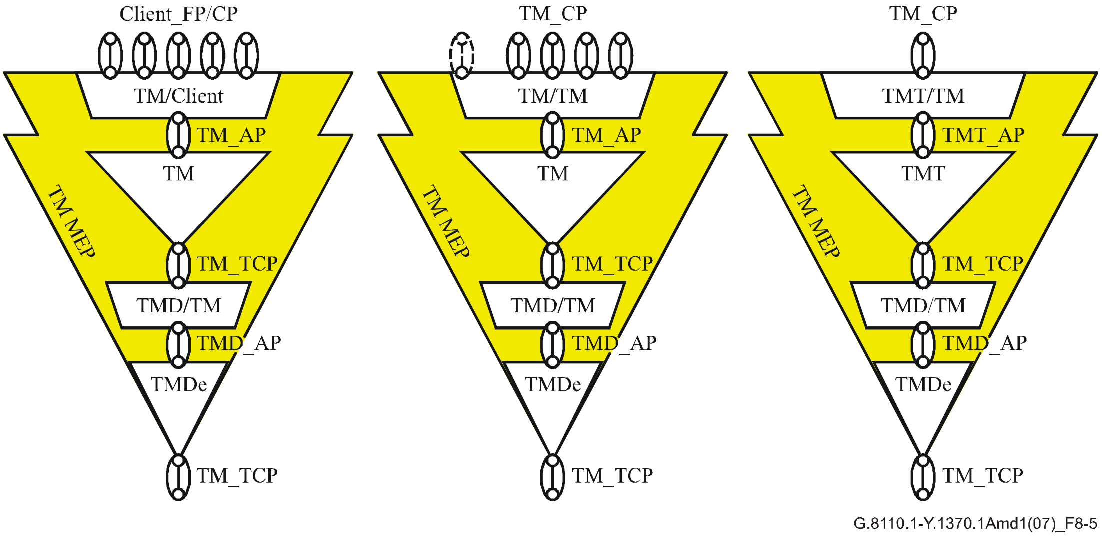

Figure 8-5 – TM and TMT MEP compound functions

8.2.7.4 T-MPLS MIP compound functions

The T-MPLS MIP compound function consists of two pairs of the T-MPLS diagnostic adaptation & trail termination functions, each facing in opposite directions (Figure 8-6).

A T-MPLS MIP function is able to respond to on-demand T-MPLS OAM signals.

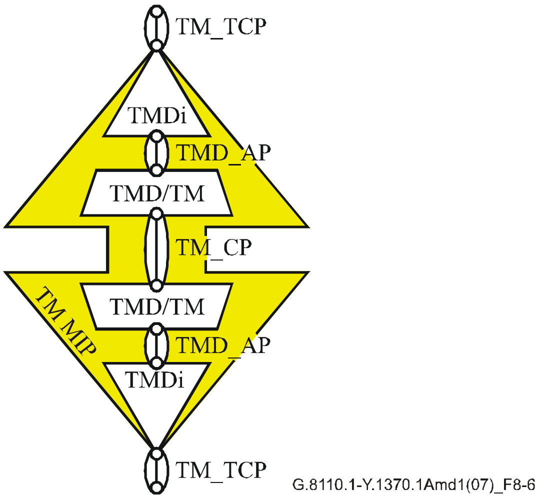

Figure 8-6 – T-MPLS MIP compound function

A variant of this T-MPLS MIP compound function is the half MIP compound function, which consists of a single pair of the T-MPLS diagnostic adaptation & trail termination functions (Figure 8-7).

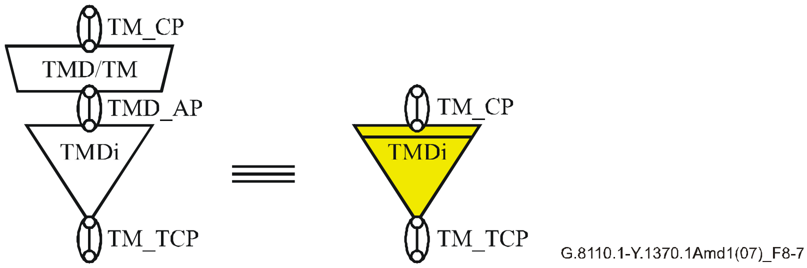

Figure 8-7 – T-MPLS half MIP compound function

8.3 T-MPLS transport processing functions

T-MPLS Transport Processing Functions are defined in clause 6.3.3.

This clause describes the functionality of the T-MPLS tandem connection and diagnostic trail termination functions and their adaptation functions to T-MPLS layer network.

8.3.1 T-MPLS trail termination functions

8.3.1.1 T-MPLS tandem connection trail termination function

The TMT_TT function is the endpoint of the T-MPLS maintenance entity group for tandem connection monitoring.

The bidirectional T-MPLS tandem connection trail termination (TMT_TT) function is performed by a co-located pair of associated unidirectional T-MPLS tandem connection trail termination source (TMT_TT_So) and sink (TMT_TT_Sk) functions.

The TMT_TT_So performs the following processes between its input and output:

– inserts tandem connection level T-MPLS OAM signals for pro-active monitoring;
– outputs the resulting TM_CI.

The TMT_TT_Sk function performs the following functions between its input and output:

– extracts and processes tandem connection level T-MPLS OAM signals for pro-active monitoring;
– outputs the resulting TM_AI.

8.3.1.2 T-MPLS diagnostic trail termination function

The TMD_TT function is an endpoint (TMDe) or intermediate point (TMDi) of T-MPLS on-demand OAM frames for a T-MPLS network or tandem connection maintenance entity group. As an endpoint of on-demand OAM it acts as originator and responder, as intermediate point it acts only as responder.

The TMD_TT_So performs the following processes between its input and output:

– inserts T-MPLS OAM signals for on-demand monitoring;
– outputs the resulting TM_CI.

The TMD_TT_Sk function performs the following functions between its input and output:

– extracts and processes T-MPLS OAM signals for on-demand monitoring;
– outputs the resulting TM_AI.

8.3.2 T-MPLS adaptation functions

The following generic processes may be assigned to a T-MPLS MEG monitoring adaptation:

– forwarding or blocking client signal depending on the administrative state;

– generation of OAM maintenance signals for alarm suppression or Lock indication.

8.3.2.1 TMT/TM adaptation

The bidirectional TMT/TM Adaptation (TMT/TM_A) function is performed by a collocated pair of T-MPLS connection monitoring adaptation source (TMT/TM_A_So) and sink (TMT/TM_A_Sk) functions.

The TMT/TM adaptation source (TMT/TM_A_So) performs the following processes between its TM_CP input and its TMT_AP output:

– Forward or block forwarding of the TM_CI signal depending on the administrative state (refer to [ITU-T X.731]) of the TMT/TM_A function. Block forwarding of TM_CI signal when the administrative state is LOCKED and insert the appropriate T-MPLS OAM signal for Lock indication instead;

– Generate the APS OAM signal to transport the CI_APS information.

The TMT/TM adaptation sink (TMT/TM_A_Sk) performs the following processes between its TMT_AP input and its TM_CP output:

– Extract the APS OAM signal and retrieve the APS information to forward it as CI_APS;

– On detection of a Signal Fail condition, add the appropriate T-MPLS OAM signal for alarm suppression at the client's TM_CI signal;

– Forward or block forwarding of the TM_CI signal depending on the administrative state (refer to [ITU-T X.731]) of the TMT/TM_A function. Block forwarding of TM_CI signal when the administrative state is LOCKED and insert the appropriate T-MPLS OAM signal for Lock indication at the client's TM_CI signal.

NOTE – For the case this function is deployed in a T-MPLS SNC/S protection scheme (refer to [ITU-T G.8131]), the administrative state should not be set to LOCKED.

8.3.2.2 TMD/TM adaptation

The bidirectional TMD/TM Adaptation (TMD/TM_A) function is performed by a collocated pair of T-MPLS connection monitoring adaptation source (TMD/TM_A_So) and sink (TMD/TM_A_Sk) functions.

The TMD/TM adaptation source (TMD/TM_A_So) performs the following processes between its TM_CP input and its TMD_AP output:

– forward signal from input to output.

The TMD/TM adaptation sink (TMD/TM_A_Sk) performs the following processes between its TMD_AP input and its TM_CP output:

– forward signal from input to output.

4.10) Additions to clause 9, Transport MPLS survivability techniques

Replace the text in clause 9 with:

This clause describes the architectural features of network strategies that may be applied to enhance the survivability of Transport MPLS networks from network link and node impairments. The survivability techniques considered for Transport MPLS networks encompass both protection and network restoration capabilities.

The following network objectives for the selection of self-healing architectures are seen as the predominant ones:

- Heal quickly (on the order of existing SDH networks).
- Coexist in harmony with possible client layer schemes (e.g., SDH). An example would be the ability to enable/disable the T-MPLS protection scheme on a per connection basis.
- Heal single points of failure.
- Gracefully accommodate multiple failures.
- Avoid hits on traffic unaffected by the failure.
- Minimize the amount of protection bandwidth required.
- Minimize the amount of signalling complexity required.
- Support prior path verification.
- Take into account T-MPLS ring interworking.
- Take into account T-MPLS mesh networks and interworking.

9.1 Protection techniques

T-MPLS linear protection architectures are defined in [ITU-T G.8131] and [ITU-T G.808.1].

T-MPLS ring protection architectures are for further study.

9.2 Network restoration

T-MPLS network restoration techniques are based on T-MPLS cross-connection. In general, the algorithms used for restoration involve re-routing. Strategies for re-routing are not technology specific and, therefore, outside the scope of this Recommendation.

Restoration can be performed by a centralized NMS system or by a distributed control plane as described in [ITU-T G.8080].

4.11) Additions to clause 10

4.11.1) Additions to clause 10.2

Add the following sentence at the end of clause 10.2 (before clause 10.2.1):

The TM/Client_A_So function in Figures 10-2 and 10-3 selects the AI_PHB in the T-MPLS layer network using the Diff-Serv information in the client_CI. The selection is client-specific.

4.11.2) Additions to clause 10.2.1

Add the following sentence at the end of clause 10.2.1 (after Figure 10-2):

NOTE – The Server and Client layers in Figure 10-2 can be T-MPLS or non T-MPLS layers. The non T-MPLS client layers are defined in clause 7.1; the non T-MPLS server layers are defined in clause 7.3.

4.11.3) Additions to clause 10.2.2

Add the following sentence at the end of clause 10.2.2 (after Figure 10-3):

NOTE – The Server and Client layers in Figure 10-3 can be T-MPLS or non T-MPLS layers. The non T-MPLS client layers are defined in clause 7.1; the non T-MPLS server layers are defined in clause 7.3.

4.12) New clause 13

13 Security aspects

Figure 13-1 describes the reference model for security in T-MPLS networks.

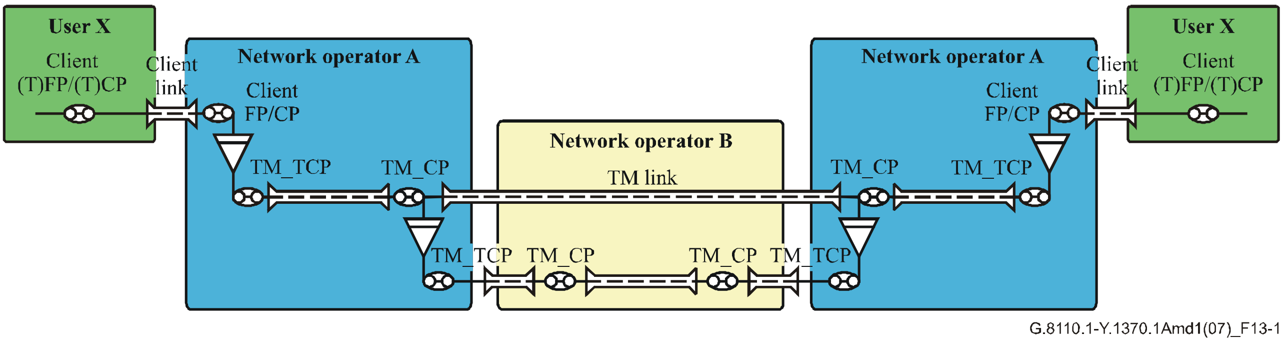

Figure 13-1 – T-MPLS security reference model

In case of detected bit errors, the server layer discards the errored frames. In case of undetected bit errors, changing a data frame into a CV or APS OAM frame could result in a short connection interruption, while changing the data frame into another OAM frame does not cause any issue. In case of undetected bit errors changing the label of a frame, this frame may be misdelivered.

Unintended misconfigurations, during connection set-up or operation, are detected by the connectivity verification OAM function and result in traffic being blocked and in interruption of the traffic of the affected connections.

Malicious misconfigurations should be prevented by security mechanisms in the management plane. These mechanisms are outside the scope of this Recommendation.

Due to the fact that T-MPLS UNI interfaces are not defined, it is not possible for the user to insert T-MPLS OAM or data frames inside the network. However, it may be possible for the user to overload the transport network: this is prevented by traffic conditioning the client layer traffic entering the T-MPLS network.

In case of multiple network domains, OAM mechanisms operating at different tandem connection monitoring levels or at different T-MPLS layer network instances are isolated from each other as described in clause 8.2.6.

On the inter-carrier NNI, it is possible for a network operator A to overload the network of network operator B: this may be prevented by traffic conditioning the T-MPLS layer traffic entering the network operator B T-MPLS network. The definition of the traffic conditioning function in T-MPLS is for further study.

To prevent a malicious intruder access to a physical media, link security (e.g., MAC Security for IEEE 802.3 interfaces as defined in [IEEE 802.1AE]) mechanisms should be used. These mechanisms are outside the scope of this Recommendation.

In case network operator wants to protect its data security and integrity when going through a not trusted portion of the network, a T-MPLS link security mechanism may be used. This mechanism is for further study.

4.13) New Annex A

Annex A

T-MPLS OAM architecture details

(This annex forms an integral part of this Recommendation)

This annex describes some architectural aspects for the OAM signals in T-MPLS functions.

A.1 T-MPLS trail termination

The T-MPLS trail termination function is defined in clause 6.3.3.1.

The T-MPLS trail termination source (TM_TT_So) inserts network connection level T-MPLS OAM signals, which carry the connectivity check, frame loss measurement and remote defect indication information.

The T-MPLS trail termination sink (TM_TT_Sk) extracts and processes network connection level T-MPLS OAM signals for connectivity check, frame loss measurement, alarm suppression, lock indication and remote defect indication information.

In case of unidirectional network connections, there is no reverse network connection that can carry remote defect indication and far-end frame loss measurement information.

A.2 T-MPLS tandem connection trail termination function

The T-MPLS tandem connection trail termination function is defined in clause 8.3.1.1.

The TMT_TT_So inserts tandem connection level T-MPLS OAM signals, which carry the connectivity check, frame loss measurement and remote defect indication information.

The TMT_TT_Sk extracts and processes tandem connection level T-MPLS OAM signals for connectivity check, frame loss measurement, alarm suppression, lock indication and remote defect indication information.

In case of unidirectional tandem connections, there is no reverse tandem connection that can carry remote defect indication and far-end frame loss measurement information.

A.3 T-MPLS diagnostic trail termination function

The T-MPLS diagnostic trail termination function is defined in clause 8.3.1.2.

The TMDe_TT_So function (endpoint role) is able to insert T-MPLS OAM signals for Loopback, diagnostic test, frame loss measurement and frame delay measurement when ordered to do so via its management point. The TMDe_TT_So function inserts OAM reply signals for Loopback, diagnostic test, frame loss measurement and frame delay measurement when ordered to do so via its remote point that is controlled by its associated TMDe_TT_Sk function. For frame loss measurement, it inserts the backward transmit frame count; while for frame delay measurement, it inserts the backward transmit timestamp.

The TMDi_TT_So function inserts T-MPLS OAM reply signals for Loopback when ordered to do so via its remote point that is controlled by its associated TMDi_TT_Sk function.

The TMD_TT_So functions receive, from one or more on-demand functions in the EMF, on-demand specific information via their management point and they construct the on-demand OAM specific TM_CI traffic unit. For the case of T-MPLS OAM signals for loss measurements, it also inserts the forward transmit frame count, and for frame delay measurement it inserts the forward transmit timestamp.

The TMDe_TT_Sk function (endpoint role) extracts and processes T-MPLS OAM signals for Loopback, diagnostic test, frame loss measurement and frame delay measurement.

It forwards to its management point the received T-MPLS OAM signals carrying the results of Loopback, diagnostic test, frame loss measurement and frame delay measurement. For the case of T-MPLS OAM signals for loss measurement it also inserts the backward receive frame count, for one-way frame delay measurement, it also inserts the forward received time stamp, and for the two-way frame delay measurement it also inserts the backward receive time stamp. The TMDe_TT_Sk function controls the insertion – by its associated TMDe_TT_So function – of the associated reply T-MPLS OAM frames for Loopback, diagnostic test, frame loss measurement and frame delay measurement after insertion of the receive forward frame count value in the frame loss measurement signal and of the receive forward timestamp in the frame delay measurement signal.

The TMDi_TT_Sk function (intermediate point role) extracts the T-MPLS OAM signals for Loopback. The TMDi_TT_Sk function controls the insertion – by its associated TMDi_TT_So function – of the associated reply T-MPLS OAM frames for Loopback.

In case of unidirectional network connections, there is no reverse network connection that can carry Loopback, bidirectional diagnostic test, single-ended frame loss measurement and two-way frame delay measurement information.

4.14) Changes to Appendix I, Functional model for describing PWE3 and MPLS network interworking

Change the following paragraph in Appendix I as follows:

Note that in T-MPLS the T-MPLS trails use [b-ITU-T G.8114] for OAM while the PW as defined by the IETF PWE3 working group is using VCCV [b-IETF VCCV].

4.15) New Appendix IV

Appendix IV

An example of T-MPLS layer structure

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

Unlike SDH and ATM technologies, which have a fixed number of layer network instances, T-MPLS supports an arbitrary number of layer network instances (or, in other words, T-MPLS supports an arbitrary label stacking depth). The number of layer network instances is in practice limited by the MTU of the underlying physical links.

This technology can be used in a number of ways to implement packet transport networks.

This appendix provides an example of a layer structure in a T-MPLS network that could be implemented using the T-MPLS technology. Alternative layer structures are not precluded.

This T-MPLS network example contains three T-MPLS layer network instances. These T-MPLS layer network instances are referred to as T-MPLS Channel (TMC), T-MPLS Path (TMP) and T-MPLS Section (TMS) layer network instances.

The TMC layer network instance provides the transport network service; a TMC connection carries a single instance of the client service. The TMC layer network instance provides OAM for inherent monitoring of the client service. The structure of the client service is outside the scope of this Recommendation and it may comprise a single client signal or a bundle of such client signal.

The TMP layer network instance provides the transport network trunks; a TMP connection carries one or more TMC signals between the edges of TMP domains. The TMP layer network instance provides OAM for trunk monitoring.

An optional TMS layer network instance provides the section-layer functionality; a TMS connection carries one or more TMP signals between T-MPLS network nodes. The TMS layer network instance provides OAM for connection monitoring of the point-to-point transmission media layer signal that interconnects T-MPLS network nodes. This optional TMS layer network instance would typically be used in cases where the physical media layer does not support the required OAM functionality adequately, the TMS connection spans more than one physical link or the TMS connection is protected.

Note that because there is a one-to-one relationship between the TMS layer network instance and the server layer trail, no TMS label stack entry is added to the frames sent over the PHY media (reference point 9 in Figure IV.1 below). This requires operating the Server/TM_A function according to mode 2 (as described in clause 7.3).

Note that in order to be able to apply the TMS layer network instance in practical networks, the server layer connection must have a point-to-point topology.

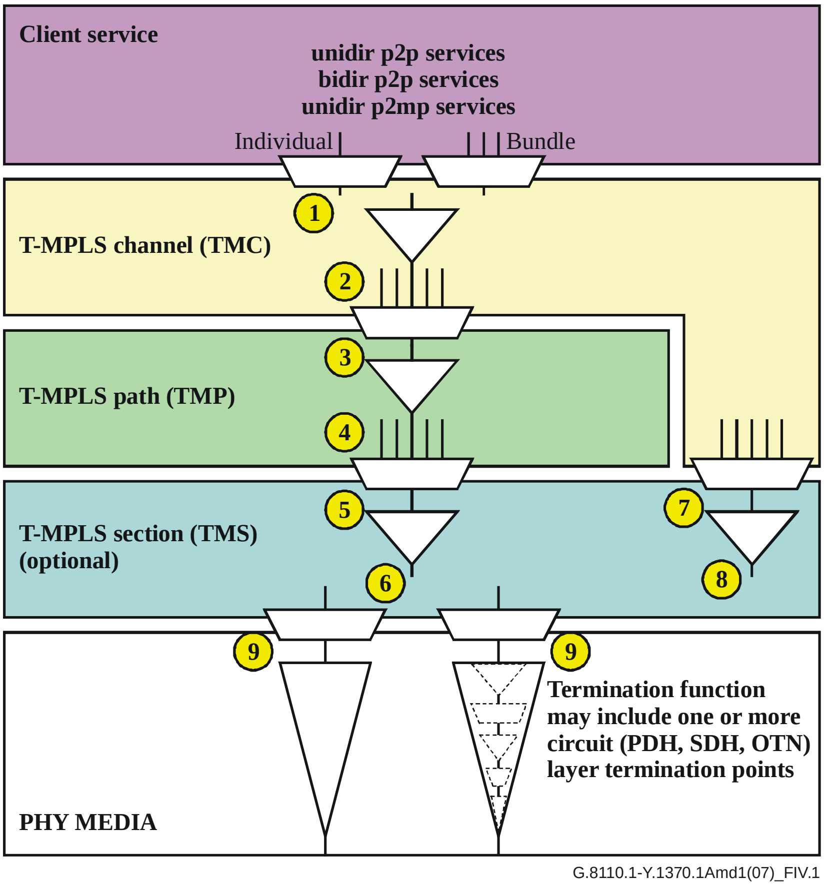

Figure IV.1 – T-MPLS network architecture (layer view) example

The T-MPLS network supports [b-ITU-T G.8114] based T-MPLS OAM in the T-MPLS layer network instances.

It is possible to support carrier's applications at any of the T-MPLS layer network instances. The T-MPLS network of one operator (B) may carry any one of the T-MPLS layer network instances of another operator (A) as a client layer service.

T-MPLS networks of two operators (C, D) may also peer at the TMC layer network instance. This mode of operation (peering) would typically be preferred to a client-server relationship between the networks when the client layer service has endpoints on both T-MPLS operator networks C and D.

T-MPLS OAM mechanisms are defined in [b-ITU-T G.8114] to support T-MPLS tandem connection monitoring (TCM). TCM will allow each owner (service provider, network operators C and D) to monitor its tandem connection.

T-MPLS networks provide uni-/bidirectional point-to-point T-MPLS and unidirectional point-to-multipoint T-MPLS connections. Within the TMC layer network instance, those connections support point-to-point and point-to-multipoint services.

The adapted information (AI), characteristic information (CI) and OAM information (OI) traffic unit formats in the different layer networks are illustrated in Figures IV.2 to IV.5. The information is numbered between 1 and 9, whose numbers relate to the location of this information in Figure IV.1.

Note that the TMS_AI in Figures IV.3 and IV.4 (left side) contains the S bit for a TMS label stack entry and the TMS_CI in Figures IV.3 and IV.4 (right side) contains both the S bit and the TTL field for a TMS label stack entry. From a functional point of view, the Server/TM_A_So function, operating according to mode 2 as described in clause 7.3, removes the S bit and the TTL field from the TMS label stack entry before sending the frame to the PHY media. In the sink direction, the Server/TM_A_Sk function, operating according to mode 2 as described in clause 7.3, inserts, from a functional point of view, an S bit equal to 0 and a TTL field equal to 254.

Therefore no TMS label stack entry is present on the frames sent over the PHY media (Figure IV.5).

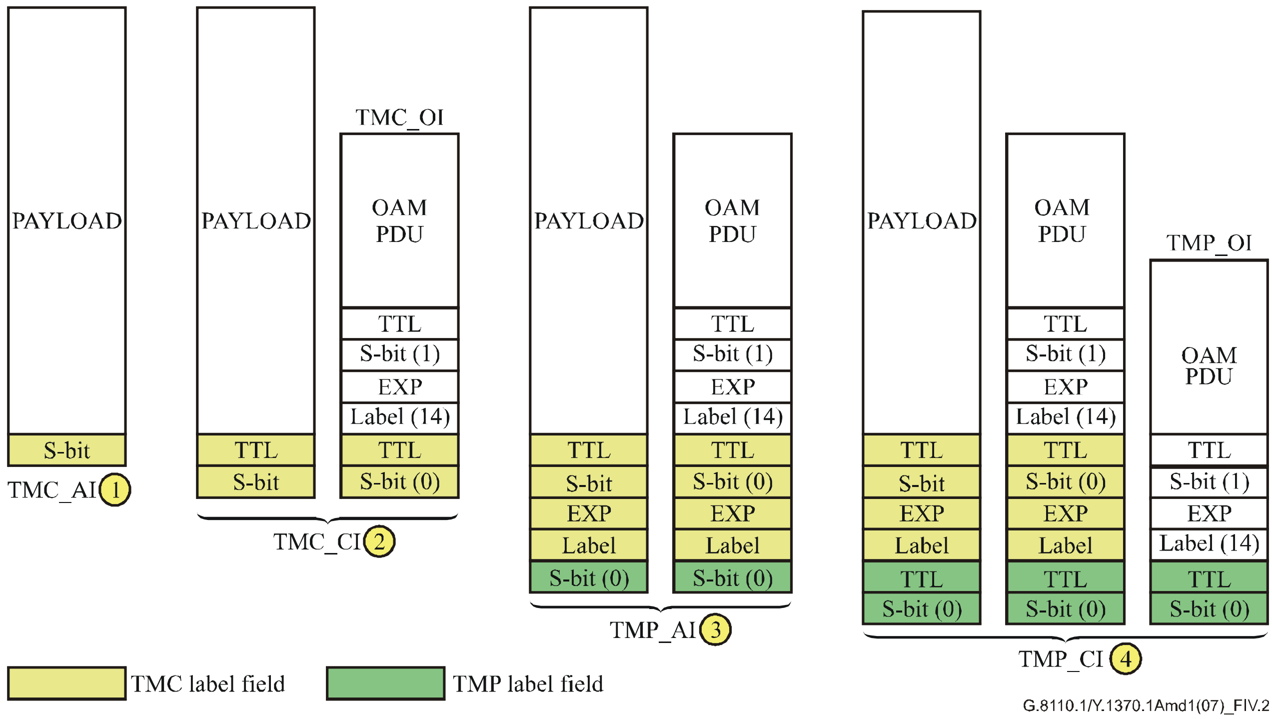

Figure IV.2 – T-MPLS network adapted and characteristic information traffic units (Reference points 1, 2, 3 and 4)

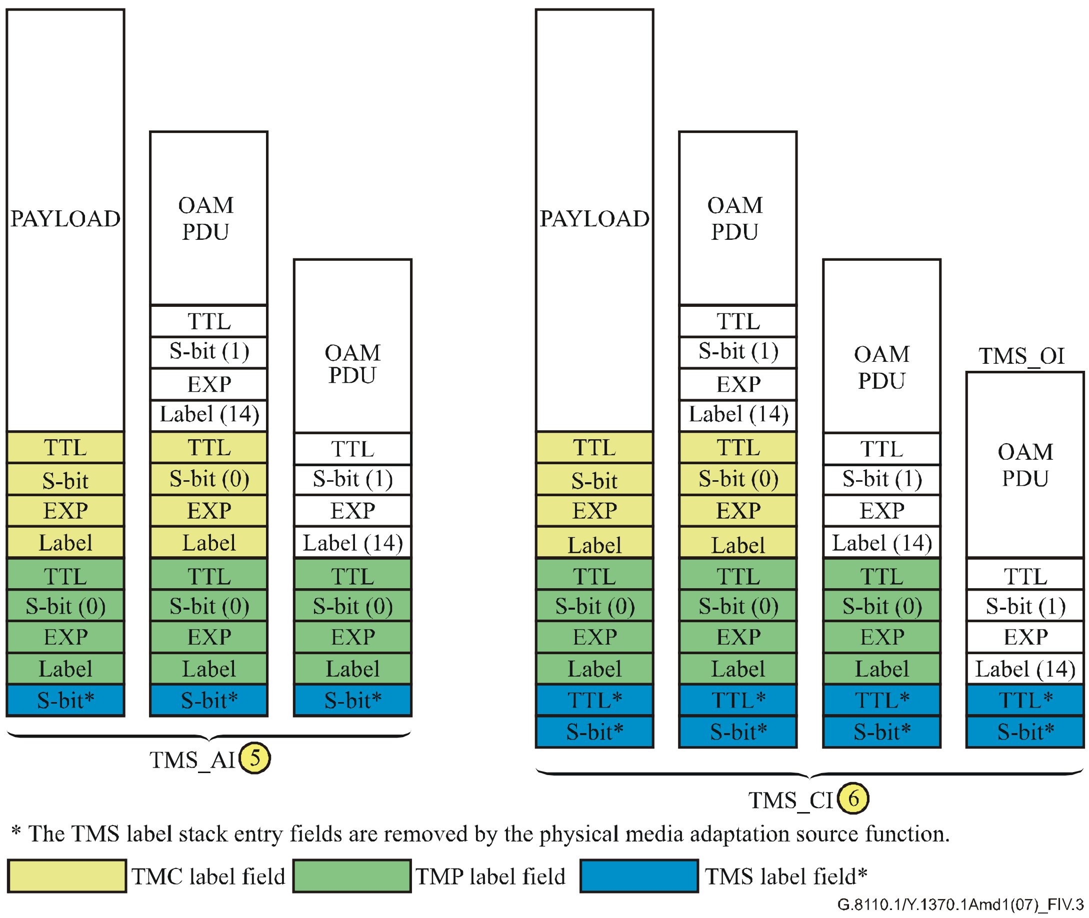

Figure IV.3 – T-MPLS network adapted and characteristic information traffic units (Reference points 5 and 6)

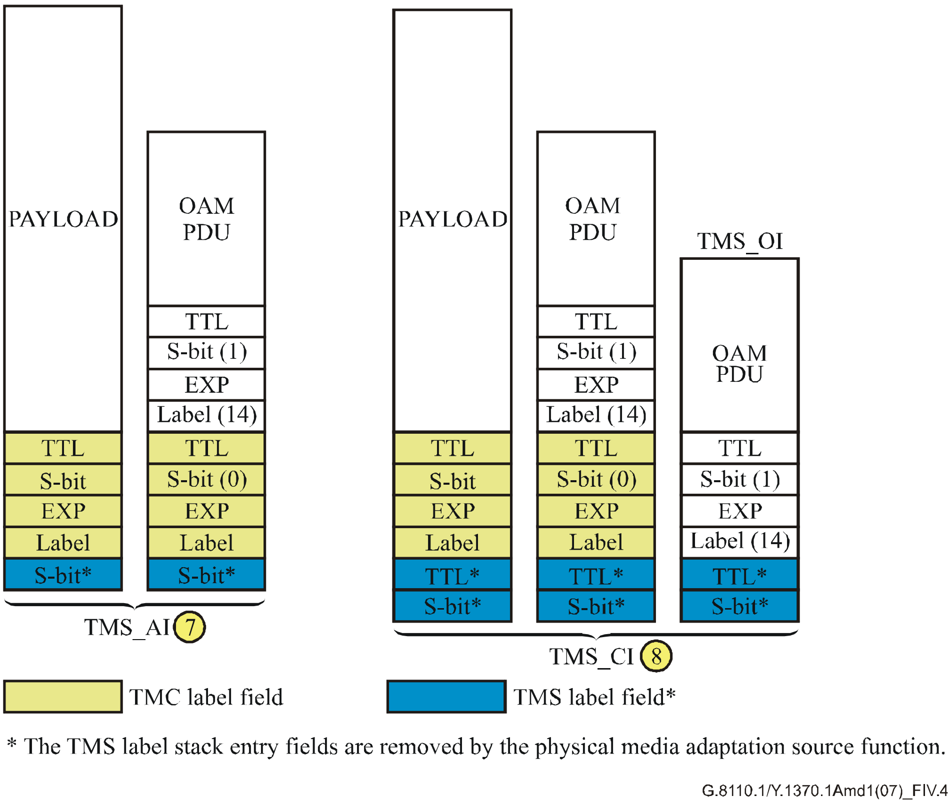

Figure IV.4 – T-MPLS network adapted and characteristic information traffic units (Reference points 7 and 8)

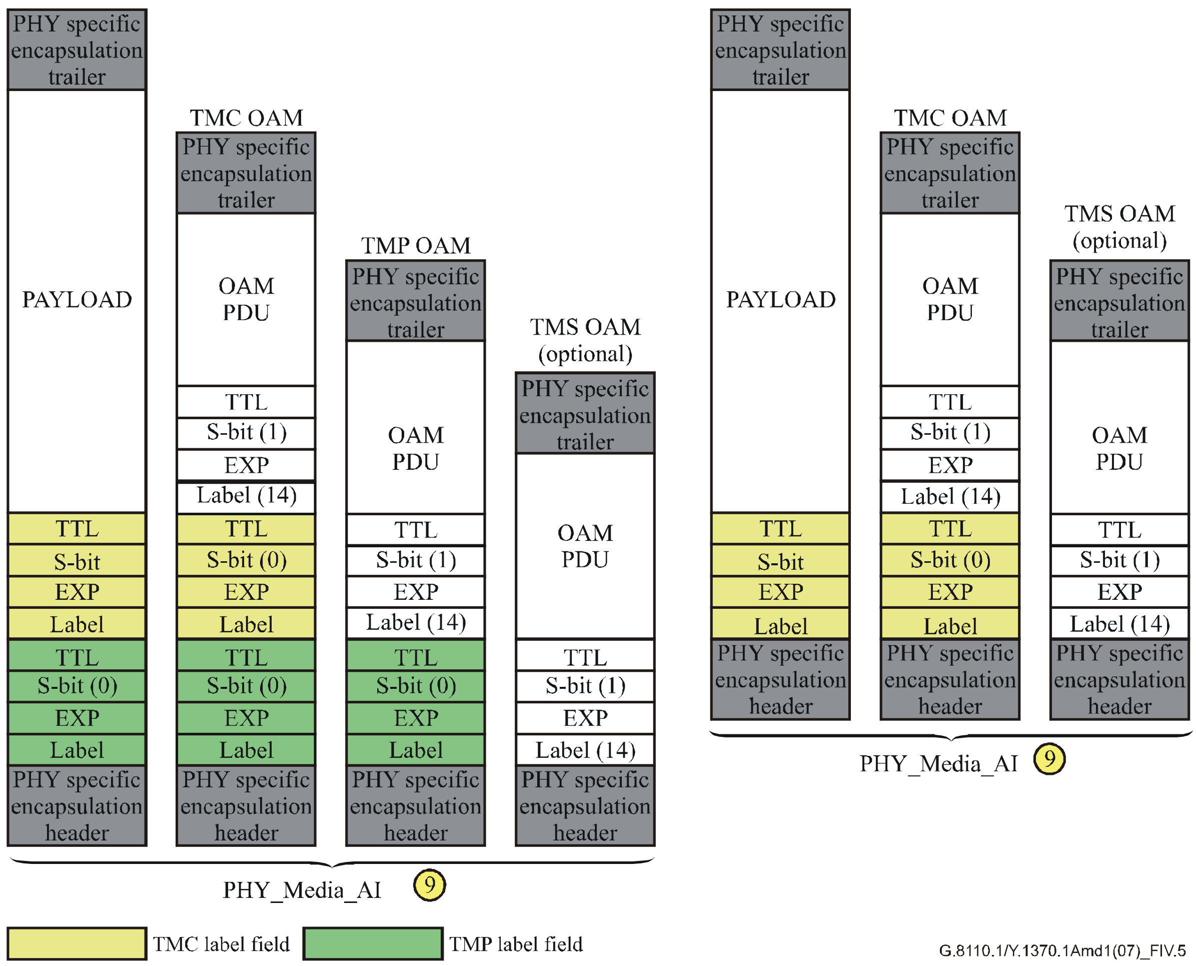

Figure IV.5 – T-MPLS network adapted and characteristic information traffic units (Reference point 9)

4.16) New Appendix V

Appendix V

Applicability of p2mp LSP to T-MPLS

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

The IETF MPLS working group is developing extensions to [IETF RFC 3031] and [IETF RFC 3032] for supporting MPLS multicast (i.e., p2mp LSPs).

NOTE 1 – This appendix will be reviewed when the relevant IETF RFCs are published. The associated bibliography references and the relevant material will be moved into the main body of the Recommendation.

[b-IETF RFC 4875] defines the p2mp LSPs as well as control plane aspects for setting up p2mp LSPs using RSVP-TE signalling. The control plane aspects are out of the scope of this Recommendation.

[b-draft-ietf-encaps] defines the meaning of a "multicast label" and the semantics to be associated to a set of "next hop label forwarding entry" (NHLFE) to which that multicast label is mapped. The architecture defined in this Recommendation is in line with [b-draft-ietf-encaps].

[b-draft-ietf-encaps] also describes the usage of "upstream-assigned labels" and "downstream-assigned labels" for MPLS packets. Unicast labels must always be downstream-assigned while multicast label may be upstream-assigned or downstream-assigned.

NOTE 2 – The concept of "downstream-assigned labels" is defined in [IETF RFC 3031] while "upstream-assigned labels" is under definition in [b-draft-ietf-label].

T-MPLS connections are supported by traffic-engineered connections in the server layer.

Therefore Ethernet broadcast media or IP-based tunnels are not used to support T-MPLS connections.

Section 3 of [b-draft-ietf-encaps] describes the usage of the two EtherType codepoints (0x8847 and 0x8848) assigned for mapping MPLS packets over Ethernet. Because T-MPLS is not supporting Ethernet broadcast media, the top labels of the T-MPLS frames encapsulated into an Ethernet frame are always downstream-assigned. Therefore the EtherType 0x8847 can be used for both unicast and multicast T-MPLS frames.

Figure V.1 represents an example on how a point-to-multipoint T-MPLS network connection (as shown in Figure 6-2) can be decomposed into point-to-multipoint T-MPLS sub-networks connections and point-to-point T-MPLS link connections.

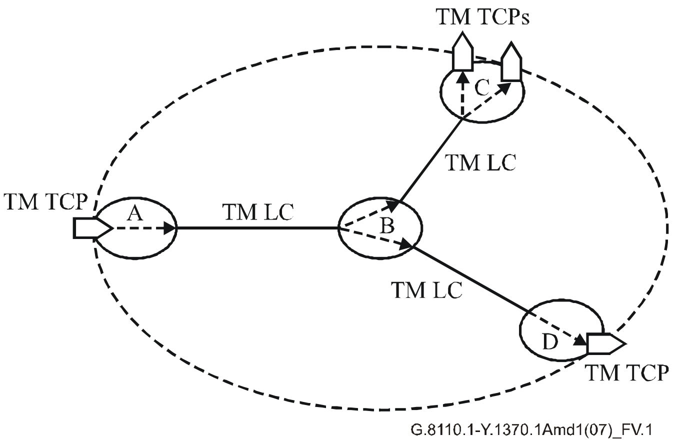

Figure V.1 – T-MPLS p2mp network connection using T-MPLS p2p link connections

Sub-network A will send a single copy of the traffic units from the TM TCP to the downstream sub-network B via a point-to-point T-MPLS LC. Sub-network B performs traffic unit replication sending one copy of the traffic unit to the downstream sub-network C and another copy to the downstream sub-network D via two different point-to-point T-MPLS link connections. Sub-network D will send the received traffic unit to its T-MPLS TCP while sub-network C performs traffic unit replication toward two T-MPLS TCPs.

According to [b-draft-ietf-encaps], when a point-to-point data link or tunnel is used, the top label of the MPLS packet must be "downstream-assigned".

Therefore for carrying a point-to-multipoint T-MPLS connection over a point-to-point T-MPLS link (supported by a point-to-point server layer trail), the label used for the T-MPLS link connection identification should be "downstream-assigned".

This means that the value of the label that is inserted at A, over the T-MPLS LC from A to B, is assigned at B.

Figure V.2 represents an example on how a point-to-multipoint T-MPLS network connection (as shown in Figure 6-2) can be decomposed into point-to-multipoint T-MPLS sub-networks connections and a point-to-multipoint T-MPLS link connection.

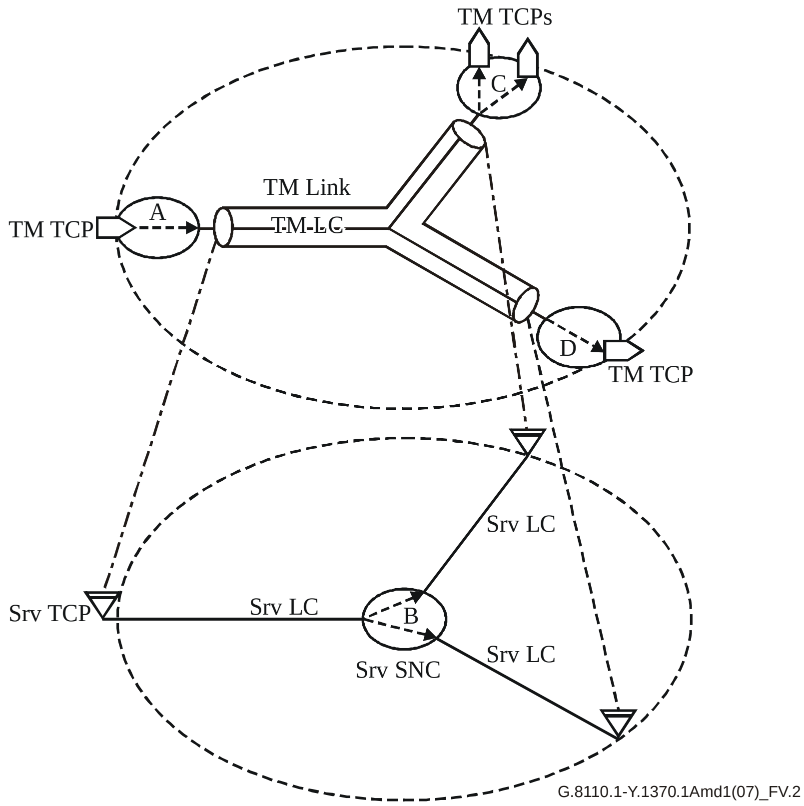

Figure V.2 – T-MPLS p2mp network connection using T-MPLS p2mp link connection

Sub-network A will send a single copy of the traffic units from the TM TCP to the downstream sub-networks C and D via a point-to-multipoint T-MPLS LC.

The server layer supporting the point-to-multipoint T-MPLS link can be any T-MPLS server layer (as defined in clause 7.3 or another T-MPLS server layer network instance). Server layer sub-network B performs traffic unit replication in the server layer delivering one copy of the traffic unit to the downstream T-MPLS sub-network C and another copy to the downstream T-MPLS sub-network D.

Sub-network D will send the received traffic unit to its T-MPLS TCP while sub-network C performs traffic unit replication toward two T-MPLS TCPs.

According to [b-draft-ietf-encaps], when a point-to-multipoint data link or tunnel is used, the top labels of all the MPLS packets sent over this link or tunnel must be of the same type: either all upstream-assigned or all downstream-assigned. In this case, all the receivers must know *a priori* which label assignment scheme is used.

NOTE 3 – The Upstream Assigned Labels over p2mp connections simplify the administration of labels.

Therefore for carrying a T-MPLS frame over a point-to-multipoint T-MPLS link (supported by a point-to-multipoint server layer trail), the label used for the T-MPLS link connection identification should be the same among all the link connections over this point-to-multipoint T-MPLS link: either all upstream-assigned or all downstream-assigned.

When the labels are upstream-assigned (i.e., assigned at sub-network A), a single T-MPLS point-to-multipoint LC is identified between sub-network A and sub-networks C and D, within the point-to-multipoint Link. In this case, a single copy of the T-MPLS traffic unit is sent from sub-network A over the point-to-multipoint T-MPLS link.

When the labels are downstream-assigned (i.e., assigned independently at sub-networks C and D), two T-MPLS point-to-multipoint link connections may be identified between sub-network A and sub-networks C and D, within the point-to-multipoint Link. In this case, two copies of the T-MPLS traffic unit may be sent from sub-network A over the point-to-multipoint T-MPLS link.

NOTE 4 – If sub-networks C and D assign the same label value, only a single T-MPLS link connection is created. In all the other cases, two link connections are created.

When a point-to-multipoint Link is used, the link connection always matches the topology of the link. If the required connectivity is less than the one provided by the point-to-multipoint link, traffic units delivered at some of the link ends will be discarded. This could result in wasting of bandwidth resources on some links.

NOTE 5 – According to [b-draft-ietf-label], a downstream LSR that receives an MPLS packet whose top label has been upstream-assigned must use a "context-specific label space" to look up the top of the label.

4.17) Additions to Bibliography

Add the following items to the Bibliography:

[b-ITU-T-G.8114] ITU-T Recommendation G.8114/Y.1373 (draft), *Operation and maintenance mechanism for T-MPLS layer networks*.

[b-draft-ietf-encaps] Internet Draft draft-ietf-mpls-multicast-encaps-03.txt (2007), *MPLS Multicast Encapsulations*.

[b-draft-ietf-label] Internet Draft draft-ietf-mpls-upstream-label-02.txt (2007), *MPLS Upstream Label Assignment and Context-Specific Label Space*.

[b-IETF RFC 4875] IETF RFC 4875 (2007), *Extensions to Resource Reservation Protocol – Traffic Engineering (RSVP-TE) for Point-to-Multipoint TE Label Switched Paths (LSPs)*.

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
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Printed in Switzerland
Geneva, 2008