           Switching Provider Edge (S-PE) Protection for MPLS and MPLS Transport
                  Profile (MPLS-TP) Static Multi-Segment Pseudowires

Abstract

   In MPLS and MPLS Transport Profile (MPLS-TP) environments, statically
   provisioned Single-Segment Pseudowires (SS-PWs) are protected against
   tunnel failure via MPLS-level and MPLS-TP-level tunnel protection.
   With statically provisioned Multi-Segment Pseudowires (MS-PWs), each
   segment of the MS-PW is likewise protected from tunnel failures via
   MPLS-level and MPLS-TP-level tunnel protection. However, static MS-
   PWs are not protected end-to-end against failure of one of the
   Switching Provider Edge Routers (S-PEs) along the path of the MS-PW.
   This document describes how to achieve this protection via redundant
   MS-PWs by updating the existing procedures in RFC 6870. It also
   contains an optional approach based on MPLS-TP Linear Protection.

Status of This Memo

   This is an Internet Standards Track document.

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1. Introduction

   In MPLS and MPLS Transport Profile (MPLS-TP) Packet Switched Networks
   (PSNs), pseudowires (PWs) are transported by MPLS(-TP) Label Switched
   Paths (LSPs), also known as tunnels.

   As described in RFC 5659 [RFC5659], Multi-Segment Pseudowires (MS-
   PWs) consist of Terminating Provider Edge Routers PEs (T-PEs), one or
   more Switching Provider Edge Routers (S-PEs), and a sequence of
   tunneled PW segments that connects one of the T-PEs with its
   "adjacent" S-PE, connects this S-PE with the next S-PE in the
   sequence, and so on until the last S-PE is connected by the last PW
   segment to the remaining T-PE. In MPLS and MPLS-TP environments,
   statically provisioned Single-Segment Pseudowires (SS-PWs) are
   protected against tunnel failure via MPLS-level and MPLS-TP-level
   tunnel protection. With statically provisioned Multi-Segment

Pseudowires (MS-PWs), each PW segment of the MS-PW is likewise
protected from tunnel failure via MPLS-level and MPLS-TP-level tunnel
protection. However, tunnel protection does not protect static MS-
PWs from failures of S-PEs along the path of the MS-PW.

RFC 6718 [RFC6718] provides a general framework for PW protection,
and RFC 6870 [RFC6870], which is based upon that framework, describes
protection procedures for MS-PWs that are dynamically signaled using
LDP. This document describes how to achieve protection against S-PE
failure in a static MS-PW by extending RFC 6870 to be applicable for
statically provisioned MS-PWs pseudowires (PWs) as well.

This document also contains an OPTIONAL alternative approach based on
MPLS-TP Linear Protection. This approach, described in Appendix A,
MUST be identically provisioned in the PE endpoints for the protected
MS-PW in order to be used. See Appendix A for further details on
this alternative approach.

This document differs from [PW-REDUNDANCY] in that it provides end-
to-end resiliency for static MS-PWs, whereas [PW-REDUNDANCY] provides
resiliency at intermediate S-PEs and resiliency for both dynamically
signaled and static MS-PWs.

PWs based on the Layer 2 Tunneling Protocol Version 3 (L2TPv3) are
outside the scope of this document.

1.1. 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].

2. Extension to RFC 6870 to Protect Statically Provisioned SS-PWs and MS-PWs

Section 3.2.3 of RFC 6718 and Appendix A.5 of RFC 6870 document how
to use redundant MS-PWs to protect an MS-PW against S-PE failure in
the case of a singly homed Customer Edge (CE), using the following
network model from RFC 6718:

```
                Native  |<----------- Pseudowires ------------>|  Native
                Service |                                      |  Service
                 (AC)   |     |<-PSN1-->|      |<-PSN2-->|      |   (AC)
                   |    V     V         V      V         V      V     |
                   |  +-----+           +-----+          +-----+      |
        +----+     |  |T-PE1|===========|S-PE1|==========|T-PE2|      |  +----+
        |    |  -------|......PW1-Seg1.......|.PW1-Seg2......|-------  |    |
        |CE1 |     |  |     |===========|     |==========|     |      |  |CE2 |
        |    |     |  +-----+           +-----+          +-----+      |  |    |
        +----+     |   . | .                                . | .     |  +----+
        +----+     |   . | .             +-----+           . | .      |
                   |   . | .|===========|     |==========  . | .
                   |   . |...PW2-Seg1......|.PW2-Seg2...|| . 
                   |   .  ===========|S-PE2|============    .
                   |   .             +-----+                .
                   |   .|===========+-----+=============    .
                   |    .....PW3-Seg1.|     |  PW3-Seg2......|
                    ===============|S-PE3|================
                                   +-----+
```
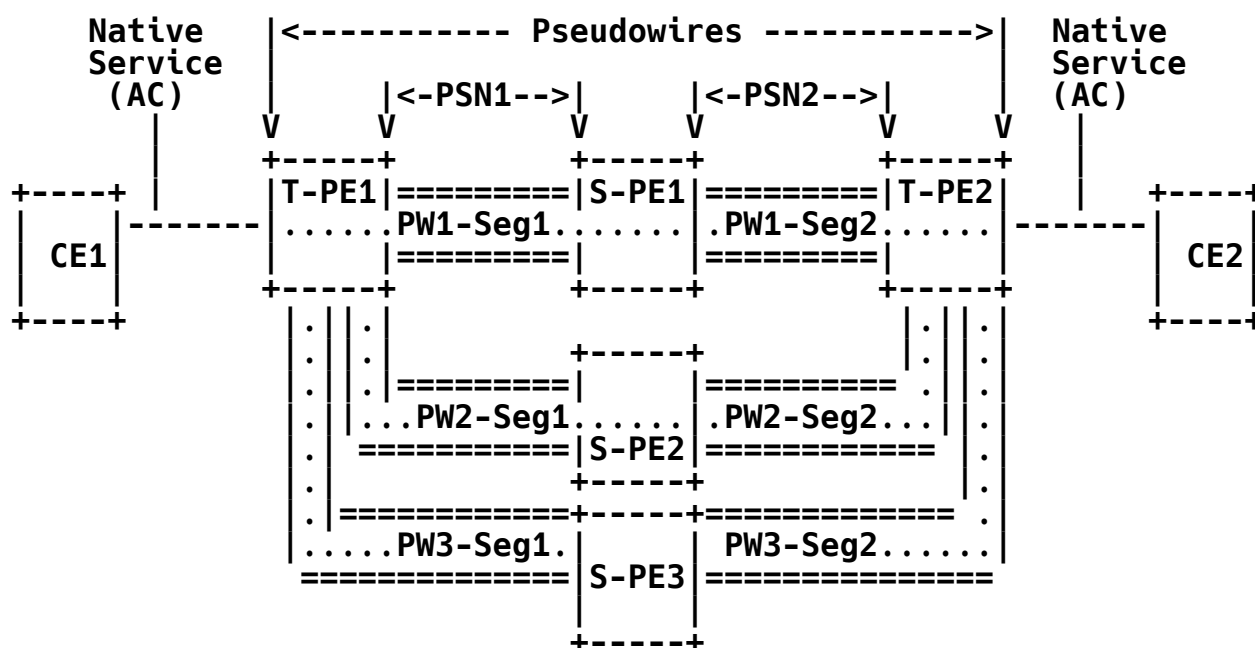
                 Figure 1: Single-Homed CE with Redundant MS-PWs

   In this figure, Customer Edge Router 1 (CE1) is connected to T-PE1,
   and CE2 is connected to T-PE2 via Attachment Circuits (ACs). There
   are three MS-PWs. PW1 is switched at S-PE1, PW2 is switched at
   S-PE2, and PW3 is switched at S-PE3. This scenario provides N:1
   protection against S-PE failure for the subset of the path of the
   emulated service from T-PE1 to T-PE2.

   The procedures in RFCs 6718 and 6870 rely on LDP-based PW status
   signaling to signal the state of the primary MS-PW that is being
   protected, and the precedence in which redundant MS-PW(s) should be
   used to protect the primary MS-PW should it fail. These procedures
   make use of information carried by the PW Status TLV, which, for
   dynamically signaled PWs, is carried by the LDP.

   However, statically provisioned PWs (SS-PWs or MS-PWs) do not use the
   LDP for PW setup and signaling; rather, they are provisioned by
   network management systems or other means at each T-PE and S-PE along
   their paths. They also do not use the LDP for status signaling.
   Rather, they use procedures defined in RFC 6478 [RFC6478] for status
   signaling via the PW Operations, Administration, and Maintenance
   (OAM) message using the PW Associated Channel Header (ACH). The PW
   Status TLV carried via this status signaling is itself identical to
   the PW Status TLV carried via LDP-based status signaling, including
   the identical PW Status Codes.

Sections 6 and 7 of RFC 6870 describe the management of a primary PW and its secondary PW(s) to provide resiliency to the failure of the primary PW. They use status codes transmitted between endpoint T-PEs using the PW Status TLV transmitted by LDP. For this management to apply to statically provisioned PWs, the PW status signaling defined in RFC 6478 MUST be used for the primary and secondary PWs. In that case, the endpoint T-PEs can then use the PW status signaling provided by RFC 6478 in place of LDP-based status signaling, so that the status-signaling-based procedures in RFC 6870 operate identically to when used with LDP-based status signaling. Note that the optional S-PE Bypass Mode defined in Section 5.5 of RFC 6478 cannot be used, as it requires LDP signaling.

3. Operational Considerations

Because LDP is not used between the T-PEs for statically provisioned MS-PWs, the negotiation procedures described in RFC 6870 cannot be used. Thus, operational care must be taken so that the endpoint T-PEs are identically provisioned regarding the use of this document, specifically whether or not MS-PW redundancy is being used, and for each protected MS-PW, the identity of the primary MS-PW and the precedence of the secondary MS-PWs.

4. Security Considerations

The security considerations defined for RFC 6478 apply to this document as well. As the security considerations in RFCs 6718 and 6870 are related to their use of LDP, they are not required for this document.

If the alternative approach in Appendix A is used, then the security considerations defined for RFCs 6378, 7271, and 7324 also apply.

5. References

5.1. 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>.

   [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>.

   [RFC6478] Martini, L., Swallow, G., Heron, G., and M. Bocci,
              "Pseudowire Status for Static Pseudowires", RFC 6478,
              DOI 10.17487/RFC6478, May 2012,
              <http://www.rfc-editor.org/info/rfc6478>.

   [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>.

   [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>.

5.2. Informative References

   [PW-REDUNDANCY]
              Dong, J. and H. Wang, "Pseudowire Redundancy on S-PE",
              Work in Progress, draft-ietf-pals-redundancy-spe-02,
              August 2015.

   [RFC5659] Bocci, M. and S. Bryant, "An Architecture for Multi-
              Segment Pseudowire Emulation Edge-to-Edge", RFC 5659,
              DOI 10.17487/RFC5659, October 2009,
              <http://www.rfc-editor.org/info/rfc5659>.

   [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>.

Appendix A. Optional Linear Protection Approach

A.1. Introduction

   In "MPLS Transport Profile (MPLS-TP) Linear Protection" [RFC6378], as
   well as in the later updates of that RFC "MPLS Transport Profile
   (MPLS-TP) Linear Protection to Match the Operational Expectations of
   Synchronous Digital Hierarchy, Optical Transport Network, and
   Ethernet Transport Network Operators" [RFC7271] and "Updates to MPLS
   Transport Profile Linear Protection" [RFC7324], the Protection State
   Coordination (PSC) protocol was defined for MPLS LSPs only.

   This appendix extends these RFCs to be applicable for PWs (SS-PW and
   MS-PW) as well. This is useful especially in the case of end-to-end
   static provisioned MS-PWs running over MPLS-TP where tunnel
   protection alone cannot be relied upon for end-to-end protection of
   PWs against S-PE failure. It also enables a uniform operational
   approach for protection at LSP and PW layers and an easier management
   integration for networks that already implement the approach in RFCs
   6378, 7271, and 7324.

   The protection architectures are those defined in [RFC6378]. For the
   purposes of this appendix, we define the protection domain of a
   point-to-point PW as consisting of two terminating PEs (T-PEs) and
   the transport paths that connect them (see Figure 2).

```
      +-----+ //=====================\\ +-----+
      |T-PE1|//      Working Path      \\|T-PE2|
      |    /|                           |\    |
      |  ?< |                           | >?  |
      |    \|                           |/    |
      |     |\\     Protection Path    //|    |
      +-----+ \\=====================// +-----+

         |<-------Protection Domain------->|
```
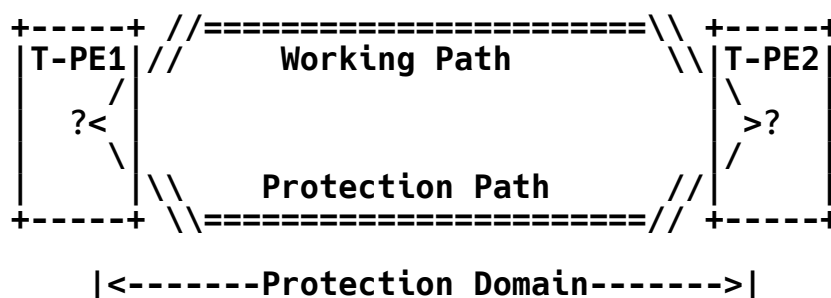
                   Figure 2: Protection Domain

   This Appendix is an OPTIONAL alternative approach to the one in
   Section 2. For interoperability, all implementations MUST include
   the approach in Section 2, even if this alternative approach is used.
   The operational considerations in Section 3 continue to apply when
   this approach is used, and operational care must be taken so that the
   endpoint T-PEs are identically provisioned regarding the use of this
   document.

A.2. Encapsulation of the PSC Protocol for Pseudowires

   The PSC protocol can be used to protect against defects on any LSP
   (segment, link, or path). In the case of MS-PW, the PSC protocol can
   also protect failed intermediate nodes (S-PE). Linear protection
   protects an LSP or PW end-to-end and if a failure is detected,
   switches traffic over to another (redundant) set of resources.

   Obviously, the protected entity does not need to be of the same type
   as the protecting entity. For example, it is possible to protect a
   link by a path. Likewise, it is possible to protect an SS-PW with an
   MS-PW, and vice versa.

   From a PSC protocol point of view, it is possible to view an SS-PW as
   a single-hop LSP and an MS-PW as a multiple-hop LSP. Thus, this
   provides end-to-end protection for the SS-PW or MS-PW. The Generic
   Associated Channel (G-Ach) carrying the PSC protocol information is
   placed in the label stack directly beneath the PW identifier. The
   PSC protocol will then work as specified in RFCs 6378, 7271, and
   7324.

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   Figure 1 and the explanatory paragraph following the figure were
   taken from RFC 6718. Figure 2 was adapted from RFC 6378.

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