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Dual-Homing Coordination for MPLS Transport Profile (MPLS-TP)
Pseudowires Protection
draft-ietf-pals-mpls-tp-dual-homing-coordination-05

Abstract

   In some scenarios, MPLS Transport Profile (MPLS-TP) Pseudowires (PWs)
   (RFC 5921) may be statically configured (management plane based),
   when a dynamic control plane is not available. A fast protection
   mechanism for MPLS-TP PWs is needed to protect against the failure of
   an Attachment Circuit (AC), the failure of a Provider Edge (PE), or a
   failure in the Packet Switched Network (PSN). The framework and
   typical scenarios of dual-homing PW local protection are described in
   [draft-ietf-pals-mpls-tp-dual-homing-protection]. This document
   proposes a dual-homing coordination mechanism for MPLS-TP PWs, which
   is used for state exchange and switchover coordination between the
   dual-homing PEs for dual-homing PW local protection.

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].

Status of This Memo

time. It is inappropriate to use Internet-Drafts as reference
material or to cite them other than as "work in progress."

This Internet-Draft will expire on July 21, 2017.

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1. Introduction

[RFC6372], [RFC6378] and [RFC7771] describe the framework and
mechanism of MPLS-TP Linear protection, which can provide protection
for the MPLS LSP and PW between the edge nodes. These mechanisms
cannot protect the failure of the Attachment Circuit (AC) or the edge
nodes. [RFC6718] and [RFC6870] specifies the PW redundancy framework
and mechanism for protecting the AC or edge node failure by adding
one or more edge nodes, but it requires PW switchover in case of an
AC failure, also PW redundancy relies on PSN protection mechanisms to
protect the failure of PW.

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 a failure occurs in the
primary AC, operators usually prefer to perform local switchover in
the dual-homing PE side and keep the working pseudowire 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 the PSN
network, which could avoid unnecessary switchover for other PWs. A
fast dual-homing PW protection mechanism is needed to protect the
failure in AC, the PE node and the PSN network to meet the above
requirements.

[I-D.ietf-pals-mpls-tp-dual-homing-protection] describes a framework
and several scenarios of dual-homing pseudowire (PW) local
protection. This document proposes a dual-homing coordination
mechanism for static MPLS-TP PWs, which is used for information
exchange and switchover coordination between the dual-homing PEs for
the dual-homing PW local protection. The proposed mechanism has been
implemented and deployed in several mobile backhaul networks which
use static MPLS-TP PWs for the backhauling of mobile traffic from the
radio access sites to the core site.

2. Overview of the Proposed Solution

Linear protection mechanisms for MPLS-TP network are defined in
[RFC6378], [RFC7271] and [RFC7324]. When such mechanisms are applied
to PW linear protection [RFC7771], both the working PW and the
protection PW are terminated on the same PE node. In order to
provide dual-homing protection for MPLS-TP PWs, some additional
mechanisms are needed.

In MPLS-TP PW dual-homing protection, the linear protection mechanism
as defined in [RFC6378] [RFC7271] and [RFC7324] on the single-homing
PE (e.g. PE3 in figure 1) is not changed, while on the dual-homing
side, the working PW and protection PW are terminated on two dual-
homing PEs (e.g. PE1 and PE2 in figure 1) respectively to protect a
failure occuring in a PE or a connected AC. As described in
[I-D.ietf-pals-mpls-tp-dual-homing-protection], a dedicated Dual-Node
Interconnection (DNI) PW is used between the two dual-homing PE nodes
to forward the traffic. In order to utilize the linear protection
mechanism [RFC7771] in the dual-homing PEs scenario, coordination
between the dual-homing PE nodes is needed, so that the dual-homing
PEs can switch the connection between the AC, the service PW and the
DNI-PW properly in a coordinated fashion by the forwarder.

```
              +----------------------------------+
              |                PE1               |
              +----------------------------------+              +----+
              |                 |                |  Working  |    |
              X     Forwarder   +    Service     X------------X    |
             /|                 |      PW        | Service PW1 |    |
      AC1 / +--------+--------+                  |             |    |
         /  |   DNI PW        |                  |             |    |
   +---*   +--------X--------+----------------+                |    |  +---+
   |   |          ^                                            |    |  |   |
   |CE1|          |   DNI PW                                |PE3 +---|CE2|
   |   |          |                                            |    |  |   |
   |   |          V                                            |    |  |   |
   +---*   +--------X--------+----------------+                |    |  +---+
        \  |   DNI PW        |                |                |    |
    AC2 \ +--------+--------+                 | Protection |    |
         \|                 |     Service     X------------X    |
          X     Forwarder   +       PW        | Service PW2 |    |
          |                 |                 |            +----+
          +----------------------------------+
          |                PE2               |
          +----------------------------------+
```
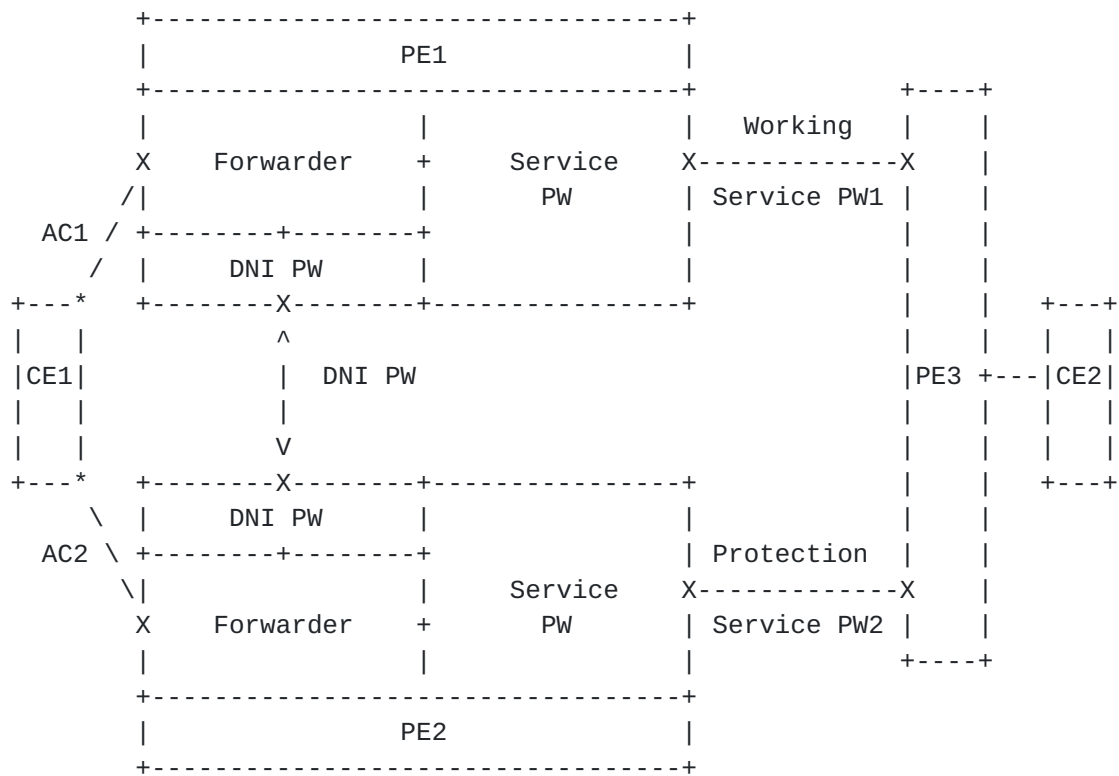
            Figure 1. Dual-homing Protection with DNI-PW

[3]. Protocol Extensions for Dual-Homing MPLS-TP PW Protection

   In dual-homing MPLS-TP PW local protection, the forwarding state of
   the dual-homing PEs are determined by the forwarding state machine 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   |
+-----------+---------+--------+--------------------+
|  Active   | Active  |  Down  |Service PW <-> AC    |
+-----------+---------+--------+--------------------+
|  Active   | Standby |  Down  |  Drop all packets   |
+-----------+---------+--------+--------------------+
|  Standby  | Active  |  Down  |  Drop all packets   |
+-----------+---------+--------+--------------------+
|  Standby  | Standby |  Down  |  Drop all packets   |
+-----------+---------+--------+--------------------+
```
        Table 1. Dual-homing PE Forwarding State Machine

   In order to achieve the dual-homing MPLS-TP PW protection,
   coordination between the dual-homing PE nodes is needed to exchange
   the PW status and protection coordination requests.

3.1. Information Exchange Between Dual-Homing PEs

   The coordination information will be sent on the DNI PW over the
   G-ACh as described in [RFC5586]. A new G-ACh channel type is defined
   for the dual-homing coordination between the dual-homing PEs of MPLS-
   TP PWs. This channel type can be used for the exchange of different
   types of information between the dual-homing PEs. This document uses
   this channel type for the exchange of PW status and switchover
   coordination between the dual-homing PEs. Other potential usages of
   this channel type are for further study and are out of the scope of
   this document.

   The MPLS-TP Dual-Homing Coordination (DHC) message is sent on the DNI
   PW between the dual-homing PEs. The format of the MPLS-TP DHC
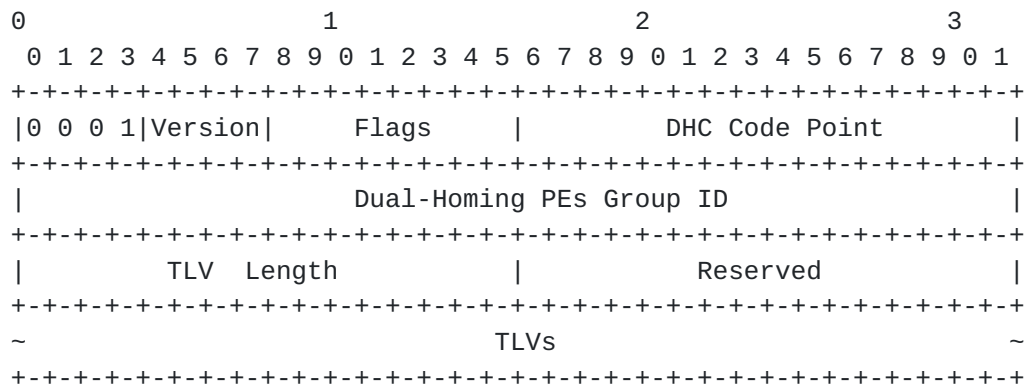   message is shown below:

```
  0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |0 0 0 1|Version|    Flags      |         DHC Code Point        |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                    Dual-Homing PEs Group ID                   |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |        TLV  Length            |            Reserved           |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  ~                            TLVs                               ~
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        Figure 2. MPLS-TP Dual-Homing Coordination Message
```

The Dual-Homing Group ID is a 4-octet unsigned integer to identify
the dual-homing group which the dual-homing PEs belong to. It MUST
be the same at both PEs in the same group.

The TLV Length field specifies the total length in octets of the
subsequent TLVs.

In this document, two TLVs are defined in MPLS-TP Dual-Homing
Coordination message for dual-homing MPLS-TP PW protection:

```
Type          Description                 Length
 1               PW Status                20 Bytes
 2          Dual-Node Switching           16 Bytes
```

The PW Status TLV is used by a dual-homing PE to report its service
PW status to the other dual-homing PE in the same dual-homing group.
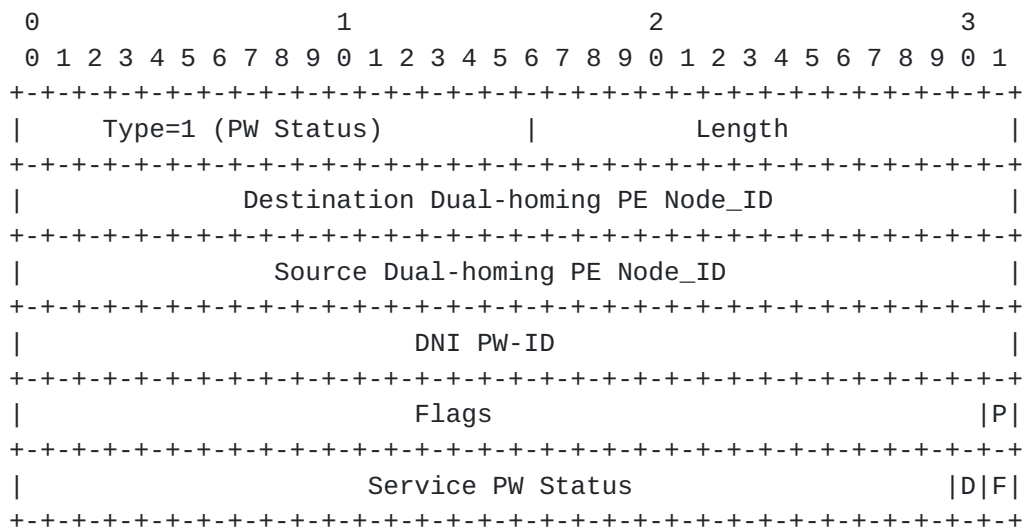
```
   0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |     Type=1 (PW Status)        |            Length             |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |             Destination Dual-homing PE Node_ID                |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |               Source Dual-homing PE Node_ID                   |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                        DNI PW-ID                              |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                         Flags                              |P|
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                    Service PW Status                    |D|F|
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                   Figure 3. PW Status TLV
```

   - The Length field specifies the length in octets of the value field
   of the TLV.

   - The Destination Dual-homing PE Node_ID is the 32-bit identifier of
   the receiver PE [RFC6370] which supports both IPv4 and IPv6
   environments. Usually it is the same as the LSR-ID of the receiver
   PE.

   - The Source Dual-homing PE Node_ID is the 32-bit identifier of the
   sending PE [RFC6370] which supports both IPv4 and IPv6 environments.
   Usually it is the same as the LSR-ID of the sending PE.

   - The DNI PW-ID field contains the 32-bit PW ID [RFC4447] of the DNI
   PW.

   - The Flags field contains 32 bit flags, in which:

   o The P (Protection) bit indicates whether the Source Dual-homing PE
      is the working PE (P=0) or the protection PE (P=1).

   o Other bits are reserved for future use, which MUST be set to 0 on
      transmission and MUST be ignored upon receipt.

   - The Service PW Status field indicates the status of the Service PW
   between the sending PE and the remote PE. Currently two bits are
   defined in the Service PW Status field:

   o F bit: If set, it indicates Signal Fail (SF) [RFC6378] on the
      service PW. It can be either a local request or a remote request
      received from the remote PE.

   o D bit: If set, it indicates Signal Degrade (SD) [RFC6378] on the
      service PW. It can be either a local request or a remote request
      received from the remote PE.

   o Other bits are reserved for future use, which MUST be set to 0 on
      transmission and MUST be ignored upon receipt.

   The Dual-Node Switching TLV is used by one dual-homing PE to send
   protection state coordination to the other PE in the same dual-homing
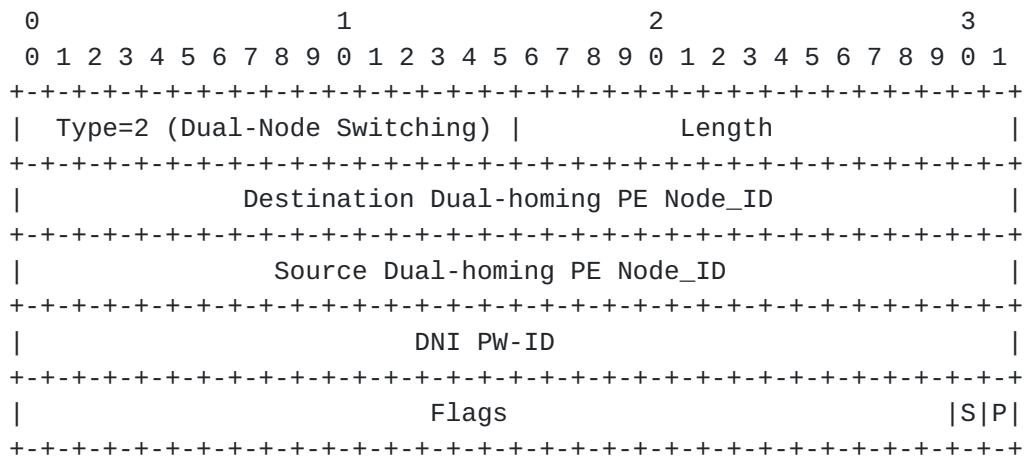   group.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Type=2 (Dual-Node Switching) |           Length              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |             Destination Dual-homing PE Node_ID                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |               Source Dual-homing PE Node_ID                   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        DNI PW-ID                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Flags                          |S|P|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                  Figure 4. Dual-Node Switching TLV
```

- The Length field specifies the length in octets of the value field
of the TLV.

- The Destination Dual-homing PE Node_ID is the 32-bit identifier of
the receiver PE [RFC6370]. Usually it is the same as the LSR-ID of
the receiver PE.

- The Source Dual-homing PE Node_ID is the 32-bit identifier of the
sending PE [RFC6370]. Usually it is the same as the LSR-ID of the
sending PE.

- The DNI PW-ID field contains the 32-bit PW-ID [RFC4447] of the DNI
PW.

- The Flags field contains 32 bit flags, in which:

o The P (Protection) bit indicates whether the Source Dual-homing PE
   is the working PE or the protection PE. It is set to 1 when the
   Source PE of the dual-node switching request is the protection PE.

o The S (PW Switching) bit indicates which service PW is used for
   forwarding traffic. It is set to 0 when traffic will be
   transported on the working PW, and is set to 1 if traffic will be
   transported on the protection PW. The value of the S bit is
   determined by the protection coordination mechanism between the
   dual-homing PEs and the remote PE.

o Other bits are reserved for future use, which MUST be set to 0 on
   transmission and MUST be ignored upon receipt.

When a change of the service PW status is detected by one of the
dual-homing PEs, it MUST be reflected in the PW Status TLV and sent
to the other dual-homing PE as quickly as possible to allow for fast

protection switching using 3 consecutive DHC messages. This set of
three messages allows for fast protection switching even if one or
two of these packets are lost or corrupted. After the transmission
of the three rapid messages, the dual-homing PE MUST send the most
recently transmitted service PW status periodically to the other
dual-homing PE on a continual basis using the DHC message.

When one dual-homing PE determines that the active service PW needs
to be switched from the working PW to the protection PW, It MUST send
the Dual-Node Switching TLV to the other dual-homing PE as quickly as
possible to allow for fast protection switching using 3 consecutive
DHC messages. After the transmission of the three messages, the
dual-homing PE MUST send the most recently transmitted Dual-Node
Switching TLV periodically to the other dual-homing PE on a continual
basis using the DHC message.

It is RECOMMENDED that the default interval of the first three rapid
DHC messages is 3.3 ms similar to [RFC6378], and the default interval
of the subsequent messages is 1 second. Both the default interval of
the three consecutive messages as well as the default interval of the
periodical messages SHALL be configurable by the operator.

3.2. Protection Procedures

The dual-homing MPLS-TP PW protection mechanism can be deployed with
the existing AC redundancy mechanisms. On the PSN network side, PSN
tunnel protection mechanism is not required, as the dual-homing PW
protection can also protect if a failure occurs in the PSN network.

This section uses the one-side dual-homing scenario as an example to
describe the dual-homing PW protection procedures, the procedures for
two-side dual-homing scenario would be similar.

On the dual-homing PE side, the role of working and protection PE are
set by the management system or local configuration. The service PW
connecting to the working PE is the working PW, and the service PW
connecting to the protection PE is called the protection PW.

On the single-homing PE side, it treats the working PW and protection
PW as if they terminate on the same remote PE node, thus normal MPLS-
TP protection coordination procedures still apply on the single-
homing PE.

The forwarding behavior of the dual-homing PEs is determined by the
components shown in the figure below:

```
            +---------------------------------+        +-----+
            |        PE1 (Working PE)          |        |     |
            +---------------------------------+        |     |
            |                  |              |        | PW1 |     |
            +      Forwarder   +    Service   X<-------->X    |     |
           /|                  |      PW      | Working |     |
          / +--------+--------+              |      PW  |     |
     AC1  / |    DNI PW       |              |         |     |
        /   +--------X--------+--------------+         |     |
 +-----+/           ^                                 |     |
 | CE1 |            |   DNI PW                         | PE3 | +---+
 +-----+            |                                 |     | ---|CE3|
      \             V                                 |     | +---+
   AC2 \    +--------X--------+--------------+         |     |
        \   | DNI PW          |              |         |     |
         \ +--------+--------+              |         |     |
          \|                  |    Service   |    PW2  |     |
           +      Forwarder   +      PW      X<-------->X    |
           |                  |              |Protection|    |
           +--------------------------------+      PW  |    |
           |       PE2 (Protection PE)       |         |    |
           +---------------------------------+        +-----+
```
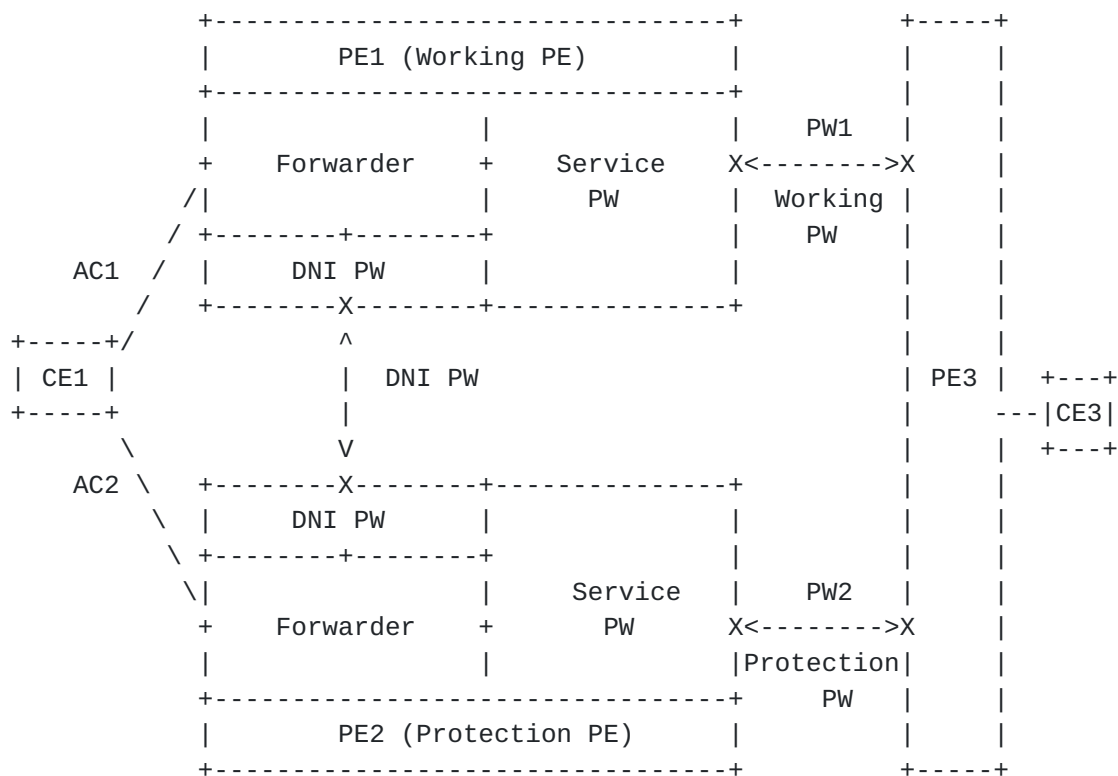
             Figure 5. Components of one-side dual-homing PW protection

   In figure 5, for each dual-homing PE, the service PW is the PW used
   to carry service between the dual-homing PE and the remote PE. The
   state of the service PW is determined by the OAM mechanisms between
   the dual-homing PEs and the remote PE.

   The DNI PW is provisioned between the two dual-homing PE nodes. It
   is used to bridge traffic when a failure occurs in the PSN network or
   in the ACs. The state of the DNI PW is determined by the OAM
   mechanism between the dual-homing PEs. Since the DNI PW is used to
   carry both the DHC messages and the service traffic during protection
   switching, it is important to ensure the robustness of the DNI PW.
   In order to avoid the DNI PW failure due to the failure of a
   particular link, it is RECOMMENDED that multiple diverse links be
   deployed between the dual-homing PEs and the underlay LSP protection
   mechanism SHOULD be enabled.

   The AC is the link which connects a dual-homing PE to the dual-homed
   CE. The status of AC is determined by the existing AC redundancy
   mechanisms, this is out of the scope of this document.

   In order to perform dual-homing PW local protection, the service PW
   status and Dual-node switching coordination requests are exchanged
   between the dual-homing PEs using the DHC message defined above.

Whenever a change of service PW status is detected by a dual-homing
PE, it MUST be reflected in the PW Status TLV and sent to the other
dual-homing PE immediately using the 3 consecutive DHC messages.
This way, both dual-homing PEs have the status of the working and
protection PW consistently.

When there is a switchover request either generated locally or
received on the protection PW from the remote PE, based on the status
of the working and protection service PW, along with the local and
remote request of the protection coordination between the dual-homing
PEs and the remote PE, the active/standby state of the service PW can
be determined by the dual-homing PEs. As the remote protection
coordination request is transmitted over the protection path, in this
case the active/standby status of the service PW is determined by the
protection PE in the dual-homing group.

If it is determined on one dual-homing PE that switchover of service
PW is needed, this dual-homing PE MUST set the S bit in the Dual-Node
Switching TLV and send it to the other dual-homing PE immediately
using the 3 consecutive DHC messages. With the exchange of service
PW status and the switching request, both dual-homing PEs are
consistent on the Active/Standby forwarding status of the working and
protection service PWs. The status of the DNI PW is determined by PW
OAM mechanism as defined in [RFC5085], and the status of ACs are
determined by existing AC redundancy mechanisms, both are out of the
scope of this document. The forwarding behavior on the dual-homing
PE nodes is determined by the forwarding state machine as shown in
table 1 .

Using the topology in figure 5 as an example, in normal state, the
working PW (PW1) is in active state, the protection PW (PW2) is in
standby state, the DNI PW is up, and AC1 is in active state according
to the AC redundancy mechanism. According to the forwarding state
machine in table 1, traffic will be forwarded through the working PW
(PW1) and the primary AC (AC1). No traffic will go through the
protection PE (PE2) or the DNI PW, as both the protection PW (PW2)
and the AC connecting to PE2 are in standby state.

If a failure occurs in AC1, the state of AC2 changes to active
according to the AC redundancy mechanism, while there is no change in
the state of the working and protection PWs. According to the
forwarding state machine in table 1, PE1 starts to forward traffic
between the working PW and the DNI PW, and PE2 starts to forward
traffic between AC2 and the DNI PW. It should be noted that in this
case only AC switchover takes place, in the PSN network traffic is
still forwarded using the working PW.

If a failure in the PSN network brings PW1 down, the failure can be
detected by PE1 or PE3 using existing OAM mechanisms. If PE1 detects
the failure of PW1, it MUST inform PE2 the state of working PW using
the PW Status TLV in the DHC messages and change the forwarding
status of PW1 to standby. On receipt of the DHC message, PE2 SHOULD
change the forwarding status of PW2 to active. Then according to the
forwarding state machine in table 1, PE1 SHOULD set up the connection
between the DNI PW and AC1, and PE2 SHOULD set up the connection
between PW2 and the DNI PW. According to the linear protection
mechanism [RFC6378], PE2 also sends an appropriate protection
coordination message [RFC6378] over the protection PW (PW2) to PE3
for the remote side to switchover from PW1 to PW2. If PE3 detects
the failure of PW1, according to linear protection mechanism
[RFC6378], it sends a protection coordination message on the
protection PW (PW2) to inform PE2 of the failure on the working PW.
Upon receipt of the message, PE2 SHOULD change the forwarding status
of PW2 to active and set up the connection according to the
forwarding state machine in table 1. PE2 SHOULD send a DHC message
to PE1 with the S bit set in the Dual-Node Switching TLV to
coordinate the switchover on PE1 and PE2. This is useful for a
unidirectional failure which cannot be detected by PE1.

If a failure brings the working PE (PE1) down, the failure can be
detected by both PE2 and PE3 using existing OAM mechanisms. Both PE2
and PE3 SHOULD change the forwarding status of PW2 to active, and
send a protection coordination message [RFC6378] on the protection PW
(PW2) to inform the remote side to switchover. According to the
existing AC redundancy mechanisms, the status of AC1 changes to
standby, and the state of AC2 changes to active. According to the
forwarding state machine in table 1, PE2 starts to forward traffic
between the PW2 and AC2.

4. IANA Considerations

This document requests that IANA assigns one new channel type for
"MPLS-TP Dual-Homing Coordination message" from the "MPLS Generalized
Associated Channel (G-ACh) Types (including Pseudowire Associated
Channel Types)" registry of the "Generic Associated Channel (G-ACh)
Parameters" registry.

```
Value   Description                              Reference
TBD     MPLS-TP Dual-Homing Coordination message   [This document]
```

This document requests that IANA creates a new sub-registry called
"MPLS-TP DHC TLVs" in the "Generic Associated Channel (G-ACh)
Parameters" registry, with fields and initial allocations as follows:

```
   Type         Description                  Length        Reference
   0x00         Reserved
   0x01         PW Status                    20 Bytes    [this document]
   0x02         Dual-Node Switching          16 Bytes    [this document]
```

The allocation policy for this registry is IETF Review as specified in [RFC5226].

5. Security Considerations

MPLS-TP is a subset of MPLS and so builds upon many of the aspects of the security model of MPLS. Please refer to [RFC5920] for generic MPLS security issues and methods for securing traffic privacy and integrity.

The DHC message defined in this document is carried in the G-ACh [RFC5586], so it is dependent on the security of the G-ACh itself. The G-ACh is a generalization of the Associated Channel defined in [RFC4385]. Thus, this document relies heavily on the security mechanisms provided for the Associated Channel as described in those two documents. The procedures and protocol extensions defined in this document do not affect the security model of MPLS-TP linear protection as defined in [RFC6378]

Uniqueness of the identifiers defined in this document is guaranteed by the assigner (e.g. the operator). Failure by an assigner to use unique values within the specified scoping for any of the identifiers defined herein could result in operational problems. Please refer to [RFC6370] for more details about the uniqueness of the identifiers.

6. Contributors

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7. References

7.1. **Normative References**

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119,
              DOI 10.17487/RFC2119, March 1997,
              <http://www.rfc-editor.org/info/rfc2119>.

   [RFC4447] Martini, L., Ed., Rosen, E., El-Aawar, N., Smith, T., and
              G. Heron, "Pseudowire Setup and Maintenance Using the
              Label Distribution Protocol (LDP)", RFC 4447,
              DOI 10.17487/RFC4447, April 2006,
              <http://www.rfc-editor.org/info/rfc4447>.

   [RFC5085] Nadeau, T., Ed. and C. Pignataro, Ed., "Pseudowire Virtual
              Circuit Connectivity Verification (VCCV): A Control
              Channel for Pseudowires", RFC 5085, DOI 10.17487/RFC5085,
              December 2007, <http://www.rfc-editor.org/info/rfc5085>.

   [RFC5586] Bocci, M., Ed., Vigoureux, M., Ed., and S. Bryant, Ed.,
              "MPLS Generic Associated Channel", RFC 5586,
              DOI 10.17487/RFC5586, June 2009,
              <http://www.rfc-editor.org/info/rfc5586>.

   [RFC6370] Bocci, M., Swallow, G., and E. Gray, "MPLS Transport
              Profile (MPLS-TP) Identifiers", RFC 6370,
              DOI 10.17487/RFC6370, September 2011,
              <http://www.rfc-editor.org/info/rfc6370>.

   [RFC6378] Weingarten, Y., Ed., Bryant, S., Osborne, E., Sprecher,
              N., and A. Fulignoli, Ed., "MPLS Transport Profile (MPLS-
              TP) Linear Protection", RFC 6378, DOI 10.17487/RFC6378,
              October 2011, <http://www.rfc-editor.org/info/rfc6378>.

   [RFC7271] Ryoo, J., Ed., Gray, E., Ed., van Helvoort, H.,
              D'Alessandro, A., Cheung, T., and E. Osborne, "MPLS
              Transport Profile (MPLS-TP) Linear Protection to Match the
              Operational Expectations of Synchronous Digital Hierarchy,
              Optical Transport Network, and Ethernet Transport Network
              Operators", RFC 7271, DOI 10.17487/RFC7271, June 2014,
              <http://www.rfc-editor.org/info/rfc7271>.

   [RFC7324] Osborne, E., "Updates to MPLS Transport Profile Linear
              Protection", RFC 7324, DOI 10.17487/RFC7324, July 2014,
              <http://www.rfc-editor.org/info/rfc7324>.

7.2. Informative References

[I-D.ietf-pals-mpls-tp-dual-homing-protection]
          Cheng, W., Wang, L., Li, H., Liu, K., Davari, S., Dong,
          J., and A. D'Alessandro, "Dual-Homing Protection for MPLS
          and MPLS-TP Pseudowires", draft-ietf-pals-mpls-tp-dual-
          homing-protection-04 (work in progress), August 2016.

[RFC4385] Bryant, S., Swallow, G., Martini, L., and D. McPherson,
          "Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for
          Use over an MPLS PSN", RFC 4385, DOI 10.17487/RFC4385,
          February 2006, <http://www.rfc-editor.org/info/rfc4385>.

[RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an
          IANA Considerations Section in RFCs", BCP 26, RFC 5226,
          DOI 10.17487/RFC5226, May 2008,
          <http://www.rfc-editor.org/info/rfc5226>.

[RFC5920] Fang, L., Ed., "Security Framework for MPLS and GMPLS
          Networks", RFC 5920, DOI 10.17487/RFC5920, July 2010,
          <http://www.rfc-editor.org/info/rfc5920>.

[RFC6372] Sprecher, N., Ed. and A. Farrel, Ed., "MPLS Transport
          Profile (MPLS-TP) Survivability Framework", RFC 6372,
          DOI 10.17487/RFC6372, September 2011,
          <http://www.rfc-editor.org/info/rfc6372>.

[RFC6718] Muley, P., Aissaoui, M., and M. Bocci, "Pseudowire
          Redundancy", RFC 6718, DOI 10.17487/RFC6718, August 2012,
          <http://www.rfc-editor.org/info/rfc6718>.

[RFC6870] Muley, P., Ed. and M. Aissaoui, Ed., "Pseudowire
          Preferential Forwarding Status Bit", RFC 6870,
          DOI 10.17487/RFC6870, February 2013,
          <http://www.rfc-editor.org/info/rfc6870>.

[RFC7771] Malis, A., Ed., Andersson, L., van Helvoort, H., Shin, J.,
          Wang, L., and A. D'Alessandro, "Switching Provider Edge
          (S-PE) Protection for MPLS and MPLS Transport Profile
          (MPLS-TP) Static Multi-Segment Pseudowires", RFC 7771,
          DOI 10.17487/RFC7771, January 2016,
          <http://www.rfc-editor.org/info/rfc7771>.

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