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                 OAM Procedures for VPWS Interworking
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Abstract

   This draft proposes OAM procedures for the Ethernet interworking, IP
   interworking and FR-ATM interworking Virtual Private
   Wire Service (VPWS).

Conventions used in this document

   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.

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2. Introduction

This draft augments OAM message mapping [OAM-MSG] with OAM
procedures for scenarios when the attachment circuit does not
correspond to the pseudo wire. When combined with procedures defined
in [OAM-MSG], comprehensive OAM interworking can be defined for VPWS
services. VPWS services are defined in the L2 VPN framework [L2VPN-
FRMK].

The following VPWS types are covered in this document:

1. VPWS with heterogeneous ACs of ATM and FR types, and in which the
   PW type is ATM or FR. In this case, FR-ATM service interworking
   [FRF8.2] is performed in PE1 (or PE2) and a FR (or ATM) PW is
   extended to the remote PE. This VPWS type will be referred to as
   ''FR-ATM Interworking VPWS''.

2. VPWS with heterogeneous ACs of ATM, FR, and Ethernet types, and
   in which the PW type is Ethernet. This VPWS type will be referred
   to as ''Ethernet Interworking VPWS''.

3. VPWS with heterogeneous ACs of ATM, FR, and Ethernet types, and
   in which the PW type is IP [ARP-Mediation]. This VPWS type will
   be referred to as ''IP Interworking VPWS''.

OAM procedures for homogeneous VPWS circuits of ATM, FR, or Ethernet
types are described in [OAM-MSG].

3. Conventions

The words "defect" and "fault" are used interchangeably to mean any condition that obstructs forwarding of user traffic between the CE endpoints of the PW service.

The words "defect notification" and "defect indication" are used interchangeably to mean any OAM message generated by a PE and sent to other nodes in the network to convey the defect state local to this PE.

An end-to-end virtual circuit in a VPWS consists of a 3 segment set: <AC, PW, AC> [L2VPN-FRMK]. Note that the AC does not need to connect a CE directly to a PE. An intermediate L2 network may exist.

A VPWS is homogeneous if AC and PW types are the same. E.g., ATM VPWS: <ATM AC, ATM PW, ATM AC>.

A VPWS is heterogeneous if any two segments of the circuit are of different types. E.g., IP interworking circuit: <ATM AC, IP PW, ATM AC>, or <ATM AC, IP PW, ETH AC>.

The PW of a VPWS can be carried over three types of Packet Switched Networks (PSNs). An "MPLS PSN" makes use of MPLS Label Switched Paths [RFC3031] as the tunneling technology to forward the PW packets. An "MPLS/IP PSN" makes use of MPLS-in-IP tunneling [RFC4023], with an MPLS shim header used as PW demultiplexer. An "L2TPv3/IP PSN" makes use of L2TPv3/IP [RFC3931] as the tunneling technology with the L2TPv3/IP Session ID as the PW demultiplexer.

If LSP-Ping [RFC4379] is run over a PW as described in [RFC5085], it will be referred to as "VCCV-Ping". If BFD is run over a PW as described in [RFC5885], it will be referred to as "VCCV-BFD".

While PWs are inherently bidirectional entities, defects and OAM messaging are related to a specific traffic direction. We use the terms "upstream" and "downstream" to identify PEs in relation to the traffic direction. A PE is upstream for the traffic it is forwarding and is downstream for the traffic it is receiving.

We use the terms "local" and "remote" to identify native service networks and ACs in relation to a specific PE. The local AC is attached to the PE in question, while the remote AC is attached to the PE at the other end of the PW.

A "transmit defect" is any defect that impacts traffic that is meant to be sent or relayed by the observing PE. A "receive defect" is any

defect that impacts traffic that is meant to be received by the observing PE. Note that a receive defect also impacts traffic meant to be relayed, and thus can be considered to incorporate two defect states. Thus when a PE enters both receive and transmit defect states of a PW service, the receive defect takes precedence over the transmit defect in terms of the consequent actions.

A "forward defect indication" (FDI) is sent in the same direction as the user traffic impacted by the defect. A "reverse defect indication" (RDI) is sent in the direction opposite to that of the impacted traffic.

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 [RFC2119].

4. Reference Model and Defect Locations

Figure 1 illustrates the VPWS network reference model with an indication of the possible defect locations. This model will be referenced in the remainder of this document for describing the OAM procedures.
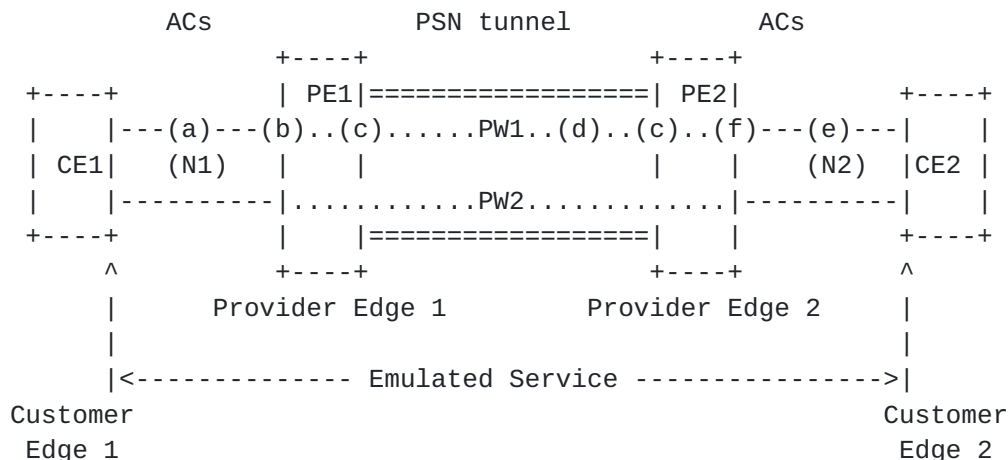
```
            ACs                 PSN tunnel            ACs
                     +----+                  +----+
   +----+            | PE1|=================| PE2|         +----+
   |    |---(a)---(b)..(c)......PW1..(d)..(c)..(f)---(e)---|    |
   | CE1|   (N1)   |    |                   |    |   (N2)  |CE2 |
   |    |----------|............PW2.............|----------|    |
   +----+          |    |=================|    |         +----+
       ^           +----+                  +----+         ^
       |       Provider Edge 1       Provider Edge 2      |
       |                                                  |
       |<-------------- Emulated Service --------------->|
     Customer                                         Customer
      Edge 1                                           Edge 2
            Figure 1: PWE3 Network Defect Locations
```

The procedures will be described in this document from the viewpoint of PE1, so that N1 is the local native service network and N2 is the remote native service network. It is assumed that the AC and PW are of different types at PE1. PE2 will typically implement the same procedures but it can use an AC and PW of the same or different types. Note that PE1 is the upstream PE for traffic originating in the local NS network N1, while it is the downstream PE for traffic originating in the remote NS network N2.

The following is a brief description of the defect locations:

   a. Defect in NS network N1. This covers any defect in network N1
      that impacts all or some ACs attached to PE1, and is thus a
      local AC defect. The defect is conveyed to PE1 and to NS
      network N2 using NS specific OAM defect indications.

   b. Defect on a PE1 AC interface (another local AC defect).

   c. Defect on a PE1 PSN interface.

   d. Defect in the PSN network. This covers any defect in the PSN
      that impacts all or some PWs between PE1 and PE2. The defect is
      conveyed to the PE using a PSN and/or a PW specific OAM defect
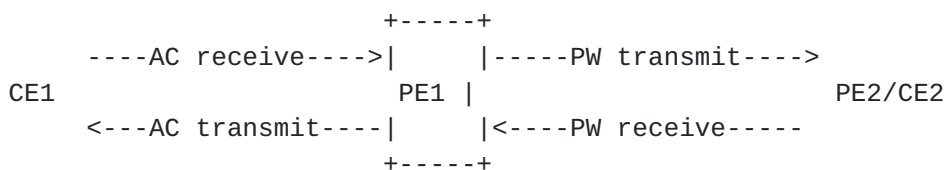   indication. Note that both data plane defects and control plane
      defects must be taken into consideration. Although control
      messages may follow a different path than PW data plane
      traffic, a control plane defect may affect the PW status.

   e. Defect in NS network N2 (another remote AC defect). This covers
      any defect in N2 which impacts all or a subset of ACs attached
      to PE2. The defect is conveyed to PE2 and to NS network N1
      using the NS OAM defect indication.

   f. Defect on a PE2 AC interface (a remote AC defect).

[5](#). **Abstract Defect States**

   sss PE1 must track four defect states that reflect the observed
   states of both directions of the PW service on both the AC and the
   PW sides.

   Defects may impact one or both directions of the PW service. The
   observed state is a combination of defects directly detected by PE1
   and defects of which it has been made aware via notifications.

```
                        +-----+
        ----AC receive---->|     |-----PW transmit---->
   CE1                     PE1 |                        PE2/CE2
        <---AC transmit----|     |<----PW receive-----
                        +-----+
```

   (arrows indicate direction of user traffic impacted by a defect)
            Figure 2: Receive and Transmit Defect States

PE1 will directly detect or be notified of AC receive or PW receive defects as they occur upstream of PE1 and impact traffic being sent to PE1. As a result, PE1 enters the AC or PW receive defect state.

In Figure 2, PE1 may be notified of a receive defect in the AC by receiving a Forward Defect indication, e.g., ATM AIS, from CE1 or an intervening network. This defect notification indicates that user traffic sent by CE1 may not be received by PE1 due to a defect. PE1 can also directly detect an AC receive defect if it resulted from a failure of the receive side in the local port or link over which the AC is configured.

Similarly, PE1 may detect or be notified of a receive defect in the PW by receiving a Forward Defect indication from PE2. If PW status is used for fault notification, this message will indicate a Local PSN-facing PW (egress) Transmit Fault or a Local AC (ingress) Receive Fault at PE2. This defect notification indicates that user traffic sent by CE2 may not be received by PE1 due to a defect. As a result, PE1 enters the PW receive defect state.

Note that a Forward Defect Indication is sent in the same direction as the user traffic impacted by the defect.

Generally, a PE cannot detect transmit defects directly and will therefore need to be notified of AC transmit or PW transmit defects by other devices.

In Figure 2, PE1 may be notified of a transmit defect in the AC by receiving a Reverse Defect indication, e.g., ATM RDI, from CE1. This defect relates to the traffic sent by PE1 to CE1 on the AC.

Similarly, PE1 may be notified of a transmit defect in the PW by receiving a Reverse Defect indication from PE2. If PW status is used for fault notification, this message will indicate a Local PSN facing PW (ingress) Receive Fault or a Local Attachment Circuit (egress) Transmit Fault at PE2. This defect impacts the traffic sent by PE1 to CE2. As a result, PE1 enters the PW transmit defect state.

Note that a Reverse Defect indication is sent in the reverse direction to the user traffic impacted by the defect.

The procedures outlined in this document define the entry and exit criteria for each of the four states with respect to the set of PW services within the document scope and the consequent actions that PE1 must perform.

When a PE enters both receive and transmit defect states related to the same PW service, then the receive defect takes precedence over transmit defect in terms of the consequent actions.

6. VPWS OAM Modes

A heterogeneous VPWS forwards packets between an AC and a PW of different types. It thus implements both NS OAM and PW OAM mechanisms.

PW OAM defect notification messages and NS OAM messages are described in [OAM-MSG]. Ethernet NS OAM messages are described in [MPLS-ETH-OAM].

Two different OAM modes are defined in [OAM-MSG], the distinction being the method of mapping between the NS and PW OAM defect notification messages.

The first mode, illustrated in Figure 3, is called the "single emulated OAM loop" mode. Here a single end-to-end NS OAM loop is emulated by transparently passing NS OAM messages over the PW. Note that the PW OAM is shown outside the PW in Figure 3, as it is transported in LDP messages or in the associated channel, not inside the PW itself.

```
   |<----- AC ----->|<----- PW ----->|<----- AC ----->|
   |                |                |                |
                 ___ ==============_
 |CE|---=NS-OAM=>---(---=NS-OAM=>---)---=NS-OAM=>---|CE|
                 ==============     /
                     \             /
                      ---=PW-OAM=>---
```
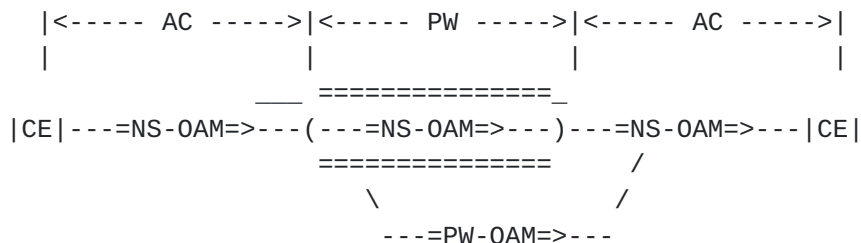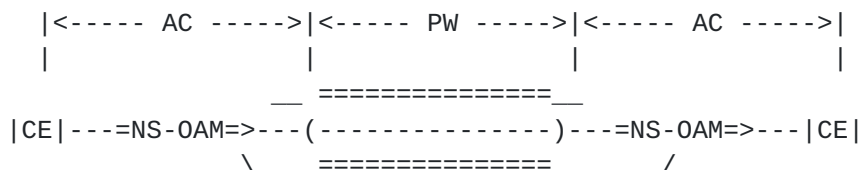
                 Figure 3: Single Emulated OAM Loop mode

The second OAM mode operates three OAM loops joined at the AC/PW boundaries of the PEs. This is referred to as the "coupled OAM loops" mode and is illustrated in Figure 4. Note that in contrast to Figure 3, NS OAM messages are never carried over the PW.

```
   |<----- AC ----->|<----- PW ----->|<----- AC ----->|
   |                |                |                |
                 __ ==============__
 |CE|---=NS-OAM=>---(---------------)---=NS-OAM=>---|CE|
                 \     ==============        /
```

```
                    \                    /
                     \                  /
                      -------=PW-OAM=>------
```
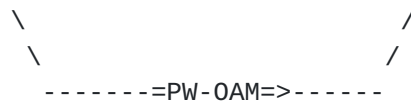
Figure 4: Coupled OAM Loops mode

The coupled OAM loops mode implements the following behavior:

a. The upstream PE (PE1) MUST terminate and translate a received
   NS defect notification message into a PW defect notification
   message.

b. The upstream PE MUST signal local failures affecting its local
   AC using PW defect notification messages to the downstream PE.

c. The upstream PE MUST signal local failures affecting the PW
   using PW defect notification messages.

d. The downstream PE (PE2) MUST insert NS defect notification
   messages into the AC when it detects or is notified of defects
   in the PW or remote AC. This includes translating received PW
   defect notification messages into NS defect notification
   messages.

Table 1 summarizes the OAM mode used with each type of VPWS covered
in this document.

VPWS Type	Single Emulated OAM Loop Mode	Coupled OAM Loops Mode
FR-ATM Interworking - ATM cell mode PW	X	
FR-ATM Interworking - FR or AAL5 PDU/SDU PW		X
Ethernet Interworking		X
IP Interworking		X

Table 1: Summary of Heterogeneous VPWS OAM Modes

7. PW Defect State Entry/Exit

The details of the PW transmit and receive defect state entry/exit
criteria are described in Section 8.2 of [OAM-MSG].

The consequent actions for an ATM AC are described in sections 9.3.1
and 9.3.2 of [OAM-MSG].

The consequent actions for a FR AC are described in sections 10.3.1
and 10.3.2 of [OAM-MSG].

The consequent actions for an Ethernet AC are described in sections
5.1 through 5.4 of [MPLS-ETH-OAM].

8. **ATM AC Defect State Entry/Exit**

The details of the ATM AC receive and transmit defect state
entry/exit criteria are described in sections 9.1 and 9.2
respectively of [OAM-MSG].

The consequent actions are described in sections 9.3.4 and 9.3.5 of
[OAM-MSG].

Note that all interworking VPWS covered in this document make use of
ATM VC as the AC. ATM VP cannot be used as a SAP in an interworking
VPWS. Therefore only ATM F5 OAM messages are relevant.

9. **FR AC Defect State Entry/Exit**

The details of the FR AC receive and transmit defect state
entry/exit criteria are described in sections 10.1 and 10.2
respectively of [OAM-MSG].

The consequent actions are described in sections 10.3.4 and 10.3.5
of [OAM-MSG]. Note however that if the FR AC is part of a FR-ATM
interworking VPWS operating in the single emulated OAM loop mode,
then the consequent actions are described sections 9.3.4 and 9.3.5
of [OAM-MSG].

10. **Ethernet AC Defect State Entry/Exit**

The details of the Ethernet AC receive and transmit defect state
entry/exit criteria are described in sections 4.1 and 4.2
respectively of [MPLS-ETH-OAM].

The consequent actions are described in sections 5.5 through 5.8 of
[MPLS-ETH-OAM].

11. **Security Considerations**

The mapping messages described in this document do not change the
security functions inherent in the actual messages. All generic

security considerations applicable to PW traffic specified in
Section 10 of [RFC3985] are applicable to NS OAM messages
transferred inside the PW.

Security considerations in Section 10 of RFC 5085 for VCCV apply to
the OAM messages thus transferred. Security considerations
applicable to the PWE3 control protocol of RFC 4447 Section 8.2
apply to OAM indications transferred using the LDP status message.

12. IANA Considerations

This document requires no IANA actions.

13. References

13.1. Normative References

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