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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
   pseudowire (PW) dual-homing local protection. A Dual-Node
   Interconncetion (DNI) PW is provisioned between the dual-homing
   Provider Edge (PE) nodes for carrying traffic when failure accurs in
   the Attachment Circuit (AC) or PW side. In order for the dual-homing
   PE nodes to determine the forwarding state of AC, PW and the DNI PW,
   necessary state exchange and coordination between the dual-homing PEs
   are needed. The PW dual-homing local protection mechanism is
   complementary to the existing PW protection mechanisms.

Requirements Language

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in RFC 2119 [RFC2119].

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material or to cite them other than as "work in progress."

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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 PW between the edge nodes. Such mechanism does not protect the
failure of the Attachement 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-pwe3-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. Such mechanism is applicable
to PWs with a dynamic control plane.

In some scenarios such as mobile backhauling, the MPLS PWs are
provisioned with dual-homing topology, in which at least the CE node
in one side is dual-homed to two PEs. If some fault occurs in the
primary AC, operators usually prefer to have the switchover only in
the dual-homing PE side and keeps the working pseudowires unchanged
if possible. This is to avoid massive PWs switchover in the mobile
backhaul network due to one AC failure in the core site, and also
could achieve efficient and balanced link bandwidth utilization.
Similarly, it is preferable to keep using the working AC when one
working PW fails in the PSN network. To meet the above requirement,
a fast dual-homing PW local protection mechanism is needed to protect
the failures in AC, the PE node and the PSN network.

This document describes a framework and several scenarios for
pseudowire (PW) dual-homing local protection. A Dual-Node
Interconncetion (DNI) PW is provisioned between the dual-homing
Provider Edge (PE) nodes for carrying traffic when failure accurs 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
mechanism defined in this document is complementary to the existing
protection mechanisms. The neccessary protocol extensions will be
described in a seperate document.

The proposed mechanism has been deployed in several mobile backhaul
networks which use static MPLS-TP PWs for the backhauling of mobile
traffic.

2. Reference Models of Dual-homing Local Protection

This section shows the reference architecture of the PE for 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, a DNI PW is provisioned to
connect the forwarders of the dual-homing PEs. It can be used to
forward traffic between the dual-homing PEs when failure accurs 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. The specific behavior of forwarder is determined according
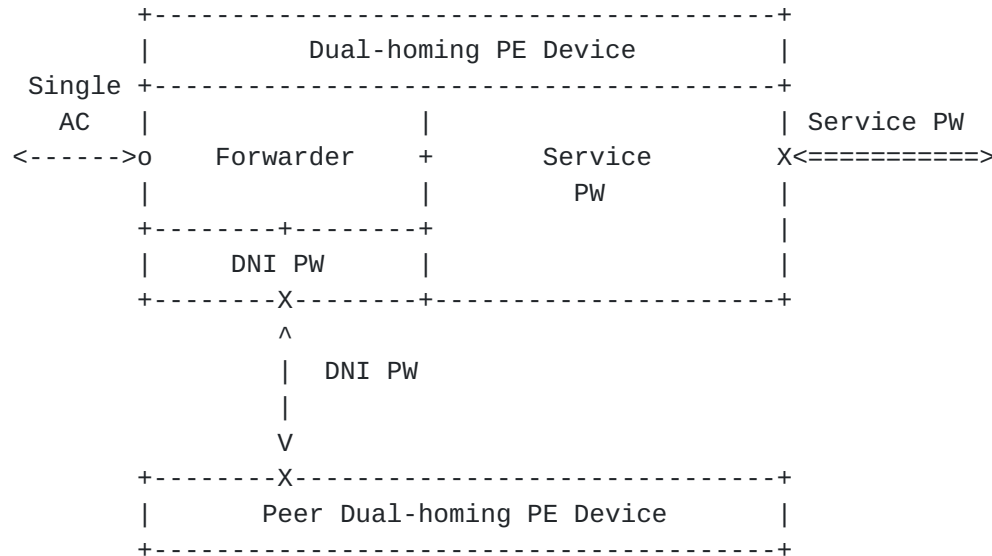to the forwarding state machine defined in this document.

```
            +----------------------------------------+
            |          Dual-homing PE Device         |
  Single  +----------------------------------------+
    AC    |                    |                   | Service PW
  <------>o     Forwarder      +      Service       X<============>
          |                    |        PW          |
          +--------+--------+                        |
          |      DNI PW      |                       |
          +--------X--------+----------------------+
                   ^
                   |  DNI PW
                   |
                   V
          +--------X------------------------------+
          |      Peer 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 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. 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 control mechanism enables the PEs and CE to determine which
   AC should be used to carry traffic between CE1 and the PSN network.
   These mechanisms/protocols are beyond the scope of this document.
   The working and protection PWs can be determined either by
   configuration or by existing signaling mechanisms.

   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 the failure occured
   in the PSN network which impacts the working PW, thus it can be an
   alternative to PSN tunnel protection mechanisms. This topology can
   be used in mobile backhauling application scenarios. For example,
   the NodeB serves as CE2 while the RNC serves as CE1. PE3 works as an
   access side MPLS device while PE1 and PE2 works as core side MPLS
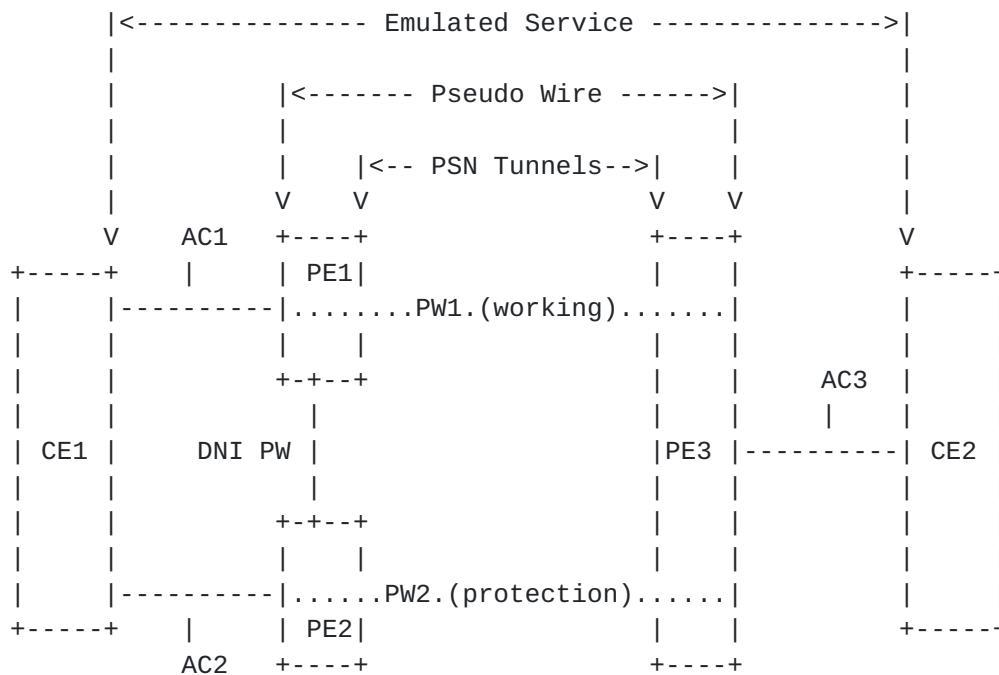   devices.

```
        |<-------------- 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 some AC redundancy mechanism. In order to keep the
   switchover local and continue using PW1 to forward traffic, the
   forwarder on PE2 needs to connect AC2 to the DNI PW, and the
   forwarder on PE1 needs to connect the DNI PW to the PW1. In this way
   the failure in the AC1 do not impact the forwarding of the service
   PWs across the network. After the switchover, traffic will go
   through the 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, 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 do not impact the state of the ACs. After
   the switchover, traffic will go through the path: CE1-(AC1)-PE1-(DNI-
   PW)-PE2-(PW2)-PE3-(AC3)-CE2.

   In both AC and PW failure cases, the dual-homing PW protection needs
   to coordinate the PEs to set the forwarding state between the AC,
   service PW and DNI PW properly.

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.
   The DNI-PWs are provisioned between the dual-homing PEs on both side.
   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 mechansims.

   This scenario can protect the node failure of one of the dual-homing
   PEs, or the failure of one of the ACs between the CEs and their dual-
   homing PEs. Meanwhile, dual-homing PW protection can protect the
   failure occured in the PSN network which impacts one of the PWs, thus
   it can be an alternative to PSN tunnel protection mechanisms. This
   scenario is mainly used for services provisioning for important
   business customers. 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
```
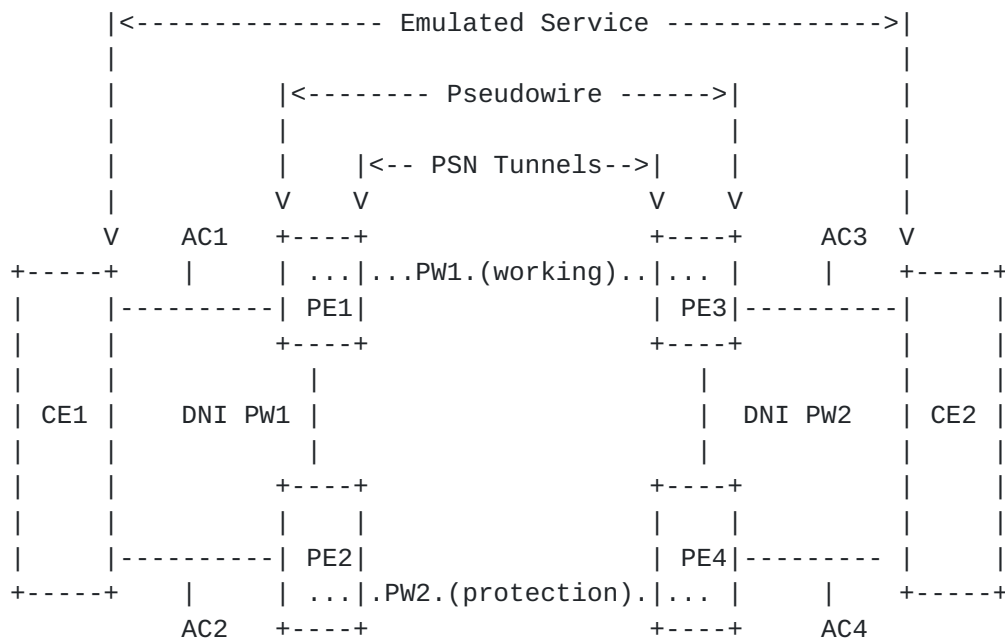
                Figure 3. Two-side dual-homing PW protection

   Consider in normal state AC1 from CE1 to PE1 is initially active and
   AC2 from CE1 to PE2 is initially standby, AC3 from CE2 to 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 some AC redundancy mechanism. In order to keep the
switchover local and continue using PW1 to forward traffic, the
forwarder on PE2 needs to connect AC2 to the DNI PW, and the
forwarder on PE1 needs to connect the DNI PW with PW1. In this way
failures in the AC side do not impact the forwarding of the service
PWs across the network. After the switchover, traffic will go
through the 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, traffic is 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 the DNI-PW1, and the
forwarder on PE2 needs to connect the DNI-PW1 to PW2. On the other
side, the forwarder of PE3 needs to connect AC3 to the DNI-PW2, and
the forwarder on PE4 needs to connect PW2 to the 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 path:
CE1-(AC1)-PE1-(DNI-PW1)-PE2-(PW2)-PE4-(DNI-PW2)-PE3-(AC3)-CE2.

In both AC and PW failure cases, the dual-homing PW protection needs
to coordinate the PEs to set the forwarding state between the AC,
service PW and the DNI PW properly.

3. Generic Dual-homing PW Protection Mechanism

As shown in the above scenarios, with the described Dual-Homing PW
Protection, the failures in the AC side do not impact the forwarding
behavior of the PWs in the PSN network, and vice-versa. This is
achieved by properly setting the forwarding state between the
following entities:

o AC

o Service PWs

o DNI PW

The forwarding behavior of the dual-homing PE nodes are determined by
the forwarding state machine as shown in table 1:

```
+-----------+---------+--------+--------------------+
|Service PW |   AC    | DNI PW | Forwarding Behavior |
+-----------+---------+--------+--------------------+
|  Active   | Active  |   Up   |Service PW <-> AC    |
+-----------+---------+--------+--------------------+
|  Active   | Standby |   Up   |Service PW <-> DNI PW|
+-----------+---------+--------+--------------------+
|  Standby  | Active  |   Up   |   DNI PW <-> AC     |
+-----------+---------+--------+--------------------+
|  Standby  | Standby |   Up   |  Drop all packets   |
+-----------+---------+--------+--------------------+
```
        Table 1. Dual-homing PE Forwarding State Machine

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 sychronization 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. This is described in a
separate document.

4. IANA Considerations

This document does not require any IANA action.

5. Security Considerations

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

6. References

6.1. Normative References

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