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Requirements for Ethernet VPN (E-VPN)
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Abstract

The widespread adoption of Ethernet L2VPN services and the advent of new applications for the technology (e.g. data center interconnect) have culminated in a new set of requirements that are not readily addressable by the current VPLS solution. In particular, multi-homing with all-active forwarding is not supported and there's no existing solution to leverage MP2MP LSPs for optimizing the delivery of multi-destination frames. Furthermore, the provisioning of VPLS, even in the context of BGP-based auto-discovery, requires network operators to specify various network parameters on top of the access configuration. This document specifies the requirements for an Ethernet VPN (E-VPN) solution which addresses the above issues.

Table of Contents

1. Specification of Requirements

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].

2. Introduction

VPLS, as defined in [RFC4664][RFC4761][RFC4762], is a proven and widely deployed technology. However, the existing solution has a number of limitations when it comes to redundancy, multicast optimization and provisioning simplicity. Furthermore, new applications are driving several new requirements for a VPLS service.

In the area of multi-homing current VPLS can only support multi-homing with active/standby resiliency model, for e.g. as described in [VPLS-BGP-MH]. Flexible multi-homing with all-active Attachment Circuits (ACs) cannot be supported by current VPLS solution.

In the area of multicast optimization, [VPLS-MCAST] describes how multicast LSPs can be used in conjunction with VPLS. However, this solution is limited to P2MP LSPs, as there's no defined solution for leveraging MP2MP LSPs with VPLS.

In the area of provisioning simplicity, current VPLS does offer a mechanism for single-sided provisioning by relying on BGP-based service auto-discovery [RFC4761][L2VPN-Sig]. This, however, still requires the operator to configure a number of network-side parameters on top of the access-side Ethernet configuration.

Furthermore, data center interconnect applications are driving the need for new service interface types which are a hybrid combination of VLAN Bundling and VLAN-based service interfaces. These are referred to as "VLAN-aware Bundling" service interfaces.

Also virtualization applications are fueling an increase in the volume of MAC addresses that are to be handled by the network, which gives rise to the requirement for having the network re-convergence upon failure be independent of the number of MAC addresses learned by the PE.

In addition, there are requirements for minimizing the amount of flooding of multi-destination frames and localizing the flooding to the confines of a given site.

Moreover, there are requirements for supporting flexible VPN topologies and policies beyond those currently covered by (H-)VPLS.

The focus of this document is on defining the requirements for a new solution, namely Ethernet VPN (E-VPN), which addresses the above issues.

Section 2 provides a summary of the terminology used. Section 3 discusses the redundancy requirements. Section 4 describes the multicast optimization requirements. Section 5 articulates the ease of provisioning requirements. Section 6 focuses on the new service interface requirements. Section 7 highlights the fast convergence requirements. Section 8 describes the flood suppression requirement, and finally section 9 discusses the requirements for supporting flexible VPN topologies and policies.

3. Terminology

CE: Customer Edge
E-VPN: Ethernet Virtual Private Network
MHD: Multi-homed Device
MHN: Multi-homed Network
LACP: Link Aggregation Control Protocol
LSP: Label Switched Path
PE: Provider Edge
PoA: Point of Attachment
PW: Pseudowire

4. Redundancy Requirements

4.1. Flow-based Load Balancing

A common mechanism for multi-homing a CE node to a set of PE nodes involves leveraging multi-chassis Ethernet link aggregation groups based on [802.1AX] LACP. [PWE3-ICCP] describes one such scheme. In Ethernet link aggregation, the load-balancing algorithms by which a

CE distributes traffic over the Attachment Circuits connecting to the PEs are quite flexible. The only requirement is for the algorithm to ensure in-order frame delivery for a given traffic flow. In typical implementations, these algorithms involve selecting an outbound link within the bundle based on a hash function that identifies a flow based on one or more of the following fields:

i. Layer 2: Source MAC Address, Destination MAC Address, VLAN
ii. Layer 3: Source IP Address, Destination IP Address
iii. Layer 4: UDP or TCP Source Port, Destination Port
iv. Combinations of the above.

A key point to note here is that [802.1AX] does not define a standard load-balancing algorithm for Ethernet bundles, and as such different implementations behave differently. As a matter of fact, a bundle operates correctly even in the presence of asymmetric load-balancing over the links. This being the case, the first requirement for active/active multi-homing is the ability to accommodate flexible flow-based load-balancing from the CE node based on L2, L3 and/or L4 header fields.

A solution MUST be capable of supporting flexible flow-based load balancing from the CE as described above. Further the MPLS network MUST be able to support flow-based load-balancing of traffic destined to the CE, even when the CE is connected to more than one PE. Thus the solution MUST be able to exercise multiple links connected to the CE, irrespective of the number of PEs that the CE is connected to.

4.2. Flow-based Multi-pathing

Any solution that meets the active-active flow based load balancing requirement described in section 3.1 MUST also be able to exercise multiple paths between a given pair of PEs. For instance if there are multiple RSVP-TE LSPs between a pair of PEs then the solution MUST be capable of load balancing traffic between those LSPs on a per flow basis. Similarly if LDP is being used as the transport LSP protocol, then the solution MUST be able to leverage LDP ECMP capabilities. The solution MUST also be able to leverage work in the MPLS WG that is in progress to improve the load balancing capabilities of the network based on entropy labels.

It is worth pointing out that flow-based multi-pathing complements flow-based load balancing described in the previous section.

4.3. Geo-redundant PE Nodes

The PE nodes offering multi-homed connectivity to a CE or access network may be situated in the same physical location (co-located),

or may be spread geographically (e.g. in different COs or POPs). The latter is desirable when offering a geo-redundant solution that ensures business continuity for critical applications in the case of power outages, natural disasters, etc. An active/active multi-homing mechanism SHOULD support both co-located as well as geo-redundant PE placement. The latter scenario often means that requiring a dedicated link between the PEs, for the operation of the multi-homing mechanism, is not appealing from cost standpoint. Furthermore, the IGP cost from remote PEs to the pair of PEs in the multi-homed setup cannot be assumed to be the same when those latter PEs are geo-redundant.

4.4. Optimal Traffic Forwarding

In a typical network, and considering a designated pair of PEs, it is common to find both single-homed as well as multi-homed CEs being connected to those PEs. An active/active multi-homing solution SHOULD support optimal forwarding of unicast traffic for all the following scenarios:

i. single-homed CE to single-homed CE
ii. single-homed CE to multi-homed CE
iii. multi-homed CE to single-homed CE
iv. multi-homed CE to multi-homed CE

This is especially important in the case of geo-redundant PEs, where having traffic forwarded from one PE to another within the same multi-homed group introduces additional latency, on top of the inefficient use of the PE node's and core nodes' switching capacity. A multi-homed group (also known as a multi-chassis LACP group) is a group of PEs supporting a multi-homed CE.

4.5. Flexible Redundancy Grouping Support

In order to simplify service provisioning and activation, the multi-homing mechanism SHOULD allow arbitrary grouping of PE nodes into redundancy groups where each redundancy group represents all multi-homed groups that share the same group of PEs. This is best explained with an example: consider three PE nodes - PE1, PE2 and PE3. The multi-homing mechanism MUST allow a given PE, say PE1, to be part of multiple redundancy groups concurrently. For example, there can be a group (PE1, PE2), a group (PE1, PE3), and another group (PE2, PE3) where CEs could be multi-homed to any one of these three redundancy groups.

4.6.
Multi-homed Network

There are applications which require an Ethernet network, rather than a single device, to be multi-homed to a group of PEs. The Ethernet network would typically run a resiliency mechanism such as MST or [G.8032] Ring Automated Protection Switching. The PEs may or may not participate in the control protocol of the Ethernet network.

A solution MUST support multi-homed network connectivity with active/standby redundancy.

A solution MUST also support multi-homed network with active/active VLAN-based load-balancing (i.e. disjoint VLAN sets active on disparate PEs).

A solution MAY support multi-homed network with active/active MAC-based load-balancing (i.e. different MAC addresses on a VLAN are reachable via different PEs).

5. Multicast Optimization Requirements

There are environments where the usage of MP2MP LSPs may be desirable for optimizing multicast, broadcast and unknown unicast traffic. [VPLS-LSM] precludes the usage of MP2MP LSPs since current VPLS solutions require an egress PE to perform learning when it receives unknown uncast packets over a LSP. This is challenging when MP2MP LSPs are used as MP2MP LSPs do not have inherent mechanisms to identify the sender. The usage of MP2MP LSPs for multicast optimization becomes tractable if the need to identify the sender for performing learning is lifted. A solution MUST be able to provide a mechanism that does not require learning when packets are received over a MP2MP LSP. Further a solution MUST be able to provide procedures to use MP2MP LSPs for optimizing delivery of multicast, broadcast and unknown unicast traffic.

6. Ease of Provisioning Requirements

As L2VPN technologies expand into enterprise deployments, ease of provisioning becomes paramount. Even though current VPLS has auto-discovery mechanisms which allow for single-sided provisioning, further simplifications are required, as outlined below:

- Single-sided provisioning behavior MUST be maintained
- For deployments where VLAN identifiers are global across the MPLS network (i.e. the network is limited to a maximum of 4K services), it is required that the devices derive the MPLS specific attributes (e.g. VPN ID, BGP RT, etc.) from the VLAN identifier. This way, it is sufficient for the network operator to configure the VLAN identifier(s) on the access circuit, and all the MPLS and BGP

parameters required for setting up the service over the core network would be automatically derived without any need for explicit configuration.

- Implementations SHOULD revert to using default values for parameters as and where applicable.

7. New Service Interface Requirements

[MEF] and [IEEE 802.1Q] have the following services specified:

- Port mode: in this mode, all traffic on the port is mapped to a single bridge domain and a single corresponding L2VPN service instance. Customer VLAN transparency is guaranteed end-to-end.

- VLAN mode: in this mode, each VLAN on the port is mapped to a unique bridge domain and corresponding L2VPN service instance. This mode allows for service multiplexing over the port and supports optional VLAN translation.

- VLAN bundling: in this mode, a group of VLANs on the port are collectively mapped to a unique bridge domain and corresponding L2VPN service instance. Customer MAC addresses must be unique across all VLANs mapped to the same service instance.

For each of the above services a single bridge domain is assigned per service instance on the PE supporting the associated service. For example, in case of the port mode, a single bridge domain is assigned for all the ports belonging to that service instance regardless of number of VLANs coming through these ports.

It is worth noting that the term 'bridge domain' as used above refers to a MAC forwarding table as defined in the IEEE bridge model, and does not denote or imply any specific implementation.

[RFC 4762] defines two types of VPLS services based on "unqualified and qualified learning" which in turn maps to port mode and VLAN mode respectively.

A solution is required to support the above three service types plus two additional service types which are primarily intended for hosted data center applications and are described below.

For hosted data center interconnect applications, network operators require the ability to extend Ethernet VLANs over a WAN using a single L2VPN instance while maintaining data-plane separation between the various VLANs associated with that instance. This gives rise to two new service interface types: VLAN-aware Bundling without Translation, and VLAN-aware Bundling with Translation.

The VLAN-aware Bundling without Translation service interface has the following characteristics:

- The service interface MUST provide bundling of customer VLANs into

a single L2VPN service instance.

- The service interface MUST guarantee customer VLAN transparency end-to-end.
- The service interface MUST maintain data-plane separation between the customer VLANs (i.e. create a dedicated bridge-domain per VLAN).
- In the special case of all-to-one bundling, the service interface MUST not assume any a priori knowledge of the customer VLANs. In other words, the customer VLANs shall not be configured on the PE, rather the interface is configured just like a port-based service.

The VLAN-aware Bundling with Translation service interface has the following characteristics:
- The service interface MUST provide bundling of customer VLANs into a single L2VPN service instance.
- The service interface MUST maintain data-plane separation between the customer VLANs (i.e. create a dedicated bridge-domain per VLAN).
- The service interface MUST support customer VLAN translation to handle the scenario where different VLAN Identifiers (VIDs) are used on different interfaces to designate the same customer VLAN.

The main difference, in terms of service provider resource allocation, between these new service types and the previously defined three types is that the new services require several bridge domains to be allocated (one per customer VLAN) per L2VPN service instance as opposed to a single bridge domain per L2VPN service instance.

8. Fast Convergence

A solution MUST provide the ability to recover from PE-CE attachment circuit failures as well as PE node failure for the case of both multi-homed device and multi-homed network. The recovery mechanism(s) MUST provide convergence time that is independent of the number of MAC addresses learned by the PE. This is particularly important in the context of virtualization applications which are fueling an increase in the number of MAC addresses to be handled by the Layer 2 network.
Furthermore, the recovery mechanism(s) SHOULD provide convergence time that is independent of the number of service instances associated with the attachment circuit or PE.

9. Flood Suppression

The solution SHOULD allow the network operator to choose whether unknown unicast frames are to be dropped or to be flooded. This attribute need to be configurable on a per service instance basis.

In addition, for the case where the solution is used for data-center interconnect, it is required to minimize the flooding of broadcast

frames outside the confines of a given site. Of particular interest is periodic ARP traffic.

Furthermore, it is required to eliminate any unnecessary flooding of unicast traffic upon topology changes, especially in the case of multi-homed site where the PEs have a priori knowledge of the backup paths for a given MAC address.

10. Supporting Flexible VPN Topologies and Policies

A solution MUST be capable of supporting flexible VPN topologies that are not constrained by the underlying mechanisms of the solution. One example of this is hub and spoke where one or more sites in the VPN are hubs and the others as spokes. The hubs are allowed to send traffic to other hubs and to spokes, while spokes can communicate only with other hubs. The solution MUST provide the ability to support hub and spoke. Further the solution MUST provide the ability to apply policies at the MAC address granularity to control which PEs in the VPN learn which MAC address and how a specific MAC address is forwarded. It MUST be possible to apply policies to allow only some of the member PEs in the VPN to send or receive traffic for a particular MAC address.

11. Security Considerations

There are no additional security aspects beyond those of VPLS/H-VPLS that need to be discussed here.

12. IANA Considerations

None.

13. Normative References

[RFC4664] "Framework for Layer 2 Virtual Private Networks (L2VPNs)", September 2006.

[RFC4761] "Virtual Private LAN Service (VPLS) Using BGP for Auto-discovery and Signaling", January 2007.

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