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Inter-AS Option D for BGP/MPLS IP VPN
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Abstract

This document describes a new option known as an Inter-AS option D to the 'Multi-AS Backbones' section of [[RFC4364](#)]. This option combines VPN VRFs at the Autonomous System Border Router (ASBR) as described in 'Option A' with the distribution of labeled VPN-IP routes as described in 'Option B'. In addition, this option allows for a data plane consisting of two methods of traffic forwarding between attached ASBR pairs.

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1. Introduction

MPLS VPN providers often need to inter-connect different ASes to provide VPN services to customers. This requires the setting up of Inter-AS connections at ASBRs. The inter-AS connections may or may not be between different providers. The mechanisms to set up inter-as connections are described in [\[RFC4364\]](#). Of particular interest for this draft are the ones documented in [section 10 of \[RFC4364\]](#).

For the option described in [section 10](#), part (a) of [\[RFC4364\]](#), commonly referred to as Option A, peering ASBRs are connected by multiple sub-interfaces, with at least one interface for each VPN that spans the two ASes. Each ASBR acts as a PE, and thinks that the other ASBR is a CE. The ASBRs associate each sub-interface with a VRF and a BGP session is established per sub-interface to signal IP (unlabeled) prefixes. As a result, traffic within the VPN VRFs is IP. The advantage of this option is that the VPNs are isolated from each other and since the traffic is IP, QoS mechanisms that operate on IP traffic can be applied to achieve customer SLAs. The drawback of this option is that there needs to be one BGP session per sub-interface (and at least one sub-interface per VPN), which can be a potential scalability concern if there are a large number of VRFs.

For the option described in [section 10](#), part (b) of [\[RFC4364\]](#), commonly referred to as Option B, peering ASBRs are connected by one or more sub-interfaces that are enabled to receive MPLS traffic. An MP-BGP session is used to distribute the labeled VPN prefixes between the ASBRs. Therefore, the traffic that flows between them is labeled. The advantage of this option is that it's more scalable, as there is no need to have one sub-interface and BGP session per VPN. The drawback of this option is that QoS mechanisms that can only be applied to IP traffic cannot be used as the traffic is MPLS. There is also no isolation between the VRFs.

The solution described in this draft aims to address the scalability concerns of Option A by using a single BGP session to signal VPN prefixes. In this solution, the forwarding connections between the ASBRs are maintained on a per-VRF basis, while the control plane information is exchanged using a single MP-BGP session.

If the solution is used between any attached ASBR pairs belonging to separate Autonomous Systems (AS), then VRF based route filtering policies via RTs is achieved directly between ASBR pairs, independent of PE based RT filtering within an AS.

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. Scope

The Inter-AS VPN option described in this draft is applicable to both, the IPv4 VPN services described in [[RFC4364](#)] and the IPv6 VPN services defined in [VPN-IPv6]. It is NOT applicable to MVPN IPv4 and MVPN IPv6 services defined in [[RFC6513](#)]. Support of existing 'Multi-AS' options, along with the new techniques are beyond the scope of this document.

3. Inter-AS Option D Reference Model

Figure 1 shows an arbitrary Multi-AS VPN interconnectivity scenario between Customer Edge routers. CE1 and CE3, interconnected by Service Providers SP1 and SP2, belong to the same VPN, say Red. CE2 and CE4 belong to a different VPN, say Green. This example shows 3 interfaces ('red', 'white' and 'green') between ASBR1 (belonging to SP1) and ASBR2 (belonging to SP2).

Interface 'red' is a VRF attachment circuit associated to VRF1 (on ASBR1 and ASBR2) for VPN Red and is used to transport labeled or native IP VPN traffic between VRF pairs. Similarly, interface 'green' is a VRF attachment circuit associated to VRF2 (on ASBR1 and ASBR2) for VPN Green and is used to transport labeled or native IP VPN traffic between VRF pairs. Interface 'white' is not associated with any VRF instances i.e. this interface is 'global' in nature (in the context of the connected ASes) and carries as a minimum all ASBR exported VPN-IP routing updates.

We shall use the term "private interface forwarding" to describe the model where packets for the "Red" VPN are forwarded on the "red" interface, while packets belonging to "Green" VPN are forwarded on the "green" interface. There are no BGP sessions running on the "red" and "green" interfaces; rather the 'white' interface carries all ASBR VPN-IP routing updates exported from VRF pairs. We shall use the term "shared interface forwarding" to describe the model where the "white" interface will be used to forward all the traffic between the ASBRs. For shared interface forwarding outside of a VRF context, interfaces 'red' and 'green' are not required. In addition to carrying all ASBR VPN-IP routing updates, interface 'white' transports labeled IP VPN traffic or native IP traffic. IP VPN

packets entering or leaving the ASBR via this interface may be forwarded using normal MPLS mechanisms (e.g. through use of the LFIB) or through a lookup within a VRF that has been identified via MPLS label values.

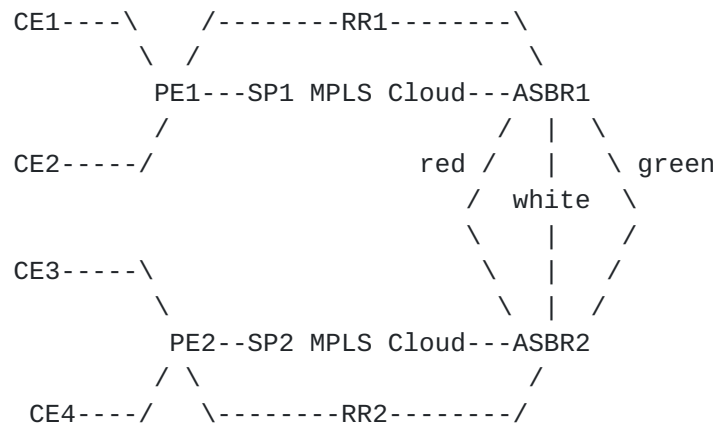


Figure 1

In the diagram above:

1. CE1 and CE3 belong to VPN Red.
2. CE2 and CE4 belong to VPN Green.
3. PE1 uses RDs RD-red1 and RD-green1 for VPN Red (VRF Red) and VPN Green (VRF Green) respectively.
4. PE2 uses RDs RD-red2 and RD-green2 for VPN Red (VRF Red) and VPN Green (VRF Green) respectively.
5. ASBR1 has VRFs Red and Green provisioned with RD-red3 and RD-green3 respectively.
6. ASBR2 has VRFs Red and Green provisioned with RD-red4 and RD-green4 respectively.
7. There are 3 interfaces between ASBR1 and ASBR2.
8. On each ASBR, one interface is associated with VRF Red and one with VRF Green. These are the interfaces marked "red" and "green" respectively.
9. There is a third interface over which there is an MP-BGP session

between the ASBRs. This is the interface marked "white".

10. VPN route importing is achieved by configuring the appropriate RTs.

11. The PE and ASBR routers in each AS peer with a route-reflector in that AS.

The following sections describe in detail the different modes of operation for Option D.

4. Private Interface Operation without Carrier's Carrier (CSC)

This section describes how route distribution and packet forwarding takes place when using the private interface forwarding option without the use of CSC, ie. the traffic sent between the private interfaces is unencapsulated.

Route Distribution:

[The following description is for VPN Red, but Route Distribution for VPN Green is exactly analogous to this]

1. CE1 advertises a prefix N to PE1.
2. PE1 advertises a VPN prefix RD-red1:N to RR1, which in turn advertises it to ASBR1 via iBGP.
3. ASBR1 imports the prefix into VPN Red and creates a prefix RD-red3:N.
4. ASBR1 advertises the imported prefix RD-red3:N to ASBR2. It sets itself as the next-hop for this prefix and also allocates a local label that is signaled with the prefix.
5. By default, ASBR1 does not advertise the source prefix RD-red1:N to ASBR2. This advertisement is suppressed as the prefix is being imported into an Option D VRF.
6. ASBR2 receives the prefix RD-red3:N and imports it into VPN Red as RD-red4:N.
7. While installing the prefix into the VRF Red RIB table, ASBR2 sets the nexthop of RD-red4:N to ASBR1's interface address in VRF Red. The routing context for this entry is also set to that of VRF Red.
8. While installing the MPLS forwarding entry for RD-red4:N, by

default, the label that was advertised by ASBR1 for the prefix is not installed in the Forwarding Information Base. This enables the traffic between the ASBRs to be IP.

9. ASBR2 advertises the imported prefix RD-Red4:N to RR2, which in turn advertises it to PE2. It sets itself as the next-hop for this prefix and also allocates a local label that is signaled as part of the VPN-IP NLRI.

10. By default, ASBR2 does not advertise the source prefix RD5:N to PE2. This advertisement is suppressed.

11. PE2 imports the RD-red4:N into VRF Red as RD-red2:N.

Packet Forwarding

The packet forwarding would work just as it would in an Option A scenario:

1. CE3 sends a packet destined for N to PE2.
2. PE2 encapsulates the packet with the VPN label allocated by ASBR2 and the IGP label (if any) needed to tunnel the packet to ASBR2.
3. The packet arrives on ASBR2 with the VPN Label, ASBR2 pops the VPN Label and sends the packet as IP to ASBR1 on the "red" interface.
4. The IP packet arrives at ASBR1 on the "red" interface. ASBR1 then encapsulates the packet with the VPN Label allocated by PE1 and the IGP label needed to tunnel the packet to PE1.
5. The packet arrives on PE1 with the VPN label; PE1 disposes the VPN label and forwards the IP packet to CE1.

5. Private Interface Forwarding with CSC

Let's assume that VPN Red is used to provide VPN service to its customer carrier who in turn provides a VPN service to a customer. This implies that VPN RED is used to provide an LSP between the PE (PE3 and PE4) loopbacks of the baby carrier in the following topology:

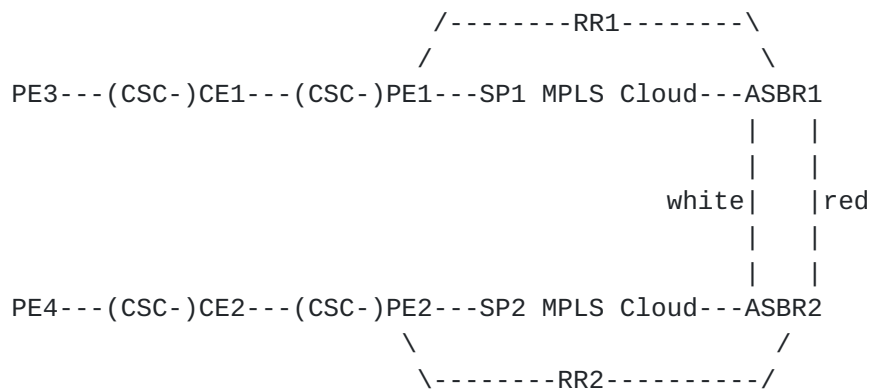


Figure 2

Thus, let's assume that in the diagram above:

1. CSC-PE1 uses RD RD-red1 for VPN Red (VRF Red).
2. CSC-PE2 uses RD RD-red2 for VPN Red (VRF Red).
3. ASBR1 has VRF Red provisioned with RD-red3.
4. ASBR2 has VRF Red provisioned with RD-red4.
5. There are 2 interfaces between ASBR1 and ASBR2.
6. On each ASBR, one interface is associated with VRF Red. This is the interface marked "red" in the Figure 2.
7. There is a second interface over which there is an MP-BGP session between the ASBRs. This interface is in the global context and is marked "white" in the figure.

Route Distribution:

1. CSC-CE1 advertises PE3s loopback N to PE1.
2. CSC-PE1 advertises a VPN prefix RD-red1:N to RR1, which advertises it to ASBR1 via MP-iBGP.
3. ASBR1 imports the prefix into VPN Red and creates a prefix RD-red3:N.
4. ASBR1 advertises the imported prefix RD-red3:N to ASBR2. It sets itself as the next-hop for this prefix and also allocates a local label that is signaled as part of the VPN-IP NLRI.
5. By default, ASBR1 does not advertise the source prefix RD-red1:N

to ASBR2. This advertisement is suppressed as the prefix is being imported into an Option D VRF.

6. ASBR2 receives the prefix RD-red3:N and imports it into VPN Red as RD-red4:N.
7. While installing the prefix into the VRF Red RIB table, ASBR2 sets the nexthop of RD-red4:N to ASBR1s interface address in VRF Red. The nexthop routing context is also set to that of VRF Red.
8. While installing the MPLS forwarding entry for RD-red4:N, the outgoing label is installed in forwarding. This enables the traffic between the ASBRs to be MPLS.
9. ASBR2 advertises the imported prefix RD-red4:N to RR2, which advertises it to CSC-PE2. It sets itself as the next-hop for this prefix and also allocates a local label that is signaled as part of the VPN-IP NLRI.
10. By default, ASBR2 does not advertise the source prefix RD-red4:N to PE2. This advertisement is suppressed.
11. PE2 imports the RD-red4:N into VRF Red as RD-red2:N.

Packet Forwarding:

1. PE4 sends a MPLS packet destined for N to CSC-CE2.
2. CSC-CE2 swaps the MPLS label and sends a packet destined for N to CSC-PE2.
3. CSC-PE2 encapsulates the packet with the VPN label allocated by ASBR2 and the IGP label needed (if any) to tunnel the packet to ASBR2.
4. The packet arrives on ASBR2 with the VPN Label, ASBR2 swaps the received VPN label with the outgoing label received from ASBR1 and sends the MPLS packet on to the VRF Red interface.
5. The MPLS packet arrives at ASBR1 on the VRF red interface, ASBR1 then swaps the received MPLS label with a label stack consisting of the VPN Label allocated by PE1 and the IGP label needed to tunnel the packet to CSC-PE1.
6. The packet arrives on CSC-PE1 with the VPN label; PE1 disposes the VPN label and forwards the MPLS packet to CSC-CE1.
7. CSC-CE1 in turn swaps the label and forwards the labeled packet

to PE3.

6. Shared Interface Forwarding

This section describes how route distribution and packet forwarding takes place when using the shared interface forwarding option. The topology is the same as in Figure 1.

Route Distribution (VPN Red):

1. CE1 advertises a prefix N to PE1.
2. PE1 advertises a VPN prefix RD-red1:N to RR1, which advertises it to ASBR1 via iBGP.
3. ASBR1 imports the prefix into VPN Red and creates a prefix RD-red3:N
4. ASBR1 advertises the imported prefix RD-red3:N to ASBR2. It sets itself as the next-hop for this prefix and also allocates a local label that is signaled with the prefix.
5. By default, ASBR1 does not advertise the source prefix RD-red1:N to ASBR2. This advertisement is suppressed as the prefix is being imported into an Option D VRF.
6. ASBR2 receives the prefix RD-red3:N and imports it into VPN Red as RD-red4:N
7. While installing the prefix into the VRF Red RIB table, ASBR2 retains the nexthop of RD-red4:N as received in the BGP update from ASBR1. This is the address of ASBR1's shared interface address in the global table. The nexthop routing context is also left unchanged and corresponds to that of the global table.
8. While installing the MPLS forwarding entry for RD-red4:N, the outgoing label is installed in forwarding. This enables the traffic between the ASBRs to be MPLS.
9. ASBR2 advertises the imported prefix RD-red4:N to RR2, which advertises it to PE2. It sets itself as the next-hop for this prefix and also allocates a local label that is signaled as part of the VPN-IP NLRI.
10. By default, ASBR2 does not advertise the source prefix RD-red4:N to PE2. This advertisement is suppressed.

11. PE2 imports the RD-red4:N into VRF Red as RD-red2:N.

Packet Forwarding:

The packet forwarding would work just as it would in an Option B scenario:

1. CE3 sends a packet destined for N to PE2.
2. PE2 encapsulates the packet with the VPN label allocated by ASBR2 and the IGP label needed to tunnel the packet to ASBR2.
3. The packet arrives on ASBR2 with the VPN Label. ASBR2 swaps the received VPN label with the outgoing label received from ASBR1 and sends the MPLS packet on to the global shared link interface.
4. The MPLS packet arrives at ASBR1 on the global shared link interface. ASBR1 then swaps the received MPLS label with a label stack consisting of the VPN Label allocated by PE1 and the IGP label needed to tunnel the packet to PE1.
5. The packet arrives on PE1 with the VPN label; PE1 disposes the VPN label and forwards the IP packet to CE1.

7. Route Advertisement to External BGP Peers

ASBR1 (refer Figure 1) does route advertisement and VPN route processing using the standard BGP-VPN rules. It processes the VRF Red RT extended community attributes and learns the label bindings associated with routes for VPN Red. VPN-IP routes are imported into VRF Red's Routing Information Base (RIB) where their RT and RD attributes, assigned by PE1 are removed.

ASBR1 VPN-IP routes are not advertised to RR1 as the original routes applicable to VPN Red sourced by PE1 were received from an internal BGP peer. Any installed routes that are not imported into VRF1 RIB MAY be advertised to external BGP peers using the existing [[RFC4364](#)] Multi-AS "Option B" techniques. Dependant on which packet forwarding method is used, routes are then exported from VRFs and advertised from ASBR1 to ASBR2 as described in the following sections.

7.1. Route Advertisement - Private interface forwarding

VPN-IP prefixes are advertised from ASBR1 to ASBR2 via a BGP session that is in the global routing table context. This implies that the advertised next-hop address is also reachable via the global routing table context. In order to force traffic to be forwarded via an

interface 'red' that is in a VRF routing table context, VRF forwarding entries need to be installed using a next-hop address that is in VRF Red's (which resides on ASBR2) routing context. The address of the next-hop could be the same as the global table address of the remote ASBR (in this case ASBR1), although this would require that the same IP address be used across all VRF attachment circuits linking ASBR pairs.

Alternatively, if a Service Provider needs to number the VRF interfaces differently from the global table VPN session, a configuration method SHOULD be available so as to map the corresponding global table VPNv4 neighbor address to an IP address reachable in the given VRF.

ASBR1 exports routes associated to VPN Red from VRF Red's RIB to BGP where RD and RT attributes, plus label bindings are attached to these routes. These labeled VPN-IP routes are advertised across interface 'red' to ASBR2 via BGP, with a label value set to implicit-null and the 'S' bit set. The routes next-hop addresses is set either to ASBR1 (usually interface 'red') or an address reachable via interface 'red'. ASBR2 imports the VRF Red's exported routes into VRF Red's RIB where the routes RT and RD attributes are removed. The next-hop of the imported routes is either set via a policy or left unchanged to an address in VRF Red's routing context. ASBR2 exports routes from VRF Red's RIB to BGP and attaches RT and RD attributes, as configured at VRF Red plus label bindings. Labeled VPN-IP routes are now advertised to PE2 via RR2 and so on. ASBR2 sets itself as the nexthop for these routes and allocates a local label. As an optimization to conserve label space, ASBR2 MAY allocate a per-VRF aggregate label as the local label while advertising the routes to iBGP peers.

7.2. Route Advertisement - Shared interface forwarding

ASBR1 exports routes associated to VPN Red from VRF Red's RIB to BGP where RD and RT attributes, plus label bindings are attached to these routes. These labeled VPN-IP routes are advertised across interface 'white' to ASBR2 via BGP, with a next-hop set to ASBR1. ASBR2 imports the VRF Red exported routes into (its local) VRF Red RIB where the routes RT and RD attributes are removed. The imported routes next-hop is set to ASBR1, available via interface 'white'. ASBR2 exports routes from VRF Red's RIB to BGP and attaches RT and RD attributes, as configured at VRF Red plus label bindings. Labeled VPN-IP routes are now advertised to PE2 via RR2 and so on.

7.3. Route Advertisement to Internal BGP Peers

All the received VPN-IP routes from an adjacent ASBR are imported into local VRFs on the receiving ASBR. The receiving ASBR needs to advertise these routes to its local IBGP sessions. The next-hop for these routes SHOULD be set to itself when the local ASBR advertises these routes to its IBGP sessions.

8. Option D Operation Requirements

8.1. Inter-AS IP VPN Route Distribution

Routes received from internal or external peers that are imported into ASBR VRFs SHOULD NOT be readvertised to any BGP neighbors. Routes that are not imported into VRFs but are installed in the ASBR's global routing table MAY be readvertised using existing Option 'B' techniques as described in the Multi-AS section of [[RFC4364](#)]. The ASBR MUST be equipped with RT based filtering mechanisms that explicitly permit all or a subset of such RT values to be readvertised to its neighbors.

VPN-IP routes that are converted by the ASBR MUST NOT be readvertised to the source peer of the route. It SHOULD be possible to remove/manipulate individual RT values when advertising routes on a per neighbor basis. This is useful where the SP wants to separate RT values advertised to EBGp peers from RT values advertised to IBGP peers.

8.2. Private Interface Forwarding Route Distribution

For private interface forwarding, labeled VPN-IP routes advertised from ASBR to ASBR MUST have their next-hop set to an address within a VRF RIB. This address will usually be the VRF attachment circuit interface.

If the Service Provider needs to number the VRF interfaces differently from the global table VPNv4 neighbor, a configuration method SHOULD be available so as to map the corresponding global table VPNv4 neighbor address to an IP address reachable in the given VRF. This route mapping policy SHOULD be configurable on both outbound and inbound peers.

8.3. Shared interface forwarding Route Distribution

For shared interface forwarding outside of a VRF context, the next-hop must be a 'global' (non VRF RIB) address on an ASBR. This address will usually be the interface linking ASBR pairs.

9. Inter-AS Quality of Service for Option D

It SHOULD be possible for the ASBR as a DS boundary node [DS-ARCH] operating traffic classification and conditioning functions to match on ingress and egress a combination of application (TCP, UDP port, RTP session, data pattern etc), IP Source Address, IP Destination Address or DS field per packet, per VRF or per VRF attachment circuit (in the case of private interface forwarding).

Once matched, the packets Layer-2 header (if applicable), IP DSCP and MPLS EXP bits or combinations of the above should be capable of being re-marked, and optionally shaped per traffic stream, depending on the DS domain's Traffic Conditioning Agreement (TCA). This will assist where different DS domains have different TCA rules.

For Private interface forwarding, the ASBR should be capable of forwarding explicit null labeled MPLS packets across VRF attachment circuits. This SHOULD assist with a pipe mode [DIFF-TUNNEL] operation of traffic conditioning behavior at the ASBR. MPLS based forwarding between attached ASBRs inherently should have these mechanisms built in.

10. Security Considerations

This document doesn't not alter the underlying security properties of BGP based VPNs. In particular, the the private interface forwarding using a new Multi-AS option defined in this document has same security implications as Multi-AS option 'a' of [RFC4364]. The global interface forwarding using a new Multi-AS option defined in this document is outside the scope of this document.

This document doesn't not alter the underlying security properties of BGP based VPNs for the shared interface forwarding using the new Multi-AS option. The security implications for this mechanism are same as Multi-AS option 'b' of [RFC4364].

11. Acknowledgements

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