International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Series Y
Supplement 4
(01/2008)

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

ITU-T Y.1300 series – Supplement on transport requirements for T-MPLS OAM and considerations for the application of IETF MPLS technology

ITU-T Y-series Recommendations – Supplement 4

ITU-T

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
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Numbering, naming and addressing	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899

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

Supplement 4 to ITU-T Y-series Recommendations

ITU-T Y.1300 series – Supplement on transport requirements for T-MPLS OAM and considerations for the application of IETF MPLS technology

Summary

This Supplement provides the requirements for the operation, administration and maintenance (OAM) functionality in T-MPLS layer networks. This Supplement is designed primarily to support point-to-point and point-to-multipoint T-MPLS connections.

It is noted that this Supplement does not address the administration aspects of OAM.

Source

Supplement 4 to ITU-T Y-series Recommendations was agreed on 25 January 2008 by ITU-T Study Group 13 (2005-2008).

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

NOTE

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

Compliance with this publication is voluntary. However, the publication may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the publication 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 publication is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this publication may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the publication development process.

As of the date of approval of this publication, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this publication. 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

Supplement 4 to ITU-T Y-series Recommendations

ITU-T Y.1300 series – Supplement on transport requirements for T-MPLS OAM and considerations for the application of IETF MPLS technology

1 Scope

This Supplement provides the requirements for the operation, administration and maintenance (OAM) functionality in T-MPLS layer networks from the perspective of transport networks and provides considerations for the application of IETF MPLS technology. These requirements may be met by one or more toolsets, the definition or selection of these toolsets is outside the scope of this Supplement. This Supplement is designed to support point-to-point and point-to-multipoint T-MPLS connections.

This requirements specification does not pre-judge whether a new OAM solution is required for T-MPLS or whether an existing OAM solution could meet them.

Since MPLS and T-MPLS are not necessarily disjoint networks, requirements to support the interoperability between T-MPLS OAM and OAMs and IETF MPLS technologies (e.g., MPLS, PWE3, L2VPN) need to be provided. Adding these requirements may result in some additions or modifications of the transport requirements identified in this Supplement.

The requirements for IETF MPLS and OAM interoperability will follow the MPLS/GMPLS change process outlined in [IETF RFC 4929].

It is noted that this Supplement does not address the administration aspects of OAM.

2 References

[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 (2006), *Characteristics of transport equipment – Description methodology and generic functionality*.

[ITU-T G.809] Recommendation ITU-T G.809 (2003), *Functional architecture of connectionless layer networks*.

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

[ITU-T G.7710] Recommendation ITU-T G.7710/Y.1701 (2007), *Common equipment management function requirements*.

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

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

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

[ITU-T M.3400] Recommendation ITU-T M.3400 (2000), *TMN management functions*.

[ITU-T Y.1541] Recommendation ITU-T Y.1541 (2006), *Network performance objectives for IP-based services*.

[ITU-T Y.1731] Recommendation ITU-T Y.1731 (2006), *OAM functions and mechanisms for Ethernet based networks*.

[IEEE 802.1ag] IEEE 802.1ag-2007, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Virtual Bridged Local Area Networks Amendment 5: Connectivity Fault Management*. <http://ieeexplore.ieee.org/servlet/opac?punumber=4431834>

[IETF BCP 61] IETF Best Current Practice 61 (2002), *Strong Security Requirements for Internet Engineering Task Force Standard Protocols*. <http://tools.ietf.org/html/bcp61>

[IETF RFC 4929] IETF RFC 4929 (2007), *Change Process for Multiprotocol Label Switching (MPLS) and Generalized MPLS (GMPLS) Protocols and Procedures*. <http://www.ietf.org/rfc/rfc4929.txt>

3 Definitions

This Supplement uses the following terms defined elsewhere:

3.1 access point (AP): See [ITU-T G.805].

3.2 anomaly: See [ITU-T G.806].

3.3 client/server layer: See [ITU-T G.806].

3.4 connection point (CP): See [ITU-T G.805].

3.5 connection: See [ITU-T G.805].

3.6 defect: See [ITU-T G.806].

3.7 failure: See [ITU-T G.806].

3.8 link connection: See [ITU-T G.805].

3.9 subnetwork connection (SNC): See [ITU-T G.805].

3.10 termination connection point (TCP): See [ITU-T G.806].

3.11 trail termination function (TT): See [ITU-T G.806].

3.12 trail: See [ITU-T G.805].

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AP	Access Point
AIS	Alarm Indication Signal
CC	Continuity and Connectivity Check
CP	Connection Point
CSF	Client Signal Fail
ETY	Ethernet Physical layer network
FCAPS	Fault, Configuration, Accounting, Performance and Security
FP	Flow point
GMPLS	Generalized Multi-Protocol Label Switching
L2VPN	Layer 2 Virtual Private Network
LC	Link Connection

MCC	Maintenance Communication Channel
ME	Maintenance Entity
MEP	Maintenance Entity Point
MIP	Maintenance Intermediate Point
MPLS	Multi-Protocol Label Switching
OAM	Operation, Administration and Maintenance
PW	Pseudo Wire
PWE3	Pseudo-Wire Emulation Edge-to-Edge
SLA	Service Level Agreement
TCP	Termination Connection Point
TFP	Termination Flow Point
TM	Transport Multi-Protocol Label Switching layer network
T-MPLS	Transport Multi-Protocol Label Switching
UNI	User Network Interface

5 Conventions

None.

6 Reference networks

This Supplement specifies the requirements for OAM functions that are applied to point-to-point and point-to-multipoint T-MPLS connections.

6.1 Point-to-point T-MPLS connections

Figure 1 provides a layered network perspective of a point-to-point connection according to the architecture defined in [ITU-T G.8110.1].

In this example, network elements A and E, which are placed in customer premises, can be associated with a client-layer CP, TCP, FP or TFP. Between the network elements B and D, which are placed at the edges of the provider's network, the client-layer link connection or link flow is transported by a T-MPLS network connection. This example is aligned with the different PW functional models described in Appendix I of [ITU-T G.8110.1].

Note that T-MPLS link connections are supported by different server layer technologies, S and Z. S and Z could be any server layer (including also the case of a T-MPLS server layer network instance). Also note that although ETY is used for the server layer from A to B and from D to E in this example, it does not preclude the use of other server layers for these portions. This flexibility applies to all the examples in this Supplement.

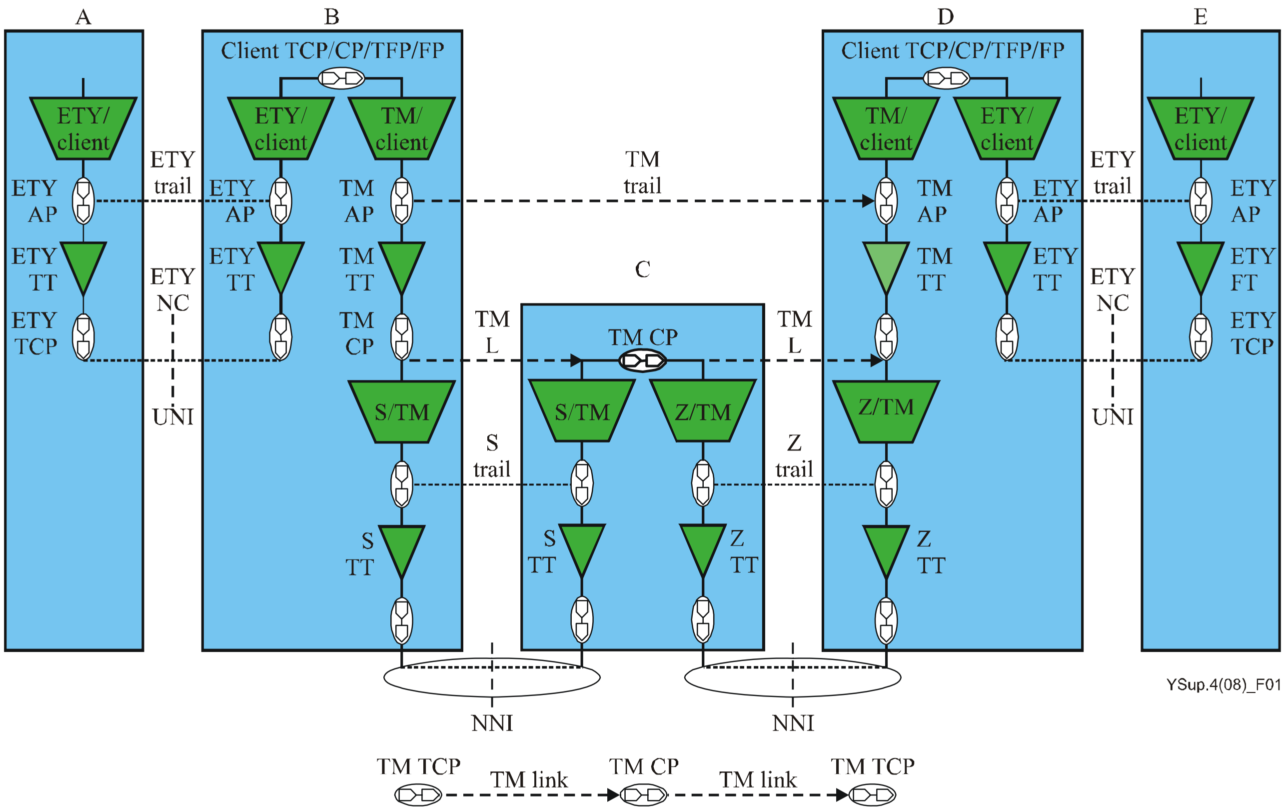


Figure 1 – Example of point-to-point T-MPLS connection reference model

Figure 2 shows the functional model of the hand-off portion between two providers. A and B denote the network elements placed at the boundary. It should be noted that the server layer between the hand-off points could be any server layer, although ETY is used in this example.

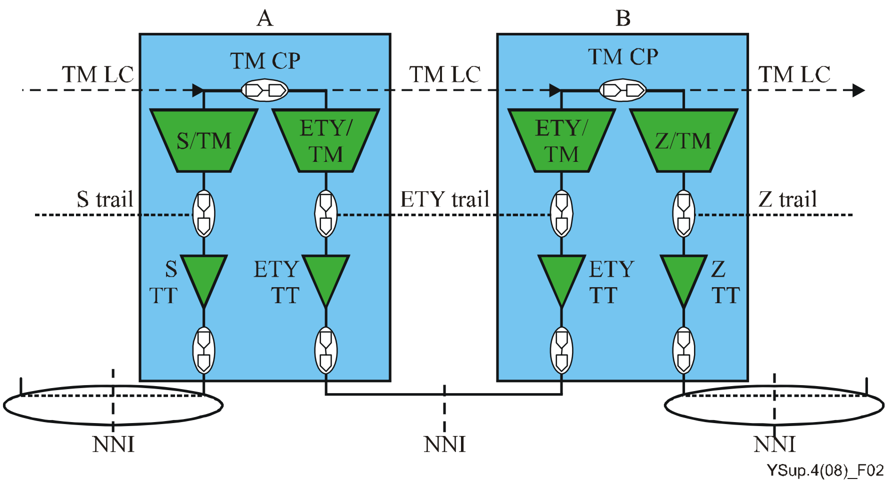


Figure 2 – Example of hand-off point reference model

The view of the reference models in terms of layer networks and the relationships can be simplified by considering only the connections present in the T-MPLS layer network (single layer network view). This is illustrated in Figure 3.

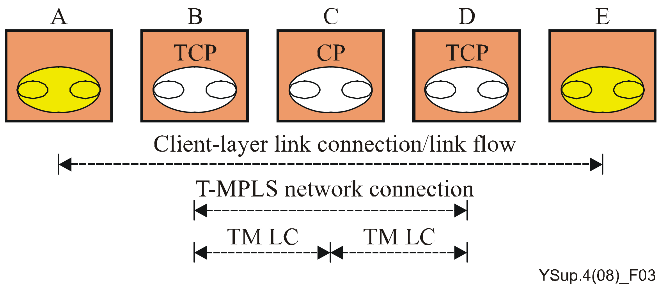


Figure 3 – Example of point-to-point connection reference models in the T-MPLS layer network (different server layer technologies)

6.2 Point-to-multipoint T-MPLS connections

Figure 4 provides a layered network perspective of a point-to-multipoint connection according to the architecture defined in [ITU-T G.8110.1].

This single layer network view can be used to describe the point-to-multipoint.

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 4.

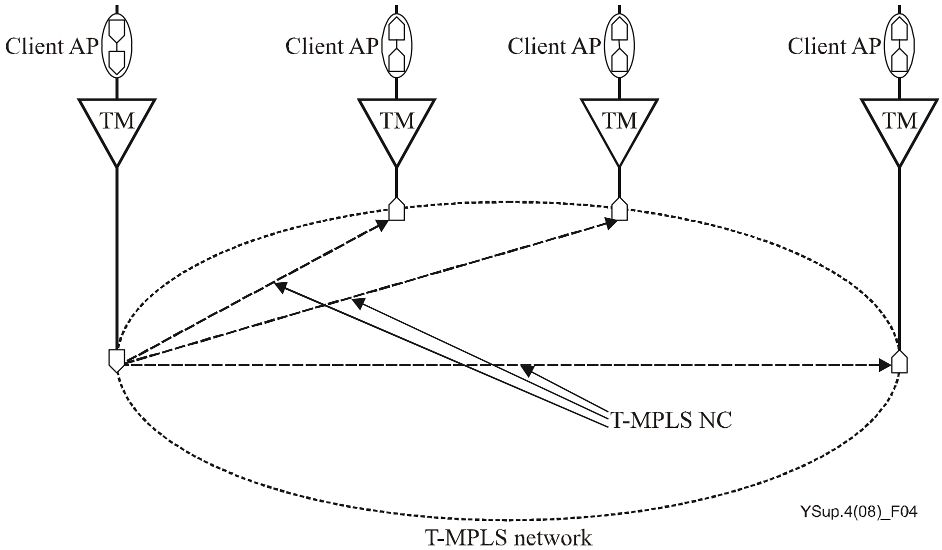
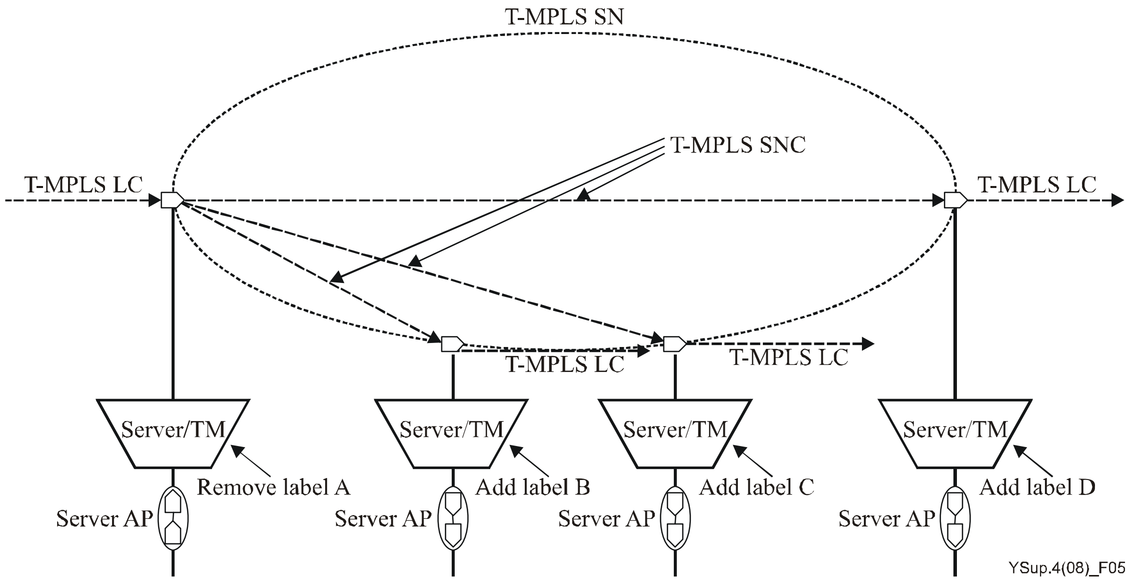


Figure 4 – Point-to-multipoint T-MPLS connection

A unidirectional point-to-multipoint subnetwork connection broadcasts the traffic from the root T-MPLS CP to the leaf T-MPLS CPs as illustrated in Figure 5. The broadcast function provided by the point-to-multipoint subnetwork connection is limited to the subnetwork in which it exists. It may form part of a broadcast function within a larger (containing) subnetwork or network connection.



NOTE – The server layer could also be T-MPLS.

Figure 5 – Point-to-multipoint T-MPLS subnetwork connection

7 Motivation for OAM functionalities for T-MPLS-based networks

It is recognized that OAM functionality is important in transport networks for ease of network operation, for verifying network performance, and to reduce operational complexity. OAM functionality is especially important for networks that are required to deliver (and hence be measurable against) network performance and availability objectives. In order to offer a reliable service over a T-MPLS layer network that can support the requirements of a service level agreement (SLA), it is necessary that the T-MPLS layer network has OAM capabilities.

The major motivations for T-MPLS OAM are discussed further below.

1) A T-MPLS layer network makes use of the connection-oriented mode of the MPLS forwarding plane. The MPLS label stacking capability as described in [ITU-T G.8110] allows the creation of multiple T-MPLS sublayers. Each of these is provided with the same OAM functions. It should be noted that OAM functions can be deployed on a per layer network instance and hierarchical basis. Detection of faults in a T-MPLS sublayer must not rely upon detection in other sublayers or layer networks, above or below.

2) Operators need the ability to determine T-MPLS availability and network performance, noting that network performance metrics are only meaningful when the connection is in the available state.

   In addition, the OAM helps to reduce operating complexity by allowing efficient and automatic detection, handling and diagnosis of defects. For further information see clauses 7 and 10 of [ITU-T G.7710].

3) Provide services that support FCAPS functionality, as described in [ITU-T M.3400], that are utilized to improve operational availability.

4) Ensure that any defect that results in misdirected customer traffic is detected/diagnosed and leads to appropriate consequent actions.

5) Minimize the number of defects that are not detected automatically before a customer reports the problem.

   NOTE 1 – Multilayer survivability strategies/mechanisms to recover connectivity after a fault has occurred are outside the scope of this Supplement.

6) It should be possible to prevent alarms being raised in a client layer or client sublayer as a result of a defect in a server layer.

7) Support the ability to do SLA verification and fault localization to a single maintenance domain within a multi-maintenance domain network (also know as tandem connection monitoring). TCM may also be used for further fault localization within a maintenance domain.

8) Support the interoperability between T-MPLS OAM and OAMs of different Ethernet transport technologies (e.g., [IEEE 802.1ag] and [ITU-T Y.1731]) and IETF MPLS technologies (e.g., MPLS, PWE3, L2VPN).

   NOTE 2 – Full interoperability has a broader architectural scope than OAM.

9) A T-MPLS-supported service may be sensitive to delay experienced by the packets during transit between T-MPLS aware devices. To determine if a T-MPLS-supported service is degraded due to packet delay, measurement of packet delay and packet delay variation must be supported. Normally, the preferred method of delay measurement is one-way delay. This is used to characterize the path delay in each direction of a bidirectional connection or characterize the path delay of unidirectional applications, e.g., multicast and broadcast applications. When one-way delay measurement is not possible, two-way delay measurement may be used as an approximation in bidirectional connections, provided the asymmetrical limitations are taken into account. For some applications, roundtrip delay measurements using a two-way delay measurement method may be sufficient.

8 General requirements for T-MPLS layer OAM functions

The following requirements should be satisfied by T-MPLS OAM:

1) Support of client/server OAM relationships between T-MPLS and its (non-T-MPLS) server layers, T-MPLS and its (non-T-MPLS) client layer and between different T-MPLS layer network instances (e.g., signal fail/signal degrade).

2) Support both on-demand and continuous connectivity verification of communication between edges of OAM maintenance entities to confirm that defects do not exist across the monitored T-MPLS maintenance entity.

3) If a defect occurs, it is necessary to detect it, diagnose it, localize it, notify network management systems, and take corrective actions appropriate to the type of defect. The primary objective is to reduce operating costs by minimizing service interruptions, operational repair times, and operational resources.

4) In the case of the service provider UNI-UNI OAM maintenance entity, T-MPLS OAM mechanisms provided should ensure (as far as reasonably practicable) that customers should not have to detect failures. It is therefore necessary that defects associated with this entity are detected and notified automatically by the service provider.

5) The following anomalies should be automatically detected and corresponding defect states, with well-defined entry/exit criteria and appropriate consequent actions, should be defined:
   – loss of connectivity;
   – misconnections;
   – unintended self-replication (e.g., looping);
   – lost packets;
   – misinserted packets (e.g., misinsertion of a packet into a T-MPLS connection).

6) It should be noted that not all of these OAM functions need to be supported for a given T-MPLS connection.

NOTE 1 – An applicability statement must be provided that says which functions are needed for which application, and which sets of functions form a matched set.

7) OAM functions should provide means to detect anomalies that impact the transport of user traffic in the network. T-MPLS OAM packets must be forwarded on the same connection as the T-MPLS user packets are forwarded.

8) It should be possible to prevent alarms being raised in a client layer or client sublayer as a result of a defect in a server layer.

NOTE 2 – Multilayer survivability strategies and mechanisms to recover connectivity after a fault has occurred are outside the scope of this Supplement.

9) The use of T-MPLS OAM functions should be optional for the operator. A network operator should be able to choose which OAM functions to use and which connections it applies them to. However, it is recommended that a CV flow is run/monitored on every connection in order to reliably detect misconnectivity defects.

10) T-MPLS OAM functions should allow scaling to support large network sizes.

11) T-MPLS OAM function should be configurable as part of connection management.

NOTE 3 – Connection management is outside the scope of this Supplement.

12) The design of T-MPLS OAM functions should ensure that when T-MPLS equipments with different OAM capabilities enabled are interconnected, user traffic should not be disturbed and unnecessary maintenance actions should not be triggered.

13) A MEP must automatically discard any not-recognized or malformed OAM packet.

NOTE 4 – The need to count the discarded packets to record malfunctions is for further study.

14) OAM packets can only be intercepted at destined MEP/MIPs. Intermediate nodes must not intercept OAM packets not destined for the local MEP/MIP.

15) The OAM packet format must be designed such that equipment that does not support MEPs at the connection endpoint automatically discards OAM at the boundary of the layer network.

NOTE 5 – The need to count the discarded packets to record malfunctions is for further study.

16) T-MPLS OAM should provide means to measure availability and network performance of a maintenance entity. Since network performance metrics are only meaningful when the T-MPLS connection is in the available state, then the entry/exit of the available state and all appropriate consequent action (such as the starting/stopping of network performance metric aggregation) should be specified.

17) The functionality of T-MPLS OAM should not be dependent on any specific server or client layer network. This is architecturally critical to ensure that layer networks can evolve without impacting other layer networks.

18) The functionality of T-MPLS OAM should be sufficiently independent of any specific control plane such that any changes in the control plane do not impose changes in user-plane OAM (including the case of no control plane). Per the previous requirement, this is also architecturally critical to ensure that user-plane and control-plane protocols can evolve without impacting each other.

19) T-MPLS continuity and connectivity check should not be dependent on the dynamic behaviour of client-layer traffic. See also [ITU-T G.806].

20) The T-MPLS OAM should continue to provide the OAM functions with a high degree of confidence under normal packet loss conditions as defined in [ITU-T Y.1541].

NOTE 6 – Quantification is for further study.

21) T-MPLS OAM requirements should address both network operators and service providers where a service provider T-MPLS connection can span across multiple network operator domains.

22) If the T-MPLS connection is being transported over networks belonging to different operators, the one that offers the service to the customer should be aware of a service fault even if the fault and detection point are located in the network of another operator.

23) T-MPLS OAM should allow for a stateless layer network interworking (also known as service interworking) between T-MPLS (based on [ITU-T G.8110.1]) and an Ethernet (based on [ITU-T G.8010]) network.

24) The design of T-MPLS OAM mechanisms shall not preclude the ability to carry other communications (e.g., APS, MCC).

    NOTE 7 – The requirements for these applications are out of scope of this Supplement.

25) The design of T-MPLS OAM shall provide mechanisms for vendor-specific and experimental OAM functions. Support of these extensions is optional, and these extensions must not interfere with the standardized OAM functions.

    NOTE 8 – The requirements for these vendor-specific and experimental OAM functions are out of scope of this Supplement.

26) T-MPLS OAM should provide mechanisms for carrying the fault indication of a client layer network instance when no client AIS is available, but a downstream indication of the defect condition is needed, e.g., CSF as described in [ITU-T G.7041].

27) T-MPLS OAM should provide mechanisms to ensure that unauthorized access is prevented from triggering any service provider/network operator T-MPLS OAM function.

28) T-MPLS OAM should provide mechanisms to ensure that service provider/network operator T-MPLS OAM packets, which are meant for their internal use, are confined within their maintenance domains. That is, they are prevented from leaking out to other maintenance domains such as customer networks or other service provider networks.

29) T-MPLS OAM messages shall be authenticated.

30) T-MPLS OAM must support measurement of two-way packet delay between two MEPs. T-MPLS OAM must not preclude the future support for measurement of one-way packet delay between two MEPs.

    NOTE 9 – Additional detailed requirements (e.g., delay variation, accuracy, precision) are outside the scope of this Supplement.

9 Requirements for T-MPLS maintenance entities

T-MPLS OAM packets can be inserted and extracted at the reference points, i.e., the T-MPLS MEPs and MIPS of the reference models (see [ITU-T G.8110.1]). The following T-MPLS maintenance entities (ME) are defined:

- service provider UNI-UNI maintenance entity in the T-MPLS layer network between reference points on the service provider network side of the UNI;
- tandem connection T-MPLS OAM maintenance entity between T-MPLS connection points. A tandem connection may be:
  - between connection points on the boundaries of two adjacent service provider/network operator network elements or networks (intra-domain ME, inter-domain ME);
  - between any connection points as required.

10 Required OAM functions

[ITU-T G.806] and [ITU-T G.7710] provide background material and terminology for the processing of anomalies, defects and faults as described in these OAM requirements.

10.1 Bidirectional point-to-point T-MPLS connections

The following *pro-active* OAM function for *fault management* is required between MEPs for bidirectional point-to-point T-MPLS connections:

- continuity and connectivity check (CC);
- alarm suppression;
- lock indication;
- packet loss measurement in both directions of the bidirectional connection;
- remote defect indication.

The following *on demand* OAM functions for *fault management* are required between MEPs for bidirectional point-to-point T-MPLS connections:

- unidirectional and bidirectional diagnostic test.

  NOTE 1 – The specification of these tests is for further study.

The following *on demand* OAM functions for *fault management* are required between MEPs and between a MEPs and MIPs for bidirectional point-to-point T-MPLS connections:

- continuity and connectivity check (CC) with different packet sizes;
- traceroute.

The following *pro-active* OAM functions for *performance management* are required between MEPs for bidirectional point-to-point T-MPLS connections:

- continuity and connectivity check (CC);
- remote defect indication;
- packet loss measurements in both directions of the bidirectional connection.

The following *on demand* OAM functions for *performance management* are required between MEPs for bidirectional point-to-point T-MPLS connections:

- Single-ended packet loss measurements;
- One-way and two-way packet delay measurements.

NOTE 2 – In case a misconnection is detected, on demand performance management shall be suspended until the misconnection has been fixed, i.e., all request/response OAM needs to be treated with caution as it cannot be assumed to function reliably, e.g., if traffic is leaking in a unidirectional sense with no return path.

10.2 Unidirectional T-MPLS connections

The following *pro-active* OAM functions *for fault management* are required between MEPs for unidirectional point-to-point and point-to-multipoint T-MPLS connections:

- continuity and connectivity check (CC);
- alarm suppression;
- lock indication;
- packet loss measurement.

The following *on demand* OAM function for *fault management* is required between MEPs for unidirectional point-to-point and point-to-multipoint T-MPLS connections:

- unidirectional diagnostic test.

The following *pro-active* OAM functions for *performance management* are required between MEPs for unidirectional point-to-point and point-to-multipoint T-MPLS connections:

- connectivity and continuity check (CC);
- packet loss measurements.

The following *on demand* OAM function for *performance management* is required between MEPs for unidirectional point-to-point and point-to-multipoint T-MPLS connections:

- one-way packet delay measurements.

11 Security aspects

Note that the OAM security requirements within this Supplement are based upon the security requirements of transport networks defined in ITU-T.

The architectural aspects for security in the T-MPLS transport layer network are described in clause 13 of [ITU-T G.8110.1].

Further analysis (e.g., as required in [IETF BCP 61]) is needed before a solution based on IETF technology can be completed.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects and next-generation networks**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2008