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

Packet over Transport aspects – MPLS over Transport aspects

Dual-homing protection for multi-protocol label switching transport profile pseudowires

Recommendation ITU-T G.8133

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Recommendation ITU-T G.8133

Dual-homing protection for multi-protocol label switching transport profile pseudowires

Summary

Recommendation ITU-T G.8133 provides architecture and mechanisms for pseudowire (PW) dual-homing protection in multi-protocol label switching transport profile (MPLS-TP) networks. It also describes the dual-homing coordination (DHC) protocol described in [IETF RFC 8184] and [IETF RFC 8185].

The mechanisms defined herein protect point-to-point MPLS-TP PWs against failures within or at the edges of the MPLS-TP network.

History

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Dual-homing, MPLS-TP, protection.

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Recommendation ITU-T G.8133

Dual-homing protection for multi-protocol label switching transport profile pseudowires

1 Scope

This Recommendation provides architecture and mechanisms for pseudowire (PW) dual-homing protection in multi-protocol label switching transport profile (MPLS-TP) networks. It also describes the dual-homing coordination (DHC) protocol defined in [IETF RFC 8184] and [IETF RFC 8185].

Both one-side and two-side dual-homing protection mechanisms are provided.

The mechanisms defined herein protect point-to-point MPLS-TP PWs against failures within or at the edges of the MPLS-TP network.

This Recommendation provides a representation of the MPLS-TP technology using the methodologies that have been used for other transport technologies (e.g., synchronous digital hierarchy (SDH), optical transport network (OTN) and the Ethernet).[1]

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.808] Recommendation ITU-T G.808 (2016), *Terms and definitions for network protection and restoration*.

[ITU-T G.7701] Recommendation ITU-T G.7701 (2016), *Common control aspects*.

[ITU-T G.8113.1] Recommendation ITU-T G.8113.1/Y.1372.1 (2016), *Operations, administration and maintenance mechanisms for MPLS-TP in packet transport networks*.

[ITU-T G.8121] Recommendation ITU-T G.8121 (2018), *Characteristics of MPLS-TP equipment functional blocks*.

[ITU-T G.8131] Recommendation ITU-T G.8131 (2014), *Linear protection switching for MPLS transport profile*.

[ITU-T X.84] Recommendation ITU-T X.84 (2004), *Support of frame relay services over MPLS core networks*

[IETF RFC 3985] IETF RFC 3985 (2005), *Pseudo wire emulation edge-to-edge (PWE3) architecture.*

[IETF RFC 5586] IETF RFC 5586 (2009), *MPLS generic associated channel.*

[IETF RFC 5654] IETF RFC 5654 (2009), *Requirements of an MPLS transport profile.*

[IETF RFC 6371] IETF RFC 6371 (2011), *Operations, administration, and maintenance framework for MPLS-based transport networks.*

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

[IETF RFC 8184] IETF RFC 8184 (2017), *Dual-homing protection for MPLS and the MPLS transport profile (MPLS-TP) pseudowires.*

[IETF RFC 8185] IETF RFC 8185 (2017), *Dual-homing coordination for MPLS transport profile (MPLS-TP) pseudowires protection.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 attachment circuit (AC) [IETF RFC 3985].

3.1.2 customer edge (CE) [ITU-T X.84].

3.1.3 protection transport entity [ITU-T G.808].

3.1.4 provider edge (PE) [ITU-T X.84].

3.1.5 recovery domain [ITU-T G.7701].

3.1.6 working transport entity [ITU-T G.808].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 attachment circuit recovery domain: A recovery domain that is adjacent to the multi-protocol label switching transport profile (MPLS-TP) dual-homing protection domain and provides reliable transfer of information of the client traffic using two redundant attachment circuits between the MPLS-TP dual-homing protection domain and one customer edge node.

3.2.2 dual-homing nodes: Two provider edge (PE) nodes that are dual homed to the same customer edge node to provide PE node resiliency at the boundary of the multi-protocol label switching transport profile transport network.

3.2.3 dual-node interconnection transport entity: The transport entity (i.e., pseudowire) established between dual-homing nodes. The dual-node interconnection transport entity is pre-established and used when there is a need for fast switchover.

3.2.4 multi-protocol label switching transport profile dual-homing protection domain: A recovery domain that uses the mechanisms described in this Recommendation to provide reliable transfer of information of client traffic through a multi-protocol label switching transport profile network.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Attachment Circuit

APC Automatic Protection Coordination

CE Customer Edge

DHC Dual-Homing Coordination

DNI Dual-Node Interconnection

G-ACh Generic Associated Channel

LSP Label Switched Path

MEP	Maintenance Entity Point
MPLS	Multi-Protocol Label Switching
MPLS-TP	Multi-Protocol Label Switching Transport Profile
OAM	Operation, Administration and Maintenance
PE	Provider Edge
PW	Pseudowire
SD	Signal Degrade
SF	Signal Fail
WTR	Wait to Restore

5 Conventions

In this document, the term DHC protocol is used to describe the means to coordinate the two MPLS-TP dual-homing nodes via the exchange of messages as described in [IETF RFC 8185].

6 Overview

[IETF RFC 8184] describes the scenarios and applications for using dual-node interconnection (DNI) PWs to provide dual-homing protection. Both one-side and two-side dual-homing protection scenarios are provided as described in clauses 2.2.1 and 2.2.2 of [IETF RFC 8184], respectively.

Figure 6-1 illustrates a reference network to describe the one-side dual-homing protection scenario where one customer edge (CE) (i.e., CE1) is attached to single node A and another CE (i.e., CE2) is attached to two dual-homing nodes (Z1 and Z2). A working transport entity (i.e., working PW) connects node A to node Z1, a protection transport entity (i.e., protection PW) connects node A to node Z2, and a DNI transport entity (DNI PW) is used to provide connectivity between nodes Z1 and Z2 during protection-switching conditions. MPLS-TP label switched paths (LSPs) are established as underlay server-layer trails for each PW, but they are not shown in Figure 6-1.

In Figure 6-1, if an attachment circuit (AC) to Z1 (i.e., AC1) fails, then the AC to Z2 (i.e., AC2) is activated and DNI PW forwards the traffic between Z1 and Z2, so that the working PW works as usual.

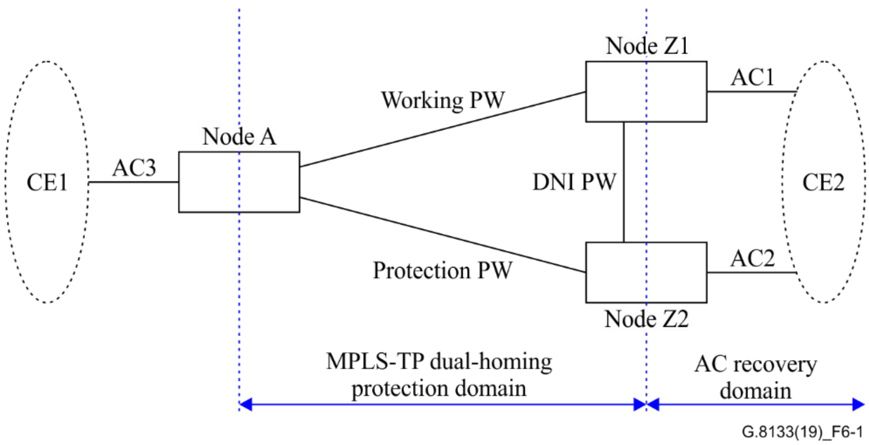

Figure 6-1 – One-side MPLS-TP dual-homing reference network

[IETF RFC 8185] specifies mechanisms to provide dual-homing protection against failures within the MPLS-TP dual-homing protection domain and the DHC protocol to coordinate protection-switching action between dual-homing nodes (Z1 and Z2). The coordination messages are transported on the DNI transport entity (DNI PW) over the generic associated channel (G-ACh).

This Recommendation assumes that the automatic protection coordination (APC) protocol, described in [ITU-T G.8131], is used to coordinate protection-switching actions between the two ends of the MPLS-TP dual-homing protection domains (i.e., nodes A and Z2).

Figure 6-2 illustrates a reference network to describe the two-side dual-homing protection scenario where CE1 is also attached to two dual-homing nodes (A1 and A2). In this case, one DHC protocol is used to coordinate protection switching between nodes A1 and A2, the other DHC protocol is used to coordinate protection switching between nodes Z1 and Z2, and the APC protocol is assumed to be used to coordinate protection switching between nodes A2 and Z2.

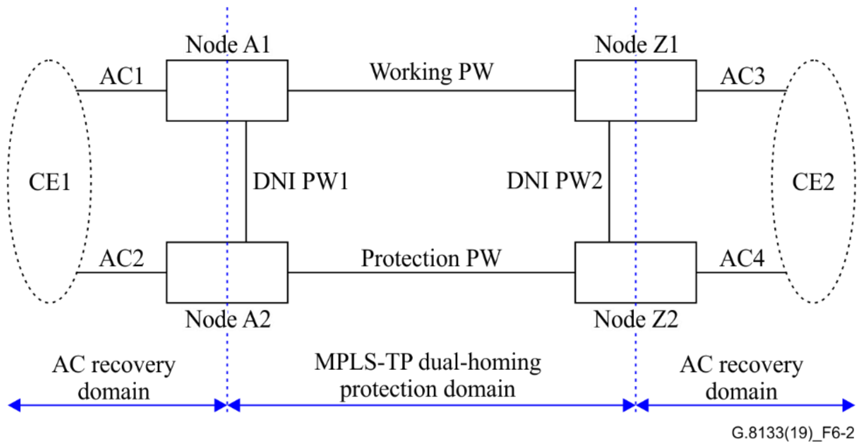

Figure 6-2 – Two-side MPLS-TP dual-homing reference network

The mechanisms used to provide protection against failures within the AC recovery domains lie outside the scope of this Recommendation. It is assumed that these mechanisms will activate one and only one AC at a given time within each AC recovery domain and are capable of reporting the active/stand-by status of a local AC to the PE node.

MPLS-TP PW dual-homing protection mechanisms operates independently from the client layer protocols (i.e., the client services in transport) encapsulated in the PW and therefore are applicable to any PW client such as the Ethernet, time division multiplexing and asynchronous transfer mode.

Through these working and protection PWs and their LSPs, services over dual-homing nodes can be protected from a single failure on either the working PW, the protection PW, a dual-homing node (node Z1 or node Z2) or an AC connecting a CE with dual-homing nodes. Recovery of multiple-failure scenarios lies outside the scope of this Recommendation.

7 Dual-homing protection architecture

Dual-homing protection architecture is based on 1:1 PW trail protection.

It supports only the bidirectional protection-switching type, i.e., both directions of the connection for a service, including the affected direction and the unaffected direction, are switched to protection.

Both revertive and non-revertive operation types are supported.

Both one-side and two-side dual-homing architectures are supported.

7.1 One-side dual-homing

In one-side dual-homing, only one side of the client sites is dual homed. The scenario is described in clause 2.2.1 of [IETF RFC 8184].

7.2 Two-side dual-homing

In two-side dual-homing, both sides of the client sites are dual homed. The scenario is described in clause 2.2.2 of [IETF RFC 8184].

8 Protection signalling

To coordinate the switching of working and protection PWs (i.e., the working and protection transport entities) and activate the DNI PW (i.e., DNI transport entity), between the dual-homing nodes, the DHC protocol as specified in clause 4 of [IETF RFC 8185] shall be used. Any status and switchover coordination messages between the dual-homing nodes shall be sent over the G-ACh [IETF RFC 5586] of the DNI PW.

The switching of working and protection PWs, between the two ends of the MPLS-TP dual-homing protection domains, is coordinated using the mechanisms described in [ITU-T G.8131]. The APC messages shall be sent over the protection PW as described in [ITU-T G.8131].

9 Functional model

The end points of each working transport entity shall have PW operation, administration and maintenance (OAM) functions to monitor the status of the working transport entity (working PW). Because the protection transport entity and the DNI transport entity are pre-established, the status of the protection transport entity (protection PW) and of the DNI transport entity (DNI PW) shall also be monitored at the end points using PW OAM functions.

APC messages are transported over the protection transport entity, and the DHC messages are exchanged over the DNI transport entity.

The functional architecture of DNI protection is shown in Figure 9-1.

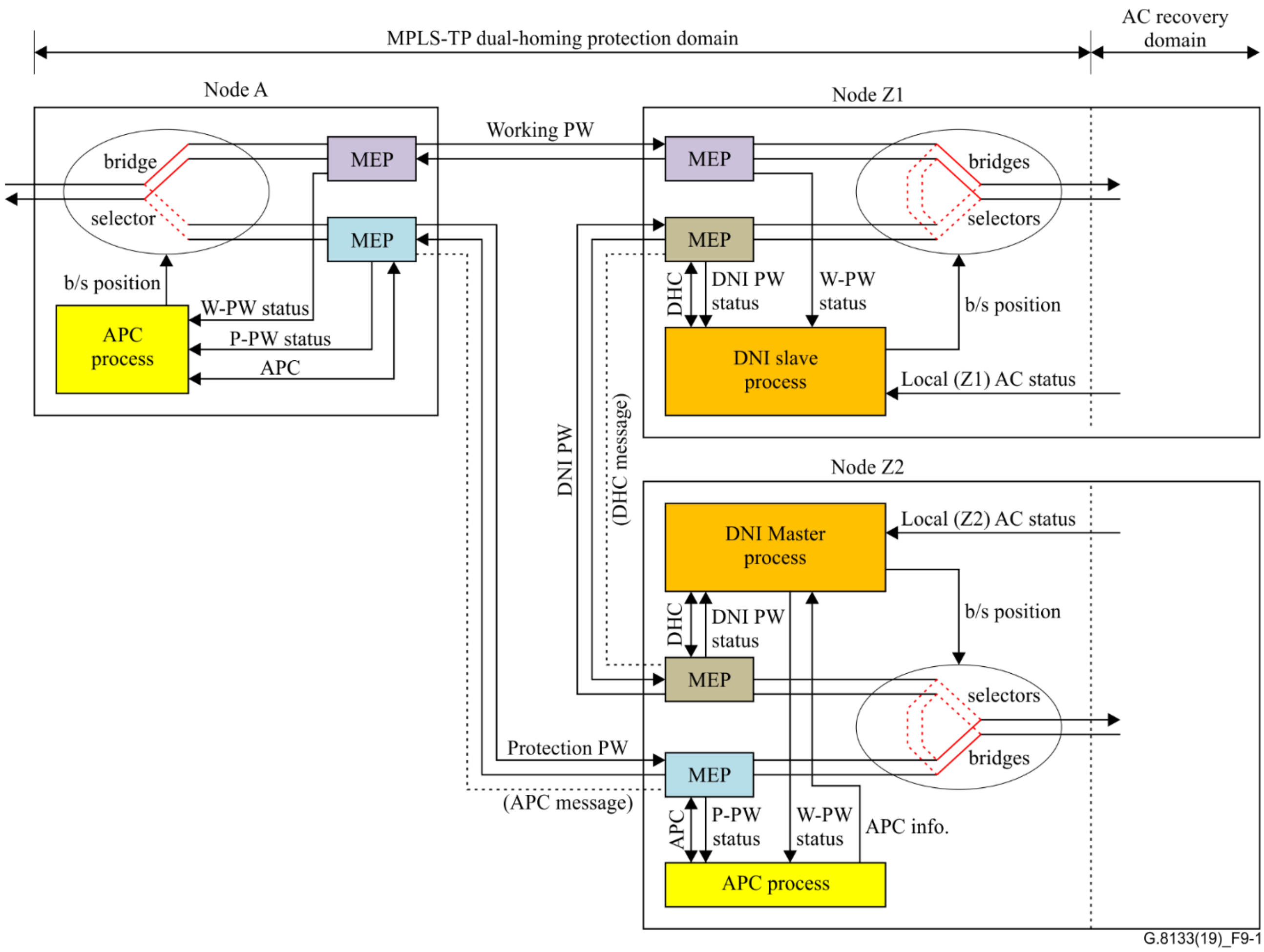

Figure 9-1 – MPLS-TP Dual-homing protection architecture

Node A implements PW trail protection, as descried in [ITU-T G.8121], so that protection switching to the protection PW in both directions can be realized as specified in [ITU-T G.8131]; while nodes Z1 and Z2 implement PW DNI protection, as described in this Recommendation and in [IETF RFC 8184] and [IETF RFC 8185].

The bridges/selectors, in nodes Z1 and Z2, implement the forwarding behaviour described in Table 1 of [IETF RFC 8185].

The APC process in node Z2 determines the new switching states of the working PW and the protection PW based on the local status of the protection PW (determined by the protection PW maintenance entity point (MEP)), the status of the working PW (from the DHC messages received by the DNI master process), the commands of the local operator and the APC messages exchanged with the remote node A. The switching state of a PW indicates whether the PW is active (i.e., used for transmitting and receiving traffic) or not. Only one of the working and protection PWs should be active at any given time.

The DNI master process in node Z2 controls the bridges/selectors forwarding behaviour within node Z2, implementing the state machine described in [IETF RFC 8185] based on the local status of the DNI PW (determined by the DNI PW MEP), the local AC status, and the switching state of the protection PW (determined by the APC process). It also exchanges DHC messages with the peer DNI slave process to send the switching state of the working PW (determined by the APC process) and to receive the peer status of the working PW.

The DNI slave process in node Z1 controls the bridges/selectors forwarding behaviour within node Z1, implementing the state machine described in [IETF RFC 8185] based on local status of the DNI PW (determined by the DNI PW MEP), the local AC status, and the switching state of the working PW (based on received DHC messages). It also transmits to the peer DNI master process, DHC messages carrying the local status of the working PW (determined by the working PW MEP).

The MPLS-TP dual-homing protection switching is modelled as an MPLS-TP dual-homing protection sub-layer (MTd), as shown in Figures 9-2 and 9-3:

– The MTd_C atomic function is a connection function implementing the dual-homing protection switching using the bridges/selectors, the DNI processes and the APC process as shown in Figure 9-1. The MTd_C atomic functions in nodes Z1 and Z2 differ depending on whether the APC process exists or not and whether the DNI process is a master or a slave.

– The MT/MTd_A atomic function inserts/extracts the APC and DHC messages to/from the protection PW and DNI PW, respectively.

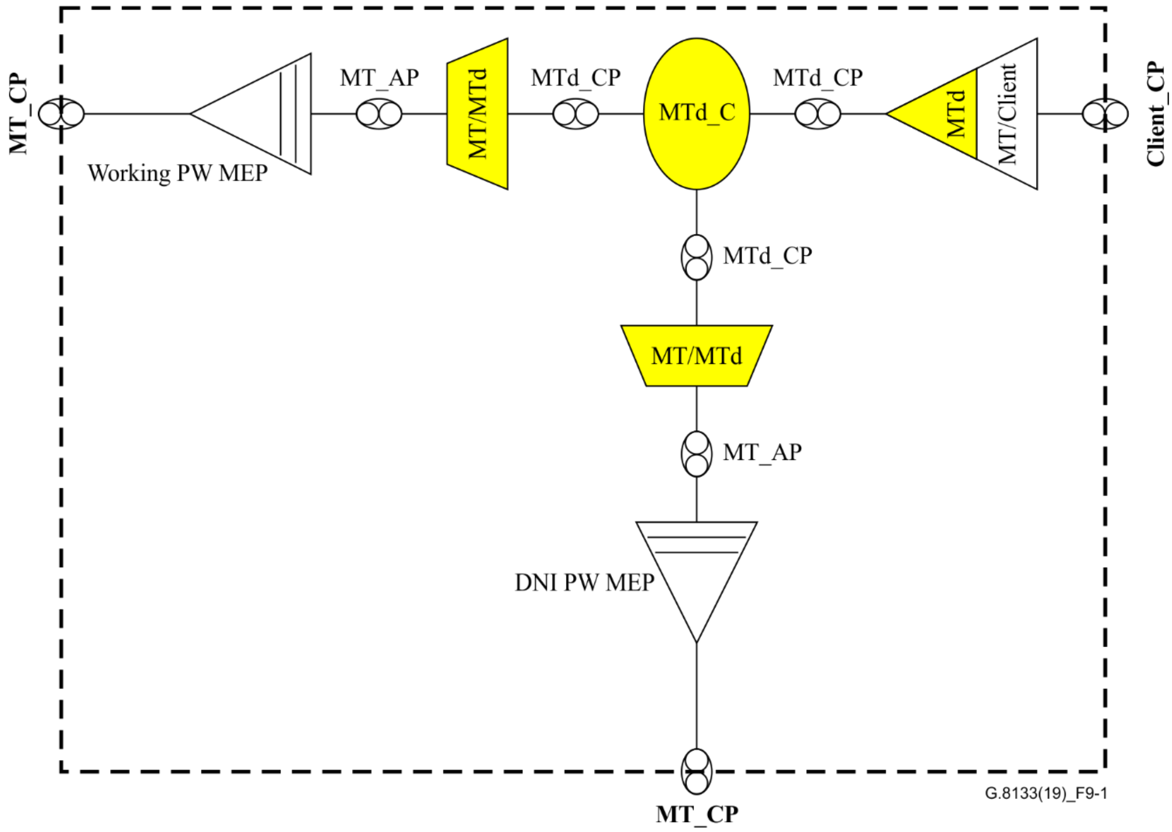

Figure 9-2 – MPLS-TP dual-homing protection sub-layer (Z1)

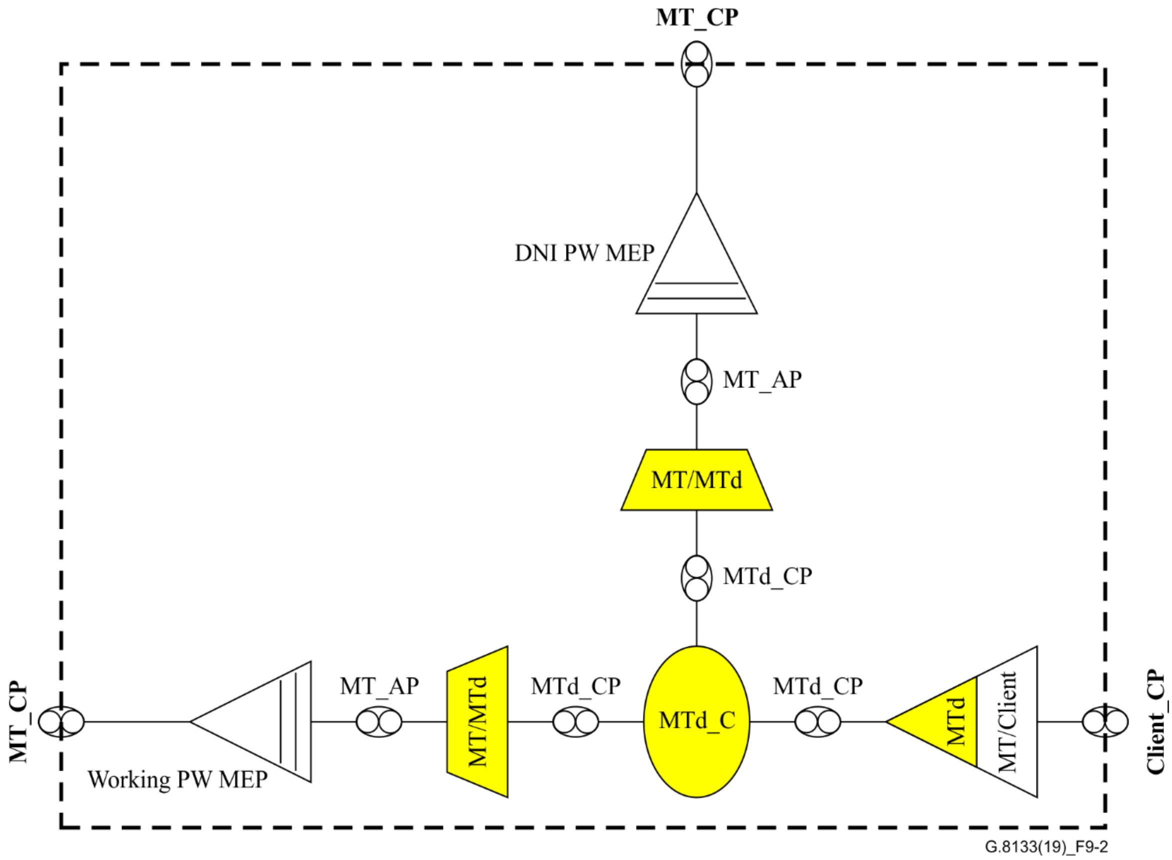

Figure 9-3 – MPLS-TP dual-homing protection sub-layer (Z2)

10 Hold-off timer

MPLS-TP dual-homing protection relies upon the hold-off timer logic described in [ITU-T G.8131] to coordinate timing of protection switches at multiple layers for working and protection PWs.

As a consequence, the hold-off timer of the APC process within the protection PE shall be configured via MTd_C_MI_PS_HoTime.

11 Wait-to-restore timer

MPLS-TP dual-homing protection relies upon the wait to restore (WTR) state described in [ITU-T G.8131] to prevent frequent operations of the protection switch due to an intermittent defect of the working transport entity.

As a consequence, the wait-to-restore timer of the APC process within the protection PE shall be configured via MTd_C_MI_PS_WTR.

12 Protection procedures

Protection procedures for MPLS-TP PW dual-homing mechanisms are described in clause 4.2 of [IETF RFC 8185].

Some examples on how they apply to one-side and two-side dual-homing scenarios are provided in Appendix I.

13 External commands

MPLS-TP dual-homing protection relies upon the external commands applied to the APC process, as described in [ITU-T G.8131], to allow operator control of the switching state of working and protection transport entities. In case of multiple protection-switching requests, the priority logic described in [ITU-T G.8131] is used to determine the switching states of the working and protection transport entities.

As a consequence, the external command shall be input into the APC process within the protection PE via MTd_C_MI_PS_ ExtCMD.

14 Failure detection

The MPLS-TP PW layer OAM is used to monitor the status of the working PW, the protection PW and the DNI PW(s). Dual-homing nodes in the dual-homing protection domain shall support the PW OAM mechanisms as defined in clause 4.3 of [IETF RFC 6371].

The defect conditions on each MPLS-TP PW are detected as described in [ITU-T G.8121].

Signal fail (SF) is declared on working and protection PW when the MPLS-TP trail termination sink (MT_TT_Sk) function in the MPLS-TP dual-homing protection domain detects a trail SF as described in [ITU-T G.8121].

Signal degrade (SD) is declared on working and protection when the MPLS-TP trail termination sink (MT_TT_Sk) function in the MPLS-TP dual-homing protection domain detects a trail signal degrade as described in [ITU-T G.8121].

DNI PW is declared to be in a down state when the MPLS-TP trail termination sink (MT_TT_Sk) function detects a trail SF or a remote defect indication (RDI) condition as described in [ITU-T G.8121].

A dual-homing node failure is regarded as the failure of the AC and of the two PWs attached to that dual-homing node.

Annex A

Forwarding state tables of protection switching

(This annex forms an integral part of this Recommendation.)

The state machines for MPLS-TP dual-homing protection are described in clause 4 of [IETF RFC 8185]. In order to achieve MPLS-TP dual-homing protection, the dual-homing nodes need to exchange PW status and protection coordination requests to coordinate their behaviours.

In order to avoid potential mistakes in duplicating the state transition tables from [IETF RFC 8185], they are omitted in this Recommendation.

Appendix I

One-side and two-side dual-homing protection examples

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

I.1 One-side dual-homing

One-side dual-homing protection is shown in clause 2.2.1 of [IETF RFC 8184] and in Figure 6-1.

When the local AC of node Z1 fails, nodes Z1 and Z2 follow the recovery procedures described in clause 4.2 of [IETF RFC 8185] while node A does not perform any protection-switching action. After the recovery procedures are completed, node A keeps forwarding the traffic between its local AC (A) and the working PW; node Z1 forwards traffic between the working PW and the DNI-PW; and node Z2 forwards traffic between the DNI-PW and its local AC (Z2).

When the working PW fails, nodes A, Z1 and Z2 apply the recovery procedures described in clause 4.2 of [IETF RFC 8185]: in particular, nodes A and Z2 use the protectionswitching mechanisms described in [ITU-T G.8131] to coordinate the activation of the protection PW. After the recovery procedures are completed, node A forwards traffic between its local AC (A) and the protection PW; node Z2 forwards traffic between the protection PW and the DNI-PW; and node Z1 forwards traffic between the DNI-PW and its local AC (Z1).

When node Z1 fails, nodes A and Z2 follow the recovery procedures described in clause 4.2 of [IETF RFC 8185]: in particular, they use the protection-switching mechanisms described in [ITU-T G.8131] to coordinate the activation of the protection PW. After the recovery procedures are completed, node A forwards the traffic between its local AC (A) and the protection PW; and node Z2 forwards traffic between the protection PW and its local AC (Z2).

I.2 Two-side dual-homing

Two-side dual-homing protection is shown in clause 2.2.2 of [IETF RFC 8184] and Figure 6-2.

When the local AC of node Z1 fails, nodes Z1 and Z2 follow the same recovery procedures described in clause 4.2 of [IETF RFC 8185], which are independent of whether the other side is using dual-homing or not, while nodes A1 and A2 do not perform any protection-switching action. After the recovery procedures are completed, node A1 keeps forwarding traffic between its local AC (A1) and the working PW; node Z1 forwards traffic between the working PW and its DNI-PW (Z1-Z2), and node Z2 forwards traffic between its DNI-PW (Z1-Z2) and its local AC (Z2).

When the working PW fails, nodes A1 and A2, as well as nodes Z1 and Z2, follow the same recovery procedures described in clause 4.2 of [IETF RFC 8185], which are independent of whether the other side is using dual-homing or not: in particular, nodes A2 and Z2 use the protection-switching mechanisms described in [ITU-T G.8131] to coordinate the activation of the protection PW. After the recovery procedures are completed, node A1 forwards traffic between its local AC (A1) and its DNI-PW (A1-A2); node A2 forwards the traffic between its DNI PW (A1-A2) and the protection PW; node Z2 forwards the traffic between the protection PW and its DNI-PW (Z1-Z2), and node Z1 forwards the traffic between its DNI-PW (Z1-Z2) and its local AC (Z1).

When node Z1 fails, node Z2 follows the same recovery procedures described in clause 4.2 of [IETF RFC 8185], which are independent of whether the other side is using dual-homing or not, while nodes A1 and A2 follows the same recovery procedure described above for the case of a working PW failure: in particular, nodes A2 and Z2 use the protection-switching mechanisms described in [ITU-T G.8131] to coordinate the activation of the protection PW. After the recovery procedures are completed, node A1 forwards traffic between its local AC (A1) and its DNI-PW (A1-A2); node A2 forwards the traffic between its DNI PW (A1-A2) and the protection PW, and node Z2 forwards traffic between the protection PW and its local AC (Z2).

Appendix II

Network objectives

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

This appendix lists network objectives.

1) MPLS-TP dual-homing protection shall be capable of protecting against the following events:
   a) MPLS-TP PW layer failures, without relying on restoration of a particular server layer;
   b) dual-homing edge node failures;
   c) ingress or egress link failures, but how the edge nodes detect an ingress or egress link failure or coordinate with the client site to switch to another dual-homing ingress or egress link lies outside the scope of this Recommendation.
2) Transfer time (Tt) in response to a single failure should be less than 50 ms within the MPLS-TP network.
3) Support only bidirectional protection switching to ensure that forward traffic and reverse traffic of a protected service are always co-routed.
4) Reuse the OAM mechanisms as described for MPLS-TP (e.g., see [ITU-T G.8113.1]).
5) Reuse the linear protection mechanism as specified in [ITU-T G.8131], and be capable to coexist with it.
6) The following externally initiated commands shall be supported (Requirement 76 of [IETF RFC 5654]): Lockout of working, lockout of protection (Requirement 105 of [IETF RFC 5654]), forced switch, manual switch, exercise and clear.
7) The following automatically initiated commands shall be supported (SF - working, SF - protection, wait-to-restore, reverse request and no request. The criteria for SF are the same as those used in [ITU-T G.8121]).
8) Support the nesting of multiple levels of protection (such as linear protection in the server LSP layer). To achieve this, mechanism(s) that allow for coordination of protection activities (e.g., hold-off timer) shall be supported.
9) Avoid protection-switching flapping (e.g., support of wait-to-restore timer).
10) Protection-switching activation can be initiated by either end or both ends of the MPLS-TP dual-homing protection domain.
11) Both revertive and non-revertive protection switching should be supported.
12) Prioritized protection between SF, SD and operator requests should be supported.

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