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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 the Multi-Protocol Label Switching transport profile layer network

Recommendation ITU-T G.8110.1/Y.1370.1



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INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
Ethernet over Transport aspects	G.8000–G.8099
MPLS over Transport aspects	G.8100–G.8199
Quality and availability targets	G.8200–G.8299
Service Management	G.8600–G.8699
ACCESS NETWORKS	G.9000–G.9999

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



Recommendation ITU-T G.8110.1/Y.1370.1

Architecture of the Multi-Protocol Label Switching transport profile layer network

Summary

Recommendation ITU-T G.8110.1/Y.1370.1 provides functional components, based on Recommendation ITU-T G.805, that allow the Multi-Protocol Label Switching Transport Profile (MPLS-TP) to be modelled in a way that is consistent with the description of other transport technologies defined by the ITU-T, (e.g., the synchronous digital hierarchy (SDH) and the optical transport network (OTN)), to simplify integration with other transport technologies.

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

NOTE – This ITU-T Recommendation is intended to be aligned with the IETF MPLS RFCs normatively referenced by this Recommendation.

In this Recommendation the architecture of MPLS-TP forwarding, operation, administration and maintenance (OAM), and network survivability is modelled from a network-level viewpoint. The description of the control plane and management plane aspects of MPLS-TP is outside the scope of this Recommendation.

The functional components described in this Recommendation also support the architecture for point-to-multipoint (p2mp) MPLS-TP label switched paths (LSPs), in compliance with IETF RFC 5331 and IETF RFC 5332.

This edition of ITU-T G.8110.1/Y.1370.1 includes the changes introduced by Erratum 1 (09/2012).

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FOREWORD

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

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

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

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

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

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Table of Contents

		Page
1	Scope	1
2	References.....	2
3	Definitions	4
4	Abbreviations and acronyms	5
5	Conventions	8
6	Functional architecture of MPLS Transport Profile (MPLS-TP) networks	8
6.1	MPLS-TP network layered structure	9
6.2	MPLS-TP layer network.....	11
6.3	MPLS-TP layer network partitioning.....	16
6.4	MPLS-TP network topology	16
6.5	MPLS-TP label behaviour	20
7	Server/client associations.....	20
7.1	MT/client adaptation	20
7.2	MT/MT adaptation	21
7.3	Server/MT adaptation	22
8	MPLS-TP OAM architecture.....	24
8.1	General	24
8.2	MPLS-TP connection and trail supervision	26
8.3	MPLS-TP maintenance entity group monitoring	28
8.4	MPLS-TP MIP.....	29
8.5	Bandwidth considerations with MPLS-TP OAM.....	30
9	MPLS-TP survivability techniques.....	30
10	MPLS-TP Diff-Serv architecture.....	30
10.1	Short-pipe model	31
10.2	Uniform model	31
11	MPLS-TP TTL behaviour	32
12	Security aspects	32
	Annex A – Default configuration options for MPLS-TP in a transport network application..	33
	Appendix I – An example of MPLS-TP layer structure	35
	Bibliography.....	41

Recommendation ITU-T G.8110.1/Y.1370.1

Architecture of the Multi-Protocol Label Switching transport profile layer network¹

1 Scope

This Recommendation provides the functional components, based on [ITU-T G.805], that are necessary to describe the deployment of Multi-Protocol Label Switching Transport Profile (MPLS-TP) in a transport network. This model allows MPLS-TP to be modelled in a way that is consistent with the description of other transport technologies defined by ITU-T, (e.g., the synchronous digital hierarchy (SDH), the optical transport network (OTN), etc.).

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- ¹ Cisco Systems has expressed concerns that the following text has been removed from the consented text: "This Recommendation complies with the transport profile of MPLS Architecture as defined by the IETF. In the event of a difference between this ITU-T Recommendation and any of the normatively referenced IETF RFCs, the RFCs will take precedence." as without this statement, interoperability issues may arise.
- ¹ France Telecom Orange has expressed its concerns that the following text has been removed from the consented text: "This Recommendation complies with the transport profile of MPLS Architecture as defined by the IETF. In the event of a difference between this ITU-T Recommendation and any of the normatively referenced IETF RFCs, the RFCs will take precedence." as without this statement, interoperability issues may arise.
- ¹ Juniper Networks has stated its concerns about the changes to the consented text of this Recommendation that it believes have introduced potential issues in implementation, deployment, and interoperability. Juniper Networks believes that it is important to provide a clarification that in the event of any misalignment, the definition of MPLS provided in the referenced RFCs takes precedence over any description or modeling of MPLS-TP provided in this Recommendation.
- ¹ Nokia Siemens Networks has expressed concerns that the following text has been removed from the consented text: "This Recommendation complies with the transport profile of MPLS Architecture as defined by the IETF. In the event of a difference between this ITU-T Recommendation and any of the normatively referenced IETF RFCs, the RFCs will take precedence." as without this statement, interoperability issues may arise.
- ¹ Telefon AB - LM Ericsson has expressed concerns that the following text has been removed from the consented text: "This Recommendation complies with the transport profile of MPLS Architecture as defined by the IETF. In the event of a difference between this ITU-T Recommendation and any of the normatively referenced IETF RFCs, the RFCs will take precedence." as without this statement, interoperability issues may arise.
- ¹ Verizon Communications has expressed concerns that the following text has been removed from the consented ITU-T G.8110.1 text: "This Recommendation complies with the transport profile of MPLS Architecture as defined by the IETF. In the event of a difference between this ITU-T Recommendation and any of the normatively referenced IETF RFCs, the RFCs will take precedence." Without this statement, interoperability issues may arise.



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1

This Recommendation provides a representation of the MPLS-TP technology using the methodologies that have been used for other transport technologies, (e.g., SDH, OTN and Ethernet).²

MPLS-TP is a connection-oriented packet-switched transport layer network technology that uses pseudowires (PWs) and MPLS-TP label switched paths (LSPs). The MPLS-TP is a profile of the MPLS that supports deployment in transport networks and allows operations in a manner consistent with other transport technologies. Its operation is independent of the mechanisms used for configuration and management. In some applications, the data plane only supports forwarding based on the MPLS label; it does not support IP forwarding.

The architecture of the MPLS-TP forwarding, operation, administration and maintenance (OAM), and network survivability, is modelled from a network-level viewpoint. The description of the control plane and management plane aspects of the MPLS-TP is outside the scope of this Recommendation.

The functional components described in this Recommendation also support the architecture for point-to-multipoint (p2mp) MPLS-TP LSPs in compliance with [IETF RFC 5331] and [IETF RFC 5332].

As the MPLS-TP is a profile of the MPLS, this Recommendation uses the applicable functional components provided in the MPLS layer network architecture of [ITU-T G.8110] and extends them with additional capabilities (e.g., OAM and protection) that are not modelled in [ITU-T G.8110].

This version of this Recommendation only provides those functional components (based on ITU-T G.805) and architectural models required to model an Ethernet service carried by a single-segment pseudowire (SS-PW) over co-routed bidirectional LSPs, which may be hierarchical, and do not use penultimate hop popping (PHP).

Other clients for LSPs (e.g., Internet Protocol (IP)), and PWs and modes of operation (e.g., multi-segment pseudowire (MS-PW) or associated bidirectional LSPs), as described in [IETF RFC 5921], are supported as defined in [IETF RFC 5921] and [IETF RFC 6215] but are not modelled in this version of the Recommendation. They will be added in future versions of this Recommendation.

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.805] Recommendation ITU-T G.805 (2000), *Generic functional architecture of transport networks*.
- [ITU-T G.806] Recommendation ITU-T G.806 (2009), *Characteristics of transport equipment – Description methodology and generic functionality*.
- [ITU-T G.808.1] Recommendation ITU-T G.808.1 (2010), *Generic protection switching – Linear trail and subnetwork protection*.

² This ITU-T Recommendation is intended to be aligned with the IETF MPLS RFCs normatively referenced by this Recommendation.

- [ITU-T G.7712] Recommendation ITU-T G.7712/Y.1703 (2010), *Architecture and specification of data communication network*.
- [ITU-T G.8010] Recommendation ITU-T G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks*.
- [ITU-T G.8013] Recommendation ITU-T G.8013/Y.1731 (2011), *OAM functions and mechanisms for Ethernet based networks*, plus Corrigendum 1 (2011).
- [ITU-T G.8080] Recommendation ITU-T G.8080/Y.1304 (2006), *Architecture for the automatically switched optical network*.
- [ITU-T G.8101] Recommendation ITU-T G.8101/Y.1355 (2010), *Terms and definitions for MPLS transport profile*.
- [ITU-T G.8110] Recommendation ITU-T G.8110/Y.1370 (2005), *MPLS layer network architecture*.
- [ITU-T M.1400] Recommendation ITU-T M.1400 (2006), *Designations for interconnections among operators' networks*.
- [ITU-T Y.1415] Recommendation ITU-T Y.1415 (2005), *Ethernet-MPLS network interworking – User plane interworking*.
- [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*.
- [IETF RFC 4385] IETF RFC 4385 (2006), *Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN*.
- [IETF RFC 4448] IETF RFC 4448 (2006), *Encapsulation Methods for Transport of Ethernet over MPLS Networks*.
- [IETF RFC 4720] IETF RFC 4720 (2006), *Pseudowire Emulation Edge-to-Edge (PWE3) Frame Check Sequence Retention*.
- [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)*.
- [IETF RFC 5331] IETF RFC 5331 (2008), *MPLS Upstream Label Assignment and Context-Specific Label Space*.
- [IETF RFC 5332] IETF RFC 5332 (2008), *MPLS Multicast Encapsulations*.
- [IETF RFC 5462] IETF RFC 5462 (2009), *Multiprotocol Label Switching (MPLS) Label Stack Entry: "EXP" Field Renamed to "Traffic Class" Field*.
- [IETF RFC 5586] IETF RFC 5586 (2009), *MPLS Generic Associated Channel*.
- [IETF RFC 5654] IETF RFC 5654 (2009), *MPLS-TP Requirements*.
- [IETF RFC 5718] IETF RFC 5718 (2010), *An Inband Data Communication Network For the MPLS Transport Profile*.
- [IETF RFC 5860] IETF RFC 5860 (2010), *Requirements for Operations, Administration, and Maintenance (OAM) in MPLS Transport Networks*.



- [IETF RFC 5921] IETF RFC 5921(2010), *A Framework for MPLS in Transport Networks*.
- [IETF RFC 5960] IETF RFC 5960 (2010), *MPLS Transport Profile Data Plane Architecture*, plus Errata 2533 (2010) and Errata 2534 (2010).
- [IETF RFC 6215] IETF RFC 6215 (2011), *MPLS Transport Profile User-to-Network and Network-to-Network Interfaces*.
- [IETF RFC 6370] IETF RFC 6370 (2011), *MPLS Transport Profile (MPLS-TP) Identifiers*.
- [IETF RFC 6371] IETF RFC 6371 (2011), *Operations, Administration, and Maintenance Framework for MPLS-Based Transport Networks*.

3 Definitions

This Recommendation uses the following terms defined in [ITU-T G.8101]:

- 3.1 access point**
- 3.2 adapted information**
- 3.3 administrative domain**
- 3.4 administrative state**
- 3.5 associated channel header**
- 3.6 bottom of stack**
- 3.7 characteristic information**
- 3.8 client/server relationship**
- 3.9 connection**
- 3.10 connection point**
- 3.11 connection supervision**
- 3.12 explicitly TC-encoded-PSC LSP**
- 3.13 G-ACh packet**
- 3.14 G-ACh packet payload**
- 3.15 generic associated channel**
- 3.16 label**
- 3.17 label inferred PHB scheduling class LSP**
- 3.18 label stack**
- 3.19 label switched path**
- 3.20 label value**
- 3.21 layer network**
- 3.22 link**
- 3.23 link connection**
- 3.24 maintenance entity**
- 3.25 maintenance entity group**
- 3.26 maintenance entity group intermediate point compound function**
- 3.27 MPLS label stack**

- 3.28 network
- 3.29 network connection
- 3.30 network survivability
- 3.31 on-demand monitoring
- 3.32 per hop behaviour
- 3.33 pro-active monitoring
- 3.34 protection
- 3.35 reference point
- 3.36 restoration
- 3.37 sublayer
- 3.38 subnetwork
- 3.39 subnetwork connection
- 3.40 tandem connection
- 3.41 termination connection point
- 3.42 time to live
- 3.43 traffic class
- 3.44 trail
- 3.45 trail termination
- 3.46 transport
- 3.47 transport entity
- 3.48 transport processing function
- 3.49 unidirectional connection

This Recommendation uses the following terms defined in [IETF RFC 5921]:

- 3.50 MPLS-TP LSP
- 3.51 MPLS Transport Profile (MPLS-TP)
- 3.52 Pseudowire

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACH	Associated Channel Header
AI	Adapted Information
AP	Access Point
APS	Automatic Protection Switching ³
ATM	Asynchronous Transfer Mode
CI	Characteristic Information

³ The IETF has not yet selected a term for this set of functions.

CII	Common Interworking Indicators
CO-PS	Connection-Oriented Packet Switched
CoS	Class of Service
CP	Connection Point
CW	Control Word
D	Data (i.e., traffic unit)
DE	Drop Eligibility
ECC	Embedded Communication Channels ⁴
ECMP	Equal Cost Multi-Path
E-LSP	Explicitly TC-encoded-PSC LSP
ETH	Ethernet MAC layer network
FP	Flow Point
G-ACh	Generic Associated Channel
GAL	Generic Associated Channel (G-ACh) Label
ICC	ITU Carrier Code
IP	Internet Protocol
iPHB	Incoming Per Hop Behaviour
LC	Link Connection
L-LSP	Label-Only-Inferred PSC LSP
LSE	Label Stack Entry
LSP	Label Switched Path
MCC	Management Communication Channel
ME	Maintenance Entity
MEG	Maintenance Entity Group
MEP	Maintenance entity group End Point
MIP	Maintenance entity group Intermediate Point
MPLS	Multi-Protocol Label Switching
MPLS-TP	Multi-Protocol Label Switching – Transport Profile
MS-PW	Multi-Segment Pseudowire
MT	Multi-Protocol Label Switching – Transport Profile
MTD	MPLS-TP Diagnostic function
MTDi	MPLS-TP Diagnostic function within MT MIP
MTS	MPLS-TP Section
NC	Network Connection
NE	Network Element

⁴ The IETF uses the term CCh.

NMS	Network Management System
NSP	Native Service Processing
OAM	Operation, Administration and Maintenance
ODU	Optical channel Data Unit
oPHB	outgoing Per Hop Behaviour
OTH	Optical Transport Hierarchy
OTN	Optical Transport Network
P	Priority
p2mp	point-to-multipoint
p2p	point-to-point
PHB	Per Hop Behaviour
PHP	Penultimate Hop Popping
PSC	PHB Scheduling Class
PW	Pseudowire
S-bit	bottom of Stack indicator
SCC	Signalling Communication Channel
SDH	Synchronous Digital Hierarchy
Sk	Sink
SN	Subnetwork
SNC	Subnetwork Connection
SNC/S	SNCP with Sublayer monitoring
SNCP	Subnetwork Connection Protection
So	Source
SPME	Sub-Path Maintenance Element
SSF	Server Signal Fail ⁵
SS-PW	Single-Segment Pseudowire
TC	Traffic Class
TCM	Tandem Connection Monitoring
TCP	Termination Connection Point
TSD	Trail Signal Degrade
TSF	Trail Signal Fail
TT	Trail Termination
TTL	Time-To-Live
VC	Virtual Container

⁵ The IETF has not yet selected a term for this abstract information element.

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.

The diagrammatic conventions for maintenance entity (ME) group (MEG) end point (MEP) and MEG intermediate point (MIP) compound functions are those of [ITU-T G.8010].

6 Functional architecture of MPLS Transport Profile (MPLS-TP) networks

The complete architecture of the MPLS-TP is defined by the IETF in [IETF RFC 5921] and [IETF RFC 6215]. Further details of the MPLS-TP architecture are provided by other framework documents such as [IETF RFC 6371], [b-IETF RFC 6372], [b-IETF RFC 5950] and [b-IETF RFC 6373].

The requirements for MPLS-TP forwarding, OAM, and network survivability are described in [IETF RFC 5654] and [IETF RFC 5860].

The MPLS-TP framework is described in [IETF RFC 5921] and [IETF RFC 6215]. The MPLS-TP OAM framework and architecture is defined in [IETF RFC 6371]. The MPLS-TP protection switching framework and architecture are based on [ITU-T G.808.1] and described in [b-IETF RFC 6372]. The structure of the identifiers for the transport entities is for further study.

NOTE – The information content of the identifiers for the transport entities is defined in [IETF RFC 6370] which specifies the use of the IP-based global ID to uniquely identify a network operator. An alternative way to uniquely identify a network operator using a combination of the country code (CC), as defined in [ITU-T G.8013], and the ITU carrier code (ICC), as defined in [ITU-T M.1400], will be defined after further study.

Control and management plane aspects are outside the scope of this Recommendation.

This Recommendation provides functional components (based on ITU-T G.805) that allow the MPLS-TP to be modelled in a way that is consistent with the description of other transport technologies defined by the ITU-T. The functional description provided in this Recommendation is generic and no particular physical partitioning of the functions is implied.

These functional components support the architecture for p2mp MPLS-TP LSPs in compliance with [IETF RFC 5331] and [IETF RFC 5332]. Further details on p2mp MPLS-TP LSPs and PWs are under definition in IETF and future versions of this Recommendation may be updated to include this new material.

The current version of this Recommendation only provides those functional components (based on ITU-T G.805) and architectural models required to model Ethernet carried by a SS-PW over hierarchical co-routed bidirectional LSPs in the network scenario provided in Annex A.

The MPLS-TP supports other clients for LSPs (e.g., IP) and PWs, multi-segment PW (MS-PW) and non-DiffServ traffic engineered (TE) LSPs, as described in [IETF RFC 5921] and [IETF RFC 6215]. Models for these clients and other modes of operations will be added to future versions of this Recommendation.

MPLS-TP conformant equipment may support additional MPLS features. These additional MPLS features are outside the scope of this Recommendation.

6.1 MPLS-TP network layered structure

One-layer network is defined to model the MPLS-TP network architecture, which is defined in [IETF RFC 5921]:

- MPLS-TP layer network.

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

The MPLS-TP layer network may be deployed recursively to provide an MPLS-TP hierarchy implemented as a label stack as per [IETF RFC 5921]. In this Recommendation, this is described by the use of sub-layering as defined in clause 8.1 of [ITU-T G.8110].

PWs can only be carried over the server layer network as specified by IETF PWE3 WG. This Recommendation describes carrying PWs over MPLS-TP LSPs.

The MPLS architecture does not have a minimum packet length. When MPLS packets are transmitted over a non-MPLS-TP server layer with a minimum frame size, the Server/MPLS-TP adaptation function will pad these packets to the minimum frame size of that non-MPLS-TP server layer. This padding is removed at the adaptation sink of the non-MPLS client. The mechanisms for mapping clients over MPLS-TP provide appropriate information (e.g., the length field in the Control Word) to remove the padding at that MPLS-TP/Client adaptation sink function.

In normal operations, all packets with the same class of service sent over an MPLS-TP connection are delivered in order; see [IETF RFC 5921]. This means that, under normal conditions, all the packets sent over a PW or explicitly traffic class (TC)-encoded per hop behaviour (PHB) scheduling class (PSC) LSP (E-LSP) within the same class of service, are delivered in order, and that all the packets sent over a label-only-inferred PSC LSP (L-LSP) are delivered in order (because L-LSPs support only a single class of service).

NOTE – The mapping of a client over an MPLS-TP must be handled to respect ordering requirements for the client. Mechanisms to achieve this are client layer specific and outside the scope of this Recommendation.

At domain boundaries, an instance of a layer or sub-layer playing a specific role in one domain may continue in the adjacent domain in another role. Roles describe particular client/server layer relationships. The characteristic information (CI) of the layer is the only necessary condition for how the layer continues between domains. In ITU-T G.805 terms, the server of a client/server relationship in one domain might be a client in the adjacent domain.

As applied to MPLS-TP domains, the layer instances of an MPLS-TP hierarchy may be described in terms of their role in the hierarchy. These roles are channel, path, and section. At a boundary between two domains, an MPLS-TP section in one domain could continue as an MPLS-TP path in the adjacent domain. In MPLS-TP, the instantiation of a sub-path maintenance element (SPME) for an LSP creates a new sub-layer but does not change the role of the LSP with respect to the MPLS-TP connection that the SPME is associated with.

Figure 6-1 illustrates that LSP2 has an MPLS-TP path role in Domain 2 and an MPLS-TP section role in Domain 1.