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## Redundancy Mechanism for Inter-domain VPLS Service

### Abstract

In many existing Virtual Private LAN Service (VPLS) inter-domain deployments (based on RFC 4762), pseudowire (PW) connectivity offers no Provider Edge (PE) node redundancy, or offers PE node redundancy with only a single domain. This deployment approach incurs a high risk of service interruption, since at least one domain will not offer PE node redundancy. This document describes an inter-domain VPLS solution that provides PE node redundancy across domains.

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## 1. Introduction

In many existing Virtual Private LAN Service (VPLS) deployments based on [RFC4762], pseudowire (PW) connectivity offers no Provider Edge (PE) node redundancy, or offers PE node redundancy with only a single domain. This deployment approach incurs a high risk of service interruption, since at least one domain will not offer PE node redundancy. This document describes an inter-domain VPLS solution that provides PE node redundancy across domains. The redundancy mechanism will provide PE node redundancy and link redundancy in both domains. The PE throughout the document refers to a routing and bridging capable PE defined in [RFC4762], Section 10. The domain in this document refers to an autonomous system (AS), or other administrative domains.

The solution relies on the use of the Inter-Chassis Communication Protocol (ICCP) [RFC7275] to coordinate between the two redundant edge nodes, and use of PW Preferential Forwarding Status Bit [RFC6870] to negotiate the PW status. There is no change to any protocol message formats and no new protocol options are introduced. This solution is a description of reusing existing protocol building blocks to achieve the desired function, but also defines implementation behavior necessary for the function to work.

## 2. 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 [RFC2119].

## 3. Motivation

Inter-AS VPLS offerings are widely deployed in service provider networks today. Typically, the Autonomous System Border Router (ASBR) and associated physical links that connect the domains carry a multitude of services. As such, it is important to provide PE node and link redundancy, to ensure high service availability and meet the end customer service level agreements (SLAs).

Several current deployments of inter-AS VPLS are implemented like inter-AS option A as described in [RFC4364], Section 10, where the Virtual Local Area Network (VLAN) is used to hand-off the services between two domains. In these deployments, PE node/link redundancy is achieved using Multi-Chassis Link Aggregation (MC-LAG) and ICCP [RFC7275]. This, however, places two restrictions on the interconnection: the two domains must be interconnected using Ethernet links, and the links must be homogeneous, i.e., of the same speed, in order to be aggregated. These two conditions cannot always

be guaranteed in live deployments. For instance, there are many scenarios where the interconnection between the domains uses packet over Synchronous Optical Networking (SONET) / Synchronous Digital Hierarchy (SDH), thereby ruling out the applicability of MC-LAG as a redundancy mechanism. As such, from a technical point of view, it is desirable to use PWs to interconnect the VPLS domains, and to offer resiliency using PW redundancy mechanisms.

Multiprotocol Border Gateway Protocol (MP-BGP) can be used for VPLS inter-domain protection, as described in [RFC6074], using either option B or option C inter-AS models. However, with this solution, the protection time relies on BGP control-plane convergence. In certain deployments, with tight SLA requirements on availability, this mechanism may not provide the desired failover time characteristics. Furthermore, in certain situations MP-BGP is not deployed for VPLS. The redundancy solution described in this document reuses ICCP [RFC7275] and PW redundancy [RFC6718] to provide fast convergence.

Furthermore, in the case where label switched multicast is not used for VPLS multicast [RFC7117], the solution described here provides a better behavior compared to inter-AS option B: with option B, each PE must perform ingress replication to all other PEs in its local as well as the remote domain. Whereas, with the ICCP solution, the PE only replicates to local PEs and to the ASBR. The ASBR then sends traffic point to point to the remote ASBR, and the remote ASBR replicates to its local PEs. As a result, the load of replication is distributed and is more efficient than option B.

Two PW redundancy modes defined in [RFC6718], namely independent mode and master/slave mode, are applicable in this solution. In order to maintain control-plane separation between two domains, the independent mode is preferred by operators. The master/slave mode provides some enhanced capabilities and, hence, is included in this document.

#### 4. Network Use Case

There are two network use cases for VPLS inter-domain redundancy: two-PWs redundancy case, and four-PWs redundancy case.

Figure 1 presents an example use case with two inter-domain PWs. PE3/PE4/PE5/PE6 may be ASBRs of their respective AS, or VPLS PEs within its own AS. PE3 and PE4 belong to one redundancy group (RG), and PE5 and PE6 belong to another RG. A deployment example of this use case is where there are only two physical links between two domains and PE3 is physically connected with PE5, and PE4 is physically connected with PE6.

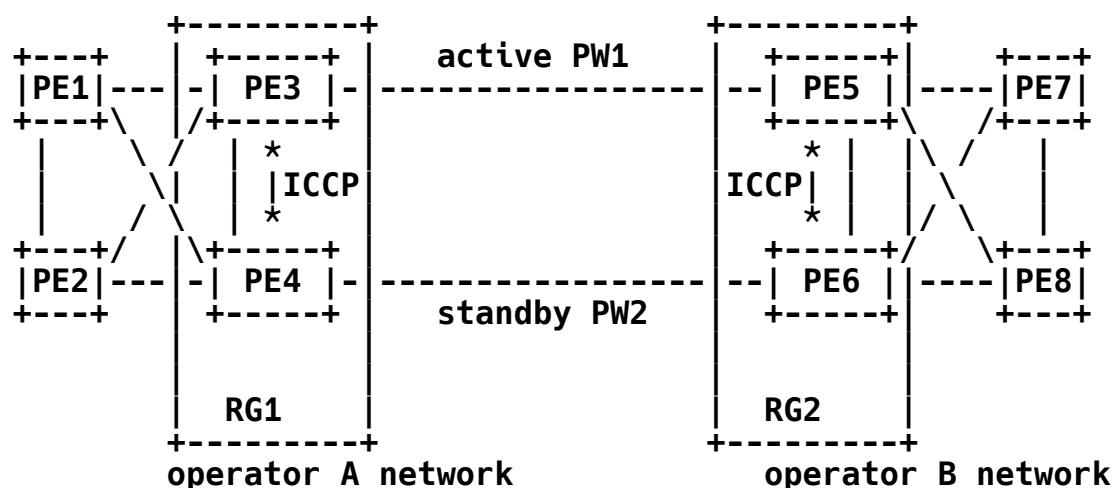


Figure 1

Figure 2 presents a four-PWs inter-domain VPLS redundancy use case. PE3/PE4/PE5/PE6 may be ASBRs of their respective AS, or VPLS PEs within its own AS. A deployment example of this use case is where there are four physical links between two domains and four PEs are physically connected with each other with four links.

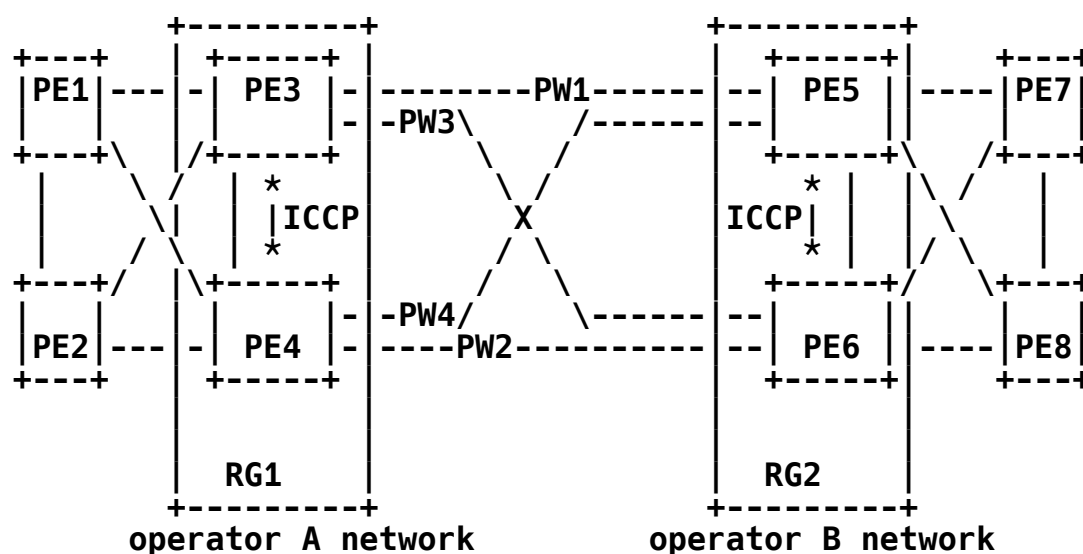


Figure 2

## 5. PW Redundancy Application Procedure for Inter-domain Redundancy

PW redundancy application procedures are described in Section 9.1 of [RFC7275]. When a PE node encounters a failure, the other PE takes over. This document reuses the PW redundancy mechanism defined in [RFC7275], with new ICCP switchover conditions as specified in following section.

There are two PW redundancy modes defined in [RFC6870]: Independent mode and Master/Slave mode. For the inter-domain four-PW scenario, it is required that PEs ensure that the same mode be supported on the two ICCP peers in the same RG. This can be achieved using manual configuration at the ICCP peers. Other methods for ensuring consistency are out of the scope of this document.

### 5.1. ICCP Switchover Condition

#### 5.1.1. Inter-domain PW Failure

When a PE receives advertisements from the active PE, in the same RG, indicating that all the inter-domain PW status has changed to DOWN/STANDBY, then if it has the highest priority (after the advertising PE), it SHOULD advertise active state for all of its associated inter-domain PWs.

#### 5.1.2. PE Node Isolation

When a PE detects failure of all PWs to the local domain, it SHOULD advertise standby state for all its inter-domain PWs to trigger remote PE to switchover.

#### 5.1.3. PE Node Failure

When a PE node detects that the active PE, that is a member of the same RG, has gone down, if the local PE has redundant PWs for the affected services and has the highest priority (after the failed PE), it SHOULD advertise the active state for all associated inter-domain PWs.

### 5.2. Inter-domain Redundancy with Two PWs

In this use case, it is recommended that the operation be as follows:

- o ICCP deployment option: ICCP is deployed on VPLS edge nodes in both domains;
- o PW redundancy mode: independent mode only;

- o Protection architectures: 1:1 (1 standby, 1 active).

The switchover rules described in Section 5.1 apply. Before deploying this inter-domain VPLS, the operators should negotiate to configure the same PW high/low priority at two PW endpoints. The inter-domain VPLS relationship normally involves a contractual process between operators, and the configuration of PW roles forms part of this process. For example, in Figure 1, PE3 and PE5 must both have higher/lower priority than PE4 and PE6; otherwise, both PW1 and PW2 will be in standby state.

### 5.3. Inter-domain Redundancy with Four PWs

In this use case, there are two options to provide protection: 1:1 and 3:1 protection. The inter-domain PWs that connect to the same PE should have proper PW priority to advertise the same active/standby state. For example, in Figure 2, both PW1 and PW3 are connected to PE3 and should advertise active/standby state.

For the 1:1 protection model, the operation would be as follows:

- o ICCP deployment option: ICCP is deployed on VPLS edge nodes in both domains;
- o PW redundancy mode: independent mode only;
- o Protection architectures: 1:1 (1 standby, 1 active).

The switchover rules described in Section 5.1 apply. In this case, the operators do not need to do any coordination of the inter-domain PW priority. The PE detecting one PW DOWN SHOULD set the other PW to STANDBY if available, and then synchronize the updated state to its ICCP peer. When a PE detects that the PWs from the ICCP peer PE are DOWN or STANDBY, it SHOULD switchover as described in Section 5.1.1.

There are two variants of the 3:1 protection model. We will refer to them as options A and B. The implementation MUST support option A and MAY support option B. Option B will be useful when the two legacy PEs in one domain do not support the function in this document. The two legacy PEs still need to support PW redundancy defined in [RFC6870] and be configured as slave node.

For option A of the 3:1 protection model, the support of the Request Switchover status bit [RFC6870] is required. The operation is as follows:

- o ICCP deployment option: ICCP is deployed on VPLS edge nodes in both domains;

- o PW redundancy mode: Independent mode with 'request switchover' bit support;
- o Protection architectures: 3:1 (3 standby, 1 active).

In this case, the procedure on the PE for the PW failure is per Section 6.3 of [RFC6870] and with the following additions:

- o When the PE detects failure of the active inter-domain PW, it SHOULD switch to the other local standby inter-domain PW if available, and send an updated LDP PW status message with the 'request switchover' bit set on that local standby inter-domain PW to the remote PE;
- o Local and remote PE SHOULD also update the new PW status to their ICCP peers, respectively, in Application Data Messages with the PW-RED Synchronization Request TLV for corresponding service, so as to synchronize the latest PW status on both PE sides.
- o While waiting for the acknowledgement, the PE that sends the 'request switchover' bit may receive a switchover request from its ICCP peer's PW remote endpoint by virtue of the ICCP synchronization. The PE MUST compare IP addresses with that PW remote peer. The PE with a higher IP address SHOULD ignore the request and continue to wait for the acknowledgement from its peer in the remote domain. The PE with the lower IP address SHOULD clear the 'request switchover' bit and set the 'Preferential Forwarding' local status bit, and update the PW status to ICCP peer.
- o The remote PE receiving the 'request switchover' bit SHOULD acknowledge the request and activate the PW only when it is ready to take over as described in Section 5.1; otherwise, it SHOULD ignore the request.

The PE node isolation failure and PE node failure is described in Section 5.1.

For option B of the 3:1 protection model, master/slave mode support is required and should be as follows:

- o ICCP deployment option: ICCP is deployed on VPLS edge nodes in only one domain;
- o PW redundancy mode: master/slave only;
- o Protection architectures: 3:1 (3 standby, 1 active).



When master/slave PW redundancy mode is employed, the network operators of two domains must agree on which domain PEs will be master, and configure the devices accordingly. The inter-domain PWs that connect to one PE should have higher PW priority than the PWs on the other PE in the same RG. The procedure on the PE for PW failure is as follows:

- o The PE with higher PW priority should only enable one PW active, and the other PWs should be in the standby state.
- o When the PE detects an active PW DOWN, it SHOULD enable the other local standby PW to be active with preference. Only when two inter-domain PWs connected to the PE are DOWN, the ICCP peer PE in the same RG SHOULD switchover as described in Section 5.1.

The PE node isolation failure and PE node failure are described in Section 5.1.

## 6. Management Considerations

When deploying the inter-domain redundancy mechanism described in this document, consistent provisioning is required for proper operation. The two domains must both use the same use case (Section 5.2 or Section 5.3). Within each section, all of the described modes and options must be provisioned identically both within each RG and between the RGs. Additionally, for the two-PWs redundancy options defined in Section 5.2, the two operators must also negotiate to configure same high/low PW priority at the two PW endpoints. If the provisioning is inconsistent, then the inter-domain redundancy mechanism may not work properly.

## 7. Security Considerations

Besides the security properties of [RFC7275] for the ICCP control plane, and [RFC4762] and [RFC6870] for the PW control plane, this document has additional security considerations for the ICCP control plane.

In this document, ICCP is deployed between two PEs or ASBRs. The two PEs or ASBRs should only be connected by a network that is well managed and whose service levels and availability are highly monitored. This should be ensured by the operator.

The state flapping on the inter-domain and intra-domain PW may cause security threats or be exploited to create denial-of-service attacks. For example, excessive PW state flapping (e.g., by malicious peer

PE's implementation) may lead to excessive ICCP exchanges. Implementations SHOULD provide mechanisms to perform control-plane policing and mitigate such types of attacks.

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