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Dual-Homing Protection for MPLS and MPLS-TP Pseudowires
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Abstract

This document describes a framework and several scenarios for a Pseudowire (PW) dual-homing local protection mechanism which avoids unnecessary switchovers and which can be used for scenarios using a control plane or not using a control plane. A Dual-Node Interconnection (DNI) PW is used for carrying traffic between the dual-homing Provider Edge (PE) nodes for carrying traffic when a failure occurs in one of the Attachment Circuits (AC) or PWs. This PW dual-homing local protection mechanism is complementary to existing PW protection mechanisms.

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1. Introduction

[RFC6372] and [RFC6378] describe the framework and mechanism of MPLS-TP Linear protection, which can provide protection for the MPLS LSP or pseudowire (PW) between the edge nodes. This mechanism does not protect the failure of the Attachment Circuit (AC) or the Provider Edge (PE) node. [RFC6718] and [RFC6870] describe the framework and mechanism for PW redundancy to provide protection for AC or PE node failure. The PW redundancy mechanism is based on the signaling of Label Distribution Protocol (LDP), which is applicable to PWs with a dynamic control plane. [I-D.ietf-pals-endpoint-fast-protection] describes a fast local repair mechanism for PW egress endpoint failures, which is based on PW redundancy, upstream label assignment and context specific label switching. The mechanism defined in [I-D.ietf-pals-endpoint-fast-protection] is only applicable to PWs with a dynamic control plane.

There is a need to support a dual-homing local protection mechanism which avoids unnecessary switches of the AC or PW, and which can be used regardless if a control plane is used. In some scenarios such as mobile backhauling, the MPLS PWs are provisioned with dual-homing

topology, in which at least the CE node on one side is dual-homed to two PEs. If some fault occurs in the primary AC, operators usually prefer to have the switchover only on the dual-homing PE side and keep the working pseudowires unchanged if possible. This is to avoid massive PW switchover in the mobile backhaul network due to the AC failure in the mobile core site, which may in turn lead to congestion due to the migration of traffic from the paths preferred by the network planners. Similarly, as multiple PWs share the physical AC in the mobile core site, it is preferable to keep using the working AC when one working PW fails in PSN network, which could avoid unnecessary switchover for other PWs. To meet the above requirements, a fast dual-homing local PW protection mechanism is needed to protect against the failures of an AC, the PE node, and the PSN network.

This document describes the framework and several typical scenarios of pseudowire (PW) dual-homing local protection. A Dual-Node Interconnection (DNI) PW is used between the dual-homing PE nodes for carrying traffic when a failure occurs in the AC or PW side. In order for the dual-homing PE nodes to determine the forwarding state of AC, PW and DNI PW, necessary state exchange and coordination between the dual-homing PEs is needed. The necessary mechanisms and protocol extensions are defined in a companion document [I-D.ietf-pals-mpls-tp-dual-homing-coordination].

2. Reference Models of Dual-homing Local Protection

This section shows the reference architecture of the dual-homing PW local protection and the usage of the architecture in different scenarios.

2.1. PE Architecture

Figure 1 shows the PE architecture for dual-homing local protection. This is based on the architecture in Figure 4a of [RFC3985]. In addition to the AC and the service PW between the local and remote

PEs, a DNI PW is used to connect the forwarders of the dual-homing PEs. It can be used to forward traffic between the dual-homing PEs when a failure occurs in the AC or service PW side. As [RFC3985] specifies: "any required switching functionality is the responsibility of a forwarder function", in this case, the forwarder is responsible for switching the payloads between three entities: the AC, the service PW and the DNI PW.


```
            +----------------------------------------+
            |          Dual-homing PE Device         |
            +----------------------------------------+
       AC   |                 |                      | Service PW
    <------>o    Forwarder    +       Service        X<===========>
            |                 |         PW           |
            +--------+--------+                      |
            |     DNI  PW     |                      |
            +--------X--------+----------------------+
                     ^
                     |  DNI  PW
                     |
                     V
            +--------X--------+----------------------+
            |     DNI  PW     |                      |
            +--------+--------+                      | Service PW
       AC   |                 |       Service        X<===========>
    <------>o    Forwarder    +         PW           |
            |                 |                      |
            +----------------------------------------+
            |          Dual-homing PE Device         |
            +----------------------------------------+
```

Figure 1: PE Architecture for Dual-homing Protection

2.2. Dual-Homing Local Protection Reference Scenarios

2.2.1. One-Side Dual-Homing Protection

Figure 2 illustrates the network scenario of dual-homing PW local protection where only one of the CEs is dual-homed to two PE nodes. CE1 is dual-homed to PE1 and PE2, while CE2 is single-homed to PE3. A DNI-PW is established between the dual-homing PEs, which is used to bridge traffic when a failure occurs in the PSN network or in the AC side. A dual-homing control mechanism enables the PEs and CE to determine which AC should be used to carry traffic between CE1 and the PSN network. The necessary control mechanisms and protocol extensions are defined in a companion document [I-D.ietf-pals-mpls-tp-dual-homing-coordination].

This scenario can protect the node failure of PE1 or PE2, or the failure of one of the ACs between CE1 and the dual-homing PEs. In addition, dual-homing PW protection can protect a failure occuring in the PSN network which impacts the working PW, thus it can be an alternative solution of PSN tunnel protection mechanisms. This topology can be used in mobile backhauling application scenarios. For example, CE2 might be a cell site equipment such as a NodeB, whilst CE1 is the shared Radio Network Controller (RNC). PE3

functions as an access side MPLS device while PE1 and PE2 function as core side MPLS devices.

```
           |<--------------- Emulated Service --------------->|
           |                                                  |
           |          |<------- Pseudo Wire ------>|          |
           |          |                            |          |
           |          |    |<-- PSN Tunnels-->|    |          |
           |          V    V                  V    V          |
           V    AC1   +----+                  +----+          V
     +-----+    |     | PE1|                  |    |          +-----+
     |     |----------|........PW1.(working).......|          |     |
     |     |          |    |                  |    |          |     |
     |     |          +-+--+                  |    |     AC3  |     |
     |     |            |                     |    |     |    |     |
     | CE1 |     DNI-PW |                     |PE3 |----------| CE2 |
     |     |            |                     |    |          |     |
     |     |          +-+--+                  |    |          |     |
     |     |          |    |                  |    |          |     |
     |     |----------|......PW2.(protection)......|          |     |
     +-----+    |     | PE2|                  |    |          +-----+
                AC2   +----+                  +----+
```

Figure 2. One-side dual-homing PW protection

Consider in normal state AC1 from CE1 to PE1 is initially active and AC2 from CE1 to PE2 is initially standby, PW1 is the working PW and PW2 is the protection PW.

When a failure occurs in AC1, then the state of AC2 changes to active based on the AC dual-homing control mechanism. In order to keep the switchover local and continue using PW1 for traffic forwarding as preferred according to traffic planning, the forwarder on PE2 needs to connect AC2 to the DNI PW, and the forwarder on PE1 needs to connect the DNI PW to PW1. In this way the failure in AC1 will not impact the forwarding of the service PWs across the network. After the switchover, traffic will go through the bidirectional path: CE1-(AC2)-PE2-(DNI-PW)-PE1-(PW1)-PE3-(AC3)-CE2.

When a failure in the PSN network affects the working PW (PW1), according to PW protection mechanisms [RFC6378], traffic is switched onto the protection PW (PW2), while the state of AC1 remains active. Then the forwarder on PE1 needs to connect AC1 to the DNI PW, and the forwarder on PE2 needs to connect the DNI PW to PW2. In this way the failure in the PSN network will not impact the state of the ACs. After the switchover, traffic will go through the bidirectional path: CE1-(AC1)-PE1-(DNI-PW)-PE2-(PW2)-PE3-(AC3)-CE2.

When a failure occurs in the working PE (PE1), it is equivalent to a failure of the working AC, the working PW and the DNI PW. The state of AC2 changes to active based on the AC dual-homing control mechanism. And according to the PW protection mechanism, traffic is switched on to the protection PW "PW2". In this case the forwarder on PE2 needs to connect AC2 to PW2. After the switchover, traffic will go through the bidirectional path: CE1-(AC2)-PE2-(PW2)-PE3-(AC3)-CE2.

2.2.2. Two-side Dual-Homing Protection

Figure 3 illustrates the network scenario of dual-homing PW protection where the CEs in both sides are dual-homed. CE1 is dual-homed to PE1 and PE2, and CE2 is dual-homed to PE3 and PE4. A dual-homing control mechanism enables the PEs and CEs to determine which

AC should be used to carry traffic between CE and the PSN network. DNI-PWs are used between the dual-homing PEs on both sides. One service PW is established between PE1 and PE3, another service PW is established between PE2 and PE4. The role of working and protection PW can be determined either by configuration or via existing signaling mechanisms.

This scenario can protect the node failure on one of the dual-homing PEs, or the failure on one of the ACs between the CEs and their dual-homing PEs. Also, dual-homing PW protection can protect if the failure occured in the PSN network which impacts one of the PWs, thus it can be used as an alternative solution of PSN tunnel protection mechanisms. Note, this scenario is mainly used for services requiring high availability as it requires redundancy of the PEs and network utilization. In this case, CE1 and CE2 can be regarded as service access points.


```
           |<---------------- Emulated Service -------------->|
           |                                                  |
           |          |<-------- Pseudowire ------>|          |
           |          |                            |          |
           |          |    |<-- PSN Tunnels-->|    |          |
           |          V    V                  V    V          |
           V    AC1   +-----+                 +-----+    AC3  V
     +------+    |     | ...|...PW1.(working)..|... |     |    +------+
```

```
     |     |----------| PE1|                  | PE3|----------|     |
     |     |          +-----+                 +-----+         |     |
     |     |            |                        |            |     |
     | CE1 |    DNI-PW1 |                        |  DNI-PW2   | CE2 |
     |     |            |                        |            |     |
     |     |          +-----+                 +-----+         |     |
     |     |          |    |                  |    |          |     |
     |     |----------| PE2|                  | PE4|--------- |     |
     +------+    |     | ...|.PW2.(protection).|... |     |    +------+
                AC2   +-----+                 +-----+    AC4
```

Figure 3. Two-side dual-homing PW protection

Consider in normal state, AC1 between CE1 and PE1 is initially active and AC2 between CE1 and PE2 is initially standby, AC3 between CE2 and PE3 is initially active and AC4 from CE2 to PE4 is initially standby, PW1 is the working PW and PW2 is the protection PW.

When a failure occurs in AC1, the state of AC2 changes to active based on the AC dual-homing control mechanism. In order to keep the switchover local and continue using PW1 for traffic forwarding, the forwarder on PE2 needs to connect AC2 to the DNI-PW1, and the forwarder on PE1 needs to connect DNI-PW1 with PW1. In this way failures in the AC side will not impact the forwarding of the service PWs across the network. After the switchover, traffic will go through the bidirectional path: CE1-(AC2)-PE2-(DNI-PW1)-PE1-(PW1)-PE3-(AC3)-CE2.

When a failure occurs in the working PW (PW1), according to the PW protection mechanism [RFC6378], traffic needs to be switched onto the protection PW "PW2". In order to keep the state of AC1 and AC3 unchanged, the forwarder on PE1 needs to connect AC1 to DNI-PW1, and the forwarder on PE2 needs to connect DNI-PW1 to PW2. On the other side, the forwarder of PE3 needs to connect AC3 to DNI-PW2, and the forwarder on PE4 needs to connect PW2 to DNI-PW2. In this way, the state of the ACs will not be impacted by the failure in the PSN network. After the switchover, traffic will go through the bidirectional path: CE1-(AC1)-PE1-(DNI-PW1)-PE2-(PW2)-PE4-(DNI-PW2)-PE3-(AC3)-CE2.

When a failure occurs in the working PE (PE1), it is equivalent to the failures of the working AC, the working PW and the DNI PW. The state of AC2 changes to active based on the AC dual-homing control mechanism. And according to the PW protection mechanism, traffic is switched on to the protection PW "PW2". In this case the forwarder on PE2 needs to connect AC2 to PW2, and the forwarder on PE4 needs to connect PW2 to DNI-PW2. After the switchover, traffic will go through the bidirectional path: CE1-(AC2)-PE2-(PW2)-PE4-(DNI-PW2)-PE3-(AC3)-CE2.

3. Generic Dual-homing PW Protection Mechanism

As shown in the above scenarios, with the described dual-homing PW protection, failures in the AC side will not impact the forwarding behavior of the PWs in the PSN network, and vice-versa.

In order for the dual-homing PEs to coordinate the traffic forwarding during the failures, synchronization of the status information of the involved entities and coordination of switchover between the dual-homing PEs are needed. For PWs with a dynamic control plane, such information synchronization and coordination can be achieved with a dynamic protocol, such as [RFC7275], possibly with some extensions. For PWs which are manually configured without a control plane, a new mechanism is needed to exchange the status information and coordinate switchover between the dual-homing PEs, e.g. over an embedded PW control channel. This is described in a companion document [I-D.ietf-pals-mpls-tp-dual-homing-coordination].

4. IANA Considerations

This document does not require any IANA action.

5. Security Considerations

The scenarios defined in this document do not affect the security model as defined in [RFC3985].

With the proposed protection mechanism, the disruption of a dual-homed AC, a component which is outside the core network, would have a reduced impact on the traffic flows in the core network. This could also avoid unnecessary congestion in the core network.

The security consideration of the DNI PW is the same as for Service PWs in the data plane [RFC3985]. Security considerations for the coordination/control mechanism will be addressed in the companion document that defines the mechanism.

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