

Internet Engineering Task Force
Internet Draft
Updates: [4761](#) (if approved)
Intended status: Standards Track
Expires: April 2013

B. Kothari
Cohere Networks

K. Kompella
Contrail Systems

W. Henderickx
F. Balus
S. Palislamovic
Alcatel-Lucent

J. Uttaro
AT&T

W. Lin
Juniper Networks

October 21, 2012

BGP based Multi-homing in Virtual Private LAN Service
draft-ietf-l2vpn-vpls-multihoming-04.txt

Abstract

Virtual Private LAN Service (VPLS) is a Layer 2 Virtual Private Network (VPN) that gives its customers the appearance that their sites are connected via a Local Area Network (LAN). It is often required for the Service Provider (SP) to give the customer redundant connectivity to some sites, often called "multi-homing". This memo shows how BGP-based multi-homing can be offered in the context of LDP and BGP VPLS solutions.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

The list of current Internet-Drafts can be accessed at
<http://www.ietf.org/ietf/1id-abstracts.txt>

The list of Internet-Draft Shadow Directories can be accessed at

<http://www.ietf.org/shadow.html>

This Internet-Draft will expire on April 21, 2013.

Kothari, et al.

Expires April 21, 2013

[Page 1]

Copyright Notice

Copyright (c) 2012 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the [Trust Legal Provisions](#) and are provided without warranty as described in the Simplified BSD License.

This document may contain material from IETF Documents or IETF Contributions published or made publicly available before November 10, 2008. The person(s) controlling the copyright in some of this material may not have granted the IETF Trust the right to allow modifications of such material outside the IETF Standards Process. Without obtaining an adequate license from the person(s) controlling the copyright in such materials, this document may not be modified outside the IETF Standards Process, and derivative works of it may not be created outside the IETF Standards Process, except to format it for publication as an RFC or to translate it into languages other than English.

Table of Contents

1.	Introduction.....	4
1.1.	General Terminology.....	4
1.2.	Conventions used in this document.....	5
2.	Background.....	6
2.1.	Scenarios.....	6
2.2.	VPLS Multi-homing Considerations.....	7
3.	Multi-homing Operations.....	8
3.1.	Provisioning Model.....	8
3.2.	Multi-homing NLRI.....	8
3.3.	Designated Forwarder Election.....	9
3.3.1.	Attributes.....	9
3.3.2.	Variables Used.....	9
3.3.2.1.	RD.....	10
3.3.2.2.	MH-ID.....	10
3.3.2.3.	VBO.....	10
3.3.2.4.	DOM.....	10
3.3.2.5.	ACS.....	10
3.3.2.6.	PREF.....	11
3.3.2.7.	PE-ID.....	11
3.4.	VPLS DF Election on PEs.....	14
3.5.	Pseudowire binding and traffic forwarding rules.....	14
3.5.1.	Site-ID Binding Properties.....	14
3.5.2.	Standby Pseudowire Properties.....	15
4.	Multi-AS VPLS.....	16
4.1.	Route Origin Extended Community.....	16
4.2.	Preference.....	16
4.3.	Use of BGP-MH attributes in Inter-AS Methods.....	17
4.3.1.	Inter-AS Method (b): EBGW Redistribution of VPLS Information between ASBRs	18
4.3.2.	Inter-AS Method (c): Multi-Hop EBGW Redistribution of VPLS Information between ASes	19
5.	MAC Flush Operations.....	20
5.1.	MAC List FLush.....	20
5.2.	Implicit MAC Flush.....	21
5.3.	Minimizing the effects of fast link transitions.....	22
6.	Backwards Compatibility.....	23
6.1.	BGP based VPLS.....	23
6.2.	LDP VPLS with BGP Auto-discovery.....	23
7.	Security Considerations.....	24
8.	IANA Considerations.....	25
9.	Acknowledgments.....	26
10.	References.....	27
10.1.	Normative References.....	27
10.2.	Informative References.....	27

1. Introduction

Virtual Private LAN Service (VPLS) is a Layer 2 Virtual Private Network (VPN) that gives its customers the appearance that their sites are connected via a Local Area Network (LAN). It is often required for a Service Provider (SP) to give the customer redundant connectivity to one or more sites, often called "multi-homing". [\[RFC4761\]](#) explains how VPLS can be offered using BGP for auto-discovery and signaling; [section 3.5](#) of that document describes how multi-homing can be achieved in this context. [\[RFC6074\]](#) explains how VPLS can be offered using BGP for auto-discovery, (BGP-AD) and [\[RFC4762\]](#) explains how VPLS can be offered using LDP for signaling. This document provides a BGP-based multi-homing solution applicable to both BGP and LDP VPLS technologies. Note that BGP MH can be used for LDP VPLS without the use of the BGP-AD solution.

[Section 2](#) lays out some of the scenarios for multi-homing, other ways that this can be achieved, and some of the expectations of BGP-based multi-homing. [Section 3](#) defines the components of BGP-based multi-homing, and the procedures required to achieve this. [Section 7](#) may someday discuss security considerations.

1.1. General Terminology

Some general terminology is defined here; most is from [\[RFC4761\]](#), [\[RFC4762\]](#) or [\[RFC4364\]](#). Terminology specific to this memo is introduced as needed in later sections.

A "Customer Edge" (CE) device, typically located on customer premises, connects to a "Provider Edge" (PE) device, which is owned and operated by the SP. A "Provider" (P) device is also owned and operated by the SP, but has no direct customer connections. A "VPLS Edge" (VE) device is a PE that offers VPLS services.

A VPLS domain represents a bridging domain per customer. A Route Target community as described in [\[RFC4360\]](#) is typically used to identify all the PE routers participating in a particular VPLS domain. A VPLS site is a grouping of ports on a PE that belong to the same VPLS domain. A Multi-homed (MH) site is uniquely identified by a MH site ID (MH-ID). Sites are referred to as local

or remote depending on whether they are configured on the PE router in context or on one of the remote PE routers (network peers).

1.2. 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 [RFC-2119](#) [[RFC2119](#)].

2. Background

This section describes various scenarios where multi-homing may be required, and the implications thereof. It also describes some of the singular properties of VPLS multi-homing, and what that means from both an operational point of view and an implementation point of view. There are other approaches for providing multi-homing such as Spanning Tree Protocol, and this document specifies use of BGP for multi-homing. Comprehensive comparison among the approaches is outside the scope of this document.

2.1. Scenarios

CE1 is a VPLS CE that is dual-homed to both PE1 and PE2 for redundant connectivity.

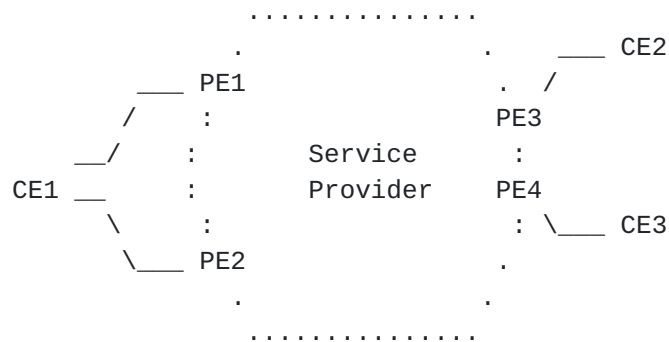


Figure 1: Scenario 1

CE1 is a VPLS CE that is dual-homed to both PE1 and PE2 for redundant connectivity. However, CE4, which is also in the same VPLS domain, is single-homed to just PE1.

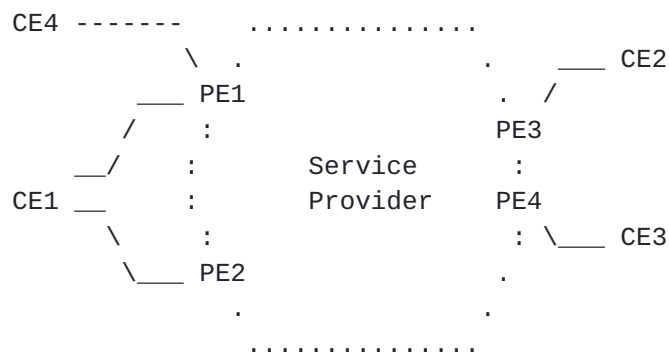


Figure 2: Scenario 2

2.2. VPLS Multi-homing Considerations

The first (perhaps obvious) fact about a multi-homed VPLS CE, such as CE1 in Figure 1 is that if CE1 is an Ethernet switch or bridge, a loop has been created in the customer VPLS. This is a dangerous situation for an Ethernet network, and the loop must be broken. Even if CE1 is a router, it will get duplicates every time a packet is flooded, which is clearly undesirable.

The next is that (unlike the case of IP-based multi-homing) only one of PE1 and PE2 can be actively sending traffic, either towards CE1 or into the SP cloud. That is to say, load balancing techniques will not work. All other PEs MUST choose the same designated forwarder for a multi-homed site. Call the PE that is chosen to send traffic to/from CE1 the "designated forwarder".

In Figure 2, CE1 and CE4 must be dealt with independently, since CE1 is dual-homed, but CE4 is not.

3. Multi-homing Operations

This section describes procedures for electing a designated forwarder among the set of PEs that are multi-homed to a customer site. The procedures described in this section are applicable to BGP based VPLS, LDP based VPLS with BGP-AD or a VPLS that contains a mix of both BGP and LDP signaled PWs.

3.1. Provisioning Model

Figure 1 shows a customer site, CE1, multi-homed to two VPLS PEs, PE1 and PE2. In order for all VPLS PEs within the same VPLS domain to elect one of the multi-homed PEs as the designated forwarder, an indicator that the PEs are multi-homed to the same customer site is required. This is achieved by assigning the same multi-homed site ID (MH-ID) on PE1 and PE2 for CE1. When remote VPLS PEs receive NLRI advertisement from PE1 and PE2 for CE1, the two NLRI advertisements for CE1 are identified as candidates for designated forwarder selection due to the same MH-ID. Thus, same MH-ID SHOULD be assigned on all VPLS PEs that are multi-homed to the same customer site. Note that a MH-ID=0 is invalid and a PE should discard such an advertisement.

3.2. Multi-homing NLRI

[Section 3.2.2 in \[RFC4761\]](#) describes the encoding of the BGP VPLS NLRI with the following fields: VE-ID, VE block offset, VE block size and label base. While this NLRI MAY be used for multi-homing, a modified version of it, as detailed in this paragraph, is used for identifying the multi-homed customers sites. The VE-ID field in the NLRI is set to MH-ID; the VE block offset, VE block size and label base are set to zero. Thus, the NLRI contains 2 octets indicating the length, 8 octets for Route Distinguisher, 2 octets for MH-ID and 7 octets with value zero.

Figure 2 shows two customer sites, CE1 and CE4, connected to PE1 with CE1 multi-homed to PE1 and PE2. CE4 does not require special addressing, being associated with the base VPLS instance identified by the VSI-ID for LDP VPLS and VE-ID for BGP VPLS. However, CE1 which is multi-homed to PE1 and PE2 requires configuration of MH-ID and both PE1 and PE2 MUST be provisioned with the same MH-ID for CE1. As stated above, to ensure backward capabilities, it is valid

to use BGP VPLS NLRI for multi-homing operations. As such, it is valid to have non-zero VE block offset, VE block size and label base in the VPLS NLRI for multi-homed site.

3.3. Designated Forwarder Election

BGP-based multi-homing for VPLS relies on Standard BGP best path selection and VPLS DF election. The net result of doing both elections is that of electing a single designated forwarder (DF) among the set of PEs to which a customer site is multi-homed. All the PEs that are elected as non-designated forwarders MUST keep their attachment circuit to the multi-homed CE in blocked status (no forwarding).

These election algorithms operate on VPLS advertisements, which include both the NLRI and attached BGP attributes. Given that semantics of BGP VPLS NLRI does not necessarily follow a standard IP Prefix form, a construct of advertisement (ADV) with the variables of interest is defined. The variables of interest are: RD, MH-ID, VBO, DOM, ACS, PREF and PE-ID, so the notation of:

$$\text{ADV} = \langle \text{RD}, \text{MH-ID}, \text{VBO}, \text{DOM}, \text{ACS}, \text{PREF}, \text{PE-ID} \rangle$$

The following sections describe two attributes needed for standard BGP best path selection and VPLS DF election, the variables derived from fields in VPLS advertisement ADV, and finally elaborate on the selection processes.

3.3.1. Attributes

The procedures below refer to two attributes: the Route Origin community (see [Section 4.1](#)) and the L2-info community (see [Section 4.2](#)). These attributes are required for inter-AS operation; for generality, the procedures below show how they are to be used. The procedures also outline how to handle the case that either or both are not present.

3.3.2. Variables Used

3.3.2.1. RD

RD is simply set to the Route Distinguisher field in the NLRI part of ADV. Actual process of assigning Route Distinguisher values must guarantee its uniqueness per PE node. Therefore, two multi-homed PEs offering the same VPLS service to a common set of CEs MUST allocate different RD values for this site respectively.

3.3.2.2. MH-ID

MH-ID is simply set to the VE-ID field in the NLRI part of ADV. The same MH-ID MUST be assigned to all PEs that are connected to the same multi-homed site.

3.3.2.3. VBO

VBO is simply set to the VE Block Offset field in the NLRI part of ADV. This field will typically be zero.

3.3.2.4. DOM

This variable, indicating the VPLS domain to which ADV belongs, is derived by applying BGP policy to the Route Target extended communities in ADV. The details of how this is done are outside the scope of this document.

3.3.2.5. ACS

ACS is the status of the attachment circuits for a given site of a VPLS. ACS = 1 if all attachment circuits for the site are down, and 0 otherwise.

For BGP-based Multi-homing, ADV MUST contain an L2-info extended community; within this community are control flags. One of these flags is the 'D' bit, described in [[I-D.kothari-l2vpn-auto-site-id](#)]. ACS is set to the value of the 'D' bit in ADV.

3.3.2.6. PREF

PREF is derived from the Local Preference (LP) attribute in ADV as well as the VPLS Preference field (VP) in the L2-info extended community. If the Local Preference attribute is missing, LP is set to 0; if the L2-info community is missing, VP is set to 0. The following table shows how PREF is computed from LP and VP.

VP Value	LP Value	PREF Value	Comment
0	0	0	malformed advertisement, unless ACS=1
0	1 to (2 ¹⁶ -1)	LP	backwards compatibility
0	2 ¹⁶ to (2 ³² -1)	(2 ¹⁶ -1)	backwards compatibility
>0	LP same as VP	VP	Implementation supports VP
>0	LP != VP	0	malformed advertisement

Table 1

3.3.2.7. PE-ID

If ADV contains a Route Origin (RO) community (see [Section 4.1](#)) with type 0x01, then PE-ID is set to the Global Administrator sub-field of the RO. Otherwise, if ADV has an ORIGINATOR_ID attribute, then PE-ID is set to the ORIGINATOR_ID. Otherwise, PE-ID is set to the BGP Identifier.

3.3.3. Election Procedures

The election procedures described in this section apply equally to BGP VPLS and LDP VPLS. Subset of these procedures documented in standard BGP best path selection deals with general IP Prefix BGP route selection processing as defined in [RFC 4271](#) and [RFC 4364](#). A separate part of the algorithm defined under VPLS DF election is very specific to designated forwarded election procedures performed on per VPLS instance bases. Given that the notion of VPLS advertisement is not commonly used destination IP Prefix, a concept of bucketization is introduced. By bucketizing advertisements and running them through two different sets of procedures based on variables of interest, we are effectively adopting common sets of route selection rules to the VPLS environment. A distinction MUST NOT be made on whether the NLRI is a multi-homing NLRI or not. Note that this is a conceptual description of the process; an implementation MAY choose to realize this differently as long as the semantics are preserved.

3.3.3.1. Bucketization and BGP Best Path Selection

From the advertisement

ADV -> <RD, MH-ID, VBO, ACS, PREF, PE-ID>

we select variables of interest that satisfy a notion of the same route as it is applicable to BGP election. As such, advertisements with the exact same RD, MH-ID and VBO are candidates for BGP Selection and put into BGP election bucket.

ADV -> <RD, MH-ID, VBO>

A standard set of BGP path selection rules, as defined in [RFC 4271](#) and 4264 is applied as tie-breaking mechanism. These tie-breaking rules are applied to candidate advertisements by a BGP speaker responsible for processing and redistribution of BGP VPLS and MH NLRI. If there is no winner and both ADVs are from the same PE, BGP path selection should simply consider this an update.

3.3.3.2. Bucketization and VPLS DF Election

An advertisement

ADV -> <RD, MH-ID, VB0, DOM, ACS, PREF, PE-ID>

is discarded if DOM is not of interest to the VPLS PE. Otherwise, ADV is put into the bucket for <DOM, MH-ID>. In other words, all advertisements for a particular VPLS domain that have the same MH-ID and common DOM are candidates for VPLS DF election. Tie breaking rules for VPLS DF election are different from standard BGP best path selection. As outlined in 3.3, the main reason for that is the fact that only single VPLS PE can be a designated forwarder for a given site. Tie-breaking rules for VPLS DF election are applied to candidate advertisements by all VPLS PEs and the actions taken by VPLS PEs based on the VPLS DF election result are described in [Section 3.4](#).

Given two advertisements ADV1 and ADV2 from a given bucket, first compute the variables needed for DF election:

ADV1 -> <RD1, MH-ID1, VB01, DOM1, ACS1, PREF1, PE-ID1>

ADV2 -> <RD2, MH-ID2, VB02, DOM2, ACS2, PREF2, PE-ID2>

Note that MH-ID1 = MH-ID2 and DOM1 = DOM2, since ADV1 and ADV2 came from the same bucket. Then the following tie-breaking rules MUST be applied in the given order.

1. if (ACS1 != 1) AND (ACS2 == 1) ADV1 wins; stop
if (ACS1 == 1) AND (ACS2 != 1) ADV2 wins; stop
else continue
2. if (PREF1 > PREF2) ADV1 wins; stop;
else if (PREF1 < PREF2) ADV2 wins; stop;
else continue
3. if (PE-ID1 < PE-ID2) ADV1 wins; stop;
else if (PE-ID1 > PE-ID2) ADV2 wins; stop;
else ADV1 and ADV2 are from the same VPLS PE

If there is no winner and ADV1 and ADV2 are from the same PE, a VPLS PE MUST retain both ADV1 and ADV2.

3.4. VPLS DF Election on PEs

DF election algorithm MUST be run by all multi-homed VPLS PEs. In addition, all other PEs SHOULD also run the DF election algorithm. As a result of the DF election, multi-homed PEs that lose the DF election for a MH-ID MUST put the ACs associated with the MH-ID in non-forwarding state. DF election result on the egress PEs can be used in traffic forwarding decision.

Figure 2 shows two customer sites, CE1 and CE4, connected to PE1 with CE1 multi-homed to PE1 and PE2. If PE1 is the designated forwarder for CE1, based on the DF election result, PE3 can chose to not send unknown unicast and multicast traffic to PE2 as PE2 is not the designated forwarder for any customer site and it has no other single homed sites connected to it.

3.5. Pseudowire binding and traffic forwarding rules

3.5.1. Site-ID Binding Properties

For the use case where a single PE provides connectivity to a set of CEs from which some are multi-homed and others are not, only single pseudowire MAY be established. For example, if PE1 provides VPLS service to CE1 and CE4 which are both part of the same VPLS domain, but different sites, and CE1 is multi-homed, but CE4 is not (as described in figure 2), PE3 would establish only single pseudowire toward PE1. A design needs to ensure that regardless of PE1's forwarding state in respect to DF or non-DF for multi-homed CE1, PE3's access to CE4 is established. Since label allocation and pseudowire established is tied to site-ID, we need to ensure that proper pseudowire bindings are established.

For set of given advertisements with the common DOM but with different Site-ID values, a VPLS PE speaker SHOULD instantiate and

bind the pseudowire based on advertisement with the lowest Site-ID value. Otherwise, binding would be completely random and during DF changes for multi-homed site, non-multi-homed CE might suffer traffic loss.

3.5.2. Standby Pseudowire Properties

As the notion of the convergence is addressed for transport plane by use of RSVP FRR and LDP LFA, it is evident that similar solution is required at the service level plane as well. This is most evident in large-scale deployments as it takes quite long time to converge. Ingress PE usually has to handle multiple relatively larger tasks and re-signal all pseudowires affected by egress PE or AC failure. Therefore, an implementation MAY choose to optimize the convergence by pre-signaling the second, standby, pseudowire toward non-DF end point for every active VPLS in 1:1 fashion. This greatly improves the convergence times. However, details of such implementation are still under research.

4. Multi-AS VPLS

This section describes multi-homing in an inter-AS context.

4.1. Route Origin Extended Community

Due to lack of information about the PEs that originate the VPLS NLRI in inter-AS operations, Route Origin Extended Community [[RFC4360](#)] is used to carry the source PE's IP address.

To use Route Origin Extended Community for carrying the originator VPLS PE's loopback address, the type field of the community MUST be set to 0x01 and the Global Administrator sub-field MUST be set to the PE's loopback IP address.

4.2. Preference

When multiple PEs are assigned the same site ID for multi-homing, it is often desired to be able to control the selection of a particular PE as the designated forwarder. [Section 3.5 in \[RFC4761\]](#) describes the use of BGP Local Preference in path selection to choose a particular NLRI, where Local Preference indicates the degree of preference for a particular VE. The use of Local Preference is inadequate when VPLS PEs are spread across multiple ASes as Local Preference is not carried across AS boundary. A new field, VPLS preference (VP), is introduced in this document that can be used to accomplish this. VPLS preference indicates a degree of preference for a particular customer site. VPLS preference is not mandatory for intra-AS operation; the algorithm explained in [Section 3.3](#) will work with or without the presence of VPLS preference.

[Section 3.2.4 in \[RFC4761\]](#) describes the Layer2 Info Extended Community that carries control information about the pseudowires. The last two octets that were reserved now carries VPLS preference as shown in Figure 3.

```

+-----+
| Extended community type (2 octets) |
+-----+
| Encaps Type (1 octet)              |
+-----+
| Control Flags (1 octet)             |
+-----+
| Layer-2 MTU (2 octet)               |
+-----+
| VPLS Preference (2 octets)         |
+-----+

```

Figure 3: Layer2 Info Extended Community

A VPLS preference is a 2-octets unsigned integer. A value of zero indicates absence of a VP and is not a valid preference value. This interpretation is required for backwards compatibility. Implementations using Layer2 Info Extended Community as described in ([Section 3.2.4](#)) [[RFC4761](#)] MUST set the last two octets as zero since it was a reserved field.

For backwards compatibility, if VPLS preference is used, then BGP Local Preference MUST be set to the value of VPLS preference. Note that a Local Preference value of zero for a MH-ID is not valid unless 'D' bit in the control flags is set (see [I-D.kothari-l2vpn-auto-site-id]). In addition, Local Preference value greater than or equal to 2^{16} for VPLS advertisements is not valid.

4.3. Use of BGP-MH attributes in Inter-AS Methods

[Section 3.4 in \[RFC4761\]](#) and [section 4 in \[RFC6074\]](#) describe three methods (a, b and c) to connect sites in a VPLS to PEs that are across multiple AS. Since VPLS advertisements in method (a) do not cross AS boundaries, multi-homing operations for method (a) remain exactly the same as they are within an AS. However, for method (b) and (c), VPLS advertisements do cross AS boundary. This section describes the VPLS operations for method (b) and method (c). Consider Figure 4 for inter-AS VPLS with multi-homed customer sites.

4.3.1. Inter-AS Method (b): EBGW Redistribution of VPLS Information between ASBRs

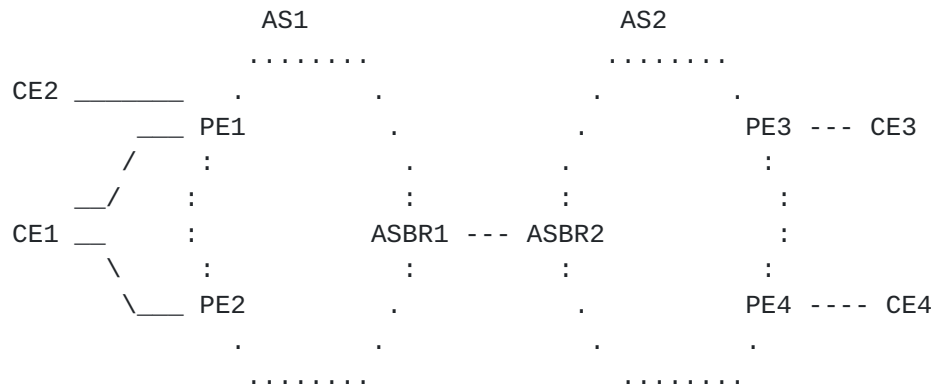


Figure 4: Inter-AS VPLS

A customer has four sites, CE1, CE2, CE3 and CE4. CE1 is multi-homed to PE1 and PE2 in AS1. CE2 is single-homed to PE1. CE3 and CE4 are also single homed to PE3 and PE4 respectively in AS2. Assume that in addition to the base LDP/BGP VPLS addressing (VSI-IDs/VE-IDs), MH ID 1 is assigned for CE1. After running DF election algorithm, all four VPLS PEs must elect the same designated forwarder for CE1 site. Since BGP Local Preference is not carried across AS boundary, VPLS preference as described in [Section 4.2](#) MUST be used for carrying site preference in inter-AS VPLS operations.

For Inter-AS method (b) ASBR1 will send a VPLS NLRI received from PE1 to ASBR2 with itself as the BGP nexthop. ASBR2 will send the received NLRI from ASBR1 to PE3 and PE4 with itself as the BGP nexthop. Since VPLS PEs use BGP Local Preference in DF election, for backwards compatibility, ASBR2 MUST set the Local Preference value in the VPLS advertisements it sends to PE3 and PE4 to the VPLS preference value contained in the VPLS advertisement it receives from ASBR1. ASBR1 MUST do the same for the NLRIs it sends to PE1

and PE2. If ASBR1 receives a VPLS advertisement without a valid VPLS preference from a PE within its AS, then ASBR1 MUST set the VPLS preference in the advertisements to the Local Preference value before sending it to ASBR2. Similarly, ASBR2 must do the same for advertisements without VPLS Preference it receives from PEs within its AS. Thus, in method (b), ASBRs MUST update the VPLS and Local Preference based on the advertisements they receive either from an ASBR or a PE within their AS.

In Figure 4, PE1 will send the VPLS advertisements with Route Origin Extended Community containing its loopback address. PE2 will do the same. Even though PE3 receives the VPLS advertisements for VE-ID 1 and 2 from the same BGP nexthop, ASBR2, the source PE address contained in the Route Origin Extended Community is different for the CE1 and CE2 advertisements, and thus, PE3 creates two PWs, one for CE1 (for VE-ID 1) and another one for CE2 (for VE-ID 2).

4.3.2. Inter-AS Method (c): Multi-Hop EBGp Redistribution of VPLS Information between ASes

In this method, there is a multi-hop E-BGP peering between the PEs or Route Reflectors in AS1 and the PEs or Route Reflectors in AS2. There is no VPLS state in either control or data plane on the ASBRs. The multi-homing operations on the PEs in this method are exactly the same as they are in intra-AS scenario. However, since Local Preference is not carried across AS boundary, the translation of LP to VP and vice versa MUST be done by RR, if RR is used to reflect VPLS advertisements to other ASes. This is exactly the same as what an ASBR does in case of method (b). A RR must set the VP to the LP value in an advertisement before sending it to other ASes and must set the LP to the VP value in an advertisement that it receives from other ASes before sending to the PEs within the AS.

5. MAC Flush Operations

In a service provider VPLS network, customer MAC learning is confined to PE devices and any intermediate nodes, such as a Route Reflector, do not have any state for MAC addresses.

Topology changes either in the service provider's network or in customer's network can result in the movement of MAC addresses from one PE device to another. Such events can result into traffic being dropped due to stale state of MAC addresses on the PE devices. Age out timers that clear the stale state will resume the traffic forwarding, but age out timers are typically in minutes, and convergence of the order of minutes can severely impact customer's service. To handle such events and expedite convergence of traffic, flushing of affected MAC addresses is highly desirable.

This section describes the scenarios where VPLS flush is desirable and the specific VPLS Flush TLVs that provide capability to flush the affected MAC addresses on the PE devices. All operations described in this section are in context of a particular VPLS domain and not across multiple VPLS domains. Mechanisms for MAC flush are described in [[I-D.kothari-l2vpn-vpls-flush](#)] for BGP based VPLS and in [[RFC4762](#)] for LDP based VPLS.

5.1. MAC List FLush

If multiple customer sites are connected to the same PE, PE1 as shown in Figure 2, and redundancy per site is desired when multi-homing procedures described in this document are in effect, then it is desirable to flush just the relevant MAC addresses from a particular site when the site connectivity is lost.

To flush particular set of MAC addresses, a PE SHOULD originate a flush message with MAC list that contains a list of MAC addresses that needs to be flushed. In Figure 2, if connectivity between CE1 and PE1 goes down and if PE1 was the designated forwarder for CE1, PE1 MAY send a list of MAC addresses that belong to CE1 to all its BGP peers.

It is RECOMMENDED that in case of excessive link flap of customer attachment circuit in a short duration, a PE should have a means to throttle advertisements of flush messages so that excessive flooding of such advertisements do not occur.

5.2. Implicit MAC Flush

Implicit MAC Flush refers to the use of BGP MH advertisements by the PEs to flush the MAC addresses learned from the previous designated forwarder.

In case of a failure, when connectivity to a customer site is lost, remote PEs learn that a particular site is no longer reachable. The local PE either withdraws the VPLS NLRI that it previously advertised for the site or it sends a BGP update message for the site's VPLS NLRI with the 'D' bit set. In such cases, the remote PEs can flush all the MACs that were learned from the PE which reported the failure.

However, in cases when a designated forwarder change occurs in absence of failures, such as when an attachment circuit comes up, the BGP MH advertisement from the PE reporting the change is not sufficient for MAC flush procedures. Consider the case in Figure 2 where PE1-CE1 link is non-operational and PE2 is the designated forwarder for CE1. Also assume that Local Preference of PE1 is higher than PE2. When PE1-CE1 link becomes operational, PE1 will send a BGP MH advertisement to all its peers. If PE3 elects PE1 as the new designated forwarder for CE1 and as a result flushes all the MACs learned from PE1 before PE2 elects itself as the non-designated forwarder, there is a chance that PE3 might learn MAC addresses from PE2 and as a result may black-hole traffic until those MAC addresses are deleted due to age out timers.

A new flag 'F' is introduced in the Control Flags Bit Vector as a deterministic way to indicate when to flush.

Control Flags Bit Vector

```

0 1 2 3 4 5 6 7
+---+---+---+---+
|D|A|F|Z|Z|Z|C|S| (Z = MUST Be Zero)
+---+---+---+---+

```

Figure 5

A designated forwarder must set the F bit and a non-designated forwarder must clear the F bit when sending BGP MH advertisements. A state transition from one to zero for the F bit can be used by a remote PE to flush all the MACs learned from the PE that is transitioning from designated forwarder to non-designated forwarder.

5.3. Minimizing the effects of fast link transitions

Certain failure scenarios may result in fast transitions of the link towards the multi-homing CE which in turn will generate fast status transitions of one or multiple multi-homed sites reflected through multiple BGP MH advertisements and LDP MAC Flush messages.

It is recommended that a timer to damp the link flaps be used for the port towards the multi-homed CE to minimize the number of MAC Flush events in the remote PEs and the occurrences of BGP state compressions for F bit transitions. A timer value more than the time it takes BGP to converge in the network is recommended.

6. Backwards Compatibility

No forwarding loops are formed when PEs or Route Reflectors that do not support procedures defined in this section co exist in the network with PEs or Route Reflectors that do support.

6.1. BGP based VPLS

As explained in this section, multi-homed PEs to the same customer site **MUST** assign the same MH-ID and related NLRI **SHOULD** contain the block offset, block size and label base as zero. Remote PEs that lack support of multi-homing operations specified in this document will fail to create any PWs for the multi-homed MH-IDs due to the label value of zero and thus, the multi-homing NLRI should have no impact on the operation of Remote PEs that lack support of multi-homing operations specified in this document.

6.2. LDP VPLS with BGP Auto-discovery

The BGP-AD NLRI has a prefix length of 12 containing only a 8 bytes RD and a 4 bytes VSI-ID. If a LDP VPLS PEs running BGP AD lacks support of multi-homing operations specified in this document, it **SHOULD** ignore a MH NLRI with the length field of 17. As a result it will not ask LDP to create any PWs for the multi-homed Site-ID and thus, the multi-homing NLRI should have no impact on LDP VPLS operation. MH PEs may use existing LDP MAC Flush to flush the remote LDP VPLS PEs or may use the implicit MAC Flush procedure.

7. Security Considerations

No new security issues are introduced beyond those that are described in [[RFC4761](#)] and [[RFC4762](#)].

8. IANA Considerations

At this time, this memo includes no request to IANA.

9. Acknowledgments

The authors would like to thank Ian Cowburn, Yakov Rekhter, Nischal Sheth, and Mitali Singh for their insightful comments and probing questions.

This document was prepared using 2-Word-v2.0.template.dot.

10. References

10.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC4761] Kompella, K. and Y. Rekhter, "Virtual Private LAN Service (VPLS) Using BGP for Auto-Discovery and Signaling", [RFC 4761](#), January 2007.
- [RFC6074] Rosen, E., "Provisioning, Autodiscovery, and Signaling in L2VPNs", [RFC 6074](#), January 2011.

10.2. Informative References

- [I-D.kothari-l2vpn-vpls-flush]
Kothari, B. and R. Fernando, "VPLS Flush in BGP-based Virtual Private LAN Service",
[draft-kothari-l2vpn-vpls-flush-00](#) (work in progress),
October 2008.
- [I-D.kothari-l2vpn-auto-site-id]
Kothari, B., Kompella, K., and T. IV, "Automatic Generation of Site IDs for Virtual Private LAN Service",
[draft-kothari-l2vpn-auto-site-id-01](#) (work in progress),
October 2008.
- [RFC4360] Sangli, S., Tappan, D., and Y. Rekhter, "BGP Extended Communities Attribute", [RFC 4360](#), February 2006.
- [RFC4364] Rosen, E. and Y. Rekhter, "BGP/MPLS IP Virtual Private Networks (VPNs)", [RFC 4364](#), February 2006.
- [RFC4456] Bates, T., Chen, E., and R. Chandra, "BGP Route Reflection: An Alternative to Full Mesh Internal BGP (IBGP)", [RFC 4456](#), April 2006.

- [RFC4762] Lasserre, M. and V. Kompella, "Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling", [RFC 4762](#), January 2007.
- [RFC4271] Rekhter, Y., Li, T., and S. Hares, "A Border Gateway Protocol 4 (BGP-4)", [RFC 4271](#), January 2006.

Authors' Addresses

Bhupesh Kothari
Cohere Networks
Email: bhupesh@cohere.net

Kireeti Kompella
Contrail Systems
Email: kireeti.kompella@gmail.com

Wim Henderickx
Alcatel-Lucent
Email: wim.henderickx@alcatel-lucent.be

Florin Balus
Alcatel-Lucent
Email: florin.balus@alcatel-lucent.com

Senad Palislaamovic
Alcatel-Lucent
Email: senad.palislaamovic@alcatel-lucent.com

James Uttaro
AT&T
200 S. Laurel Avenue
Middletown, NJ 07748, US
Email: uttaro@att.com

Wen Lin
Juniper Networks
Email: wlin@juniper.net