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### **IPv6-Only PE Design for IPv4-NLRI with IPv6-NH**

#### **Abstract**

As Enterprises and Service Providers upgrade their brown field or green field MPLS/SR core to an IPv6 transport, Multiprotocol BGP (MP-BGP) now plays an important role in the transition of their Provider (P) core network as well as Provider Edge (PE) Edge network from IPv4 to IPv6. Operators must be able to continue to support IPv4 customers when both the Core and Edge networks are IPv6-Only.

This document details an important External BGP (eBGP) PE-CE Edge and Inter-AS IPv6-Only peering design that leverages the MP-BGP capability exchange by using IPv6 peering as pure transport, allowing both IPv4 Network Layer Reachability Information (NLRI) and IPv6 Network Layer Reachability Information (NLRI) to be carried over the same (Border Gateway Protocol) BGP TCP session. The design change provides the same Dual Stacking functionality that exists today with separate IPv4 and IPv6 BGP sessions as we have today. With this design change from a control plane perspective a single IPv6 is required for both IPv4 and IPv6 routing updates and from a data plane forwarding perspective an IPv6 address need only be configured on the PE and CE interface for both IPv4 and IPv6 packet forwarding.

This document provides a much needed solution for Internet Exchange Point (IXP) that are facing IPv4 address depletion at large peering points. With this design, IXP can now deploy PE-CE IPv6-Only eBGP Edge or Inter-AS peering design to eliminate IPv4 provisioning at the Edge. This core and edge IPv6-Only peering design paradigm change can apply to any eBGP peering, public internet or private, which can be either Core networks, Data Center networks, Access networks or can be any eBGP peering scenario. This document provides vendor specific test cases for the IPv6-Only peering design as well as test results for the five major vendors stakeholders in the routing and switching industry, Cisco, Juniper, Arista, Nokia and

Huawei. With the test results provided for the IPv6-Only Edge peering design, the goal is that all other vendors around the world that have not been tested will begin to adopt and implement this new Best Current Practice for eBGP IPv6-Only Edge peering.

As this issue with IXP IPv4 address depletion is a critical issue around the world, it is imperative for an immediate solution that can be implemented quickly. This Best Current Practice IPv6-only eBGP peering design specification will help proliferate IPv6-Only deployments at the eBGP Edge network peering points to starting immediately at a minimum with operators around the world using Cisco, Juniper, Arista, Nokia and Huawei. As other vendors start to implement this Best Current Practice, the IXP IPv4 address depletion gap will eventually be eliminated.

### **Status of This Memo**

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## 1. Introduction

As Enterprises and Service Providers upgrade their brown field or green field MPLS/SR core to an IPv6 transport such as MPLS LDPv6, SR-MPLSv6 or SRv6, Multiprotocol BGP (MP-BGP) now plays an important role in the transition of the Provider (P) core networks and Provider Edge (PE) edge networks from IPv4 to IPv6. Operators have a requirement to support IPv4 customers and must be able to support IPv4 address family and Sub-Address-Family Virtual Private Network (VPN)-IPv4, and Multicast VPN IPv4 customers.

IXP are also facing IPv4 address depletion at their peering points, which are large Layer 2 transit backbones that service providers peer and exchange IPv4 and IPv6 Network Layer Reachability Information (NLRI). Today, these transit exchange points are Dual Stacked. With this IPv6-only BGP peering design, only IPv6 is configured on the PE-CE interface, the Provider Edge (PE) - Customer Edge (CE), or Inter-AS ASBR (Autonomous System Boundary Router) to ASBR (Autonomous System Boundary Router) PE-PE Provider Edge (PE) - Provider Edge (PE), the IPv6 BGP peer is now used to carry IPv4 (Network Layer Reachability Information) NLRI over an IPv6 next hop using IPv6 next hop encoding defined in [RFC8950], while continuing to forward both IPv4 and IPv6 packets. In the framework of this design the PE is no longer Dual Stacked. However in the case of the CE, PE-CE link CE side of the link is no longer Dual Stacked, however all other internal links within the CE domain may or maynot be Dual stacked. In the Inter-AS case the ASBR-ASBR PE-PE peering all peerings would be now IPv6-Only for all Inter-AS options Peering Option-A, Option-B, Option-AB and Option-C per [RFC4364]. We now refer to this PE as an "IPv6-Only PE" using the IPv6-Only PE Design framework.

MP-BGP specifies that the set of usable next-hop address families is determined by the Address Family Identifier (AFI) and the Subsequent Address Family Identifier (SAFI). Historically the AFI/SAFI definitions for the IPv4 address family only have provisions for advertising a Next Hop address that belongs to the IPv4 protocol when advertising IPv4 or VPN-IPv4. [RFC8950] specifies the extensions necessary to allow advertising IPv4 NLRI, Virtual Private Network Unicast (VPN-IPv4) NLRI, Multicast Virtual Private Network (MVPN-IPv4) NLRI with a Next Hop address that belongs to the IPv6 protocol. This comprises of an extended next hop encoding MP-REACH BGP capability exchange to allow the address of the Next Hop for IPv4 NLRI, VPN-IPv4 NLRI and MVPN-IPv4 NLRI to also belong to the IPv6 Protocol. [RFC8950] defines the encoding of the Next Hop to determine which of the protocols the address actually belongs to, and a new BGP Capability allowing MP-BGP Peers to discover dynamically whether they can exchange IPv4 NLRI and VPN-IPv4 NLRI with an IPv6 Next Hop.

The current specification for carrying IPv4 NLRI of a given address family via a Next Hop of a different address family is now defined in [RFC8950], and specifies the extended next hop encoding MP-REACH capability extension necessary to do so. This comprises an extension of the AFI/SAFI definitions to allow the address of the Next Hop for IPv4 NLRI or VPN-IPv4 NLRI to belong to either the IPv4 or the IPv6 protocol, the encoding of the Next Hop information to determine which of the protocols the address belongs to, and a new BGP Capability allowing MP-BGP peers to dynamically discover whether they can exchange IPv4 NLRI and VPN- IPv4 NLRI with an IPv6 Next Hop.

With the new extensions defined in [RFC8950] supporting NLRI and next hop address family mismatch, the BGP peer session can now be treated as a pure TCP transport and carry both IPv4 and IPv6 NLRI at the Provider Edge (PE) - Customer Edge (CE) or Inter-AS ASBR to ASBR PE-PE over a single IPv6 TCP session. This allows for the elimination of dual stack from the PE-CE and Inter-AS ASBR-ASBR PE-PE peering point, and now enable the peering to be IPv6-ONLY. The elimination of IPv4 on the PE-CE and Inter-AS ASBR-ASBR PE-PE peering points translates into OPEX expenditure savings of point-to-point infrastructure links as well as /31 address space savings and administration and network management of both IPv4 and IPv6 BGP peers. This reduction decreases the number of PE-CE BGP peers by fifty percent, which is a tremendous cost savings for operators.

While the savings exists at the Edge eBGP PE-CE peering, on the core side PE to Route Reflector (RR) peering carrying <AFI/SAFI> IPv4 <1/1>, VPN-IPV4 <1/128>, and Multicasat VPN <1/129>, there is no savings as the Provider (P) Core is IPv6 Only and thus can only have an IPv6 peer and must use [RFC8950] extended next hop encoding to carrying IPv4 NLRI IPv4 <2/1>, VPN-IPV4 <2/128>, and Multicasat VPN <2/129> over an IPv6 next hop.

This IPv6-Only PE design is applicable to both PE-CE Edge over a IPv4-Only Core, IPv6-Only Core as well as Global table or VPN overlay scenario as well as all Inter-AS Options Option-A, Option-B, Option-AB and Option-C The following Address Family (AFI) / Subsequent Address Family (SAFI) will be tested with both IPv4-Only Core, IPv6-Only Core and Global Routing Table (GRT) and IP Virtual Private Network (VPN) [RFC4364]. <AFI/SAFI> IPv4 <1/1>, VPN-IPV4 <1/128>, and Multicasat VPN <1/129>.

This document provides a much needed solution for Internet Exchange Point (IXP) that are facing IPv4 address depletion at large peering points. With this design, IXP can now use deploy PE-CE IPv6-Only eBGP Edge and Inter-AS peering design to eliminate IPv4 provisioning at the PE Edge as well as PE Inter-AS. This core and edge IPv6-Only peering design paradigm change can apply to any eBGP peering, public

internet or private, which can be either Core networks, Data Center networks, Access networks or can be any eBGP peering scenario. This document provides detailed vendor specific test cases and test results for the IPv6-Only peering design as well as successful test results between five major vendors stakeholders in the routing and switching industry, Cisco, Juniper, Arista, Nokia and Huawei. With the test results provided for the IPv6-Only Edge peering design, the goal is that all other vendors around the world that have not been tested will begin to adopt and implement this new best practice for eBGP IPv6-Only Edge peering. This will give confidence to operators to start the proliferation of this IPv6-Only PE design.

As this issue with IXP address depletion is a critical issue around the world, it is imperative for an immediate solution that can be implemented quickly. This best practice IPv6-only eBGP peering design specification will help proliferate IPv6-Only deployments at the eBGP Edge and Inter-AS network peering points starting immediately at a minimum with operators around the world using Cisco, Juniper, Arista, Nokia and Huawei.

## **2. Requirements Language**

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

## **3. Terminology**

Terminology used in defining the IPv6-Only Edge specification.

AFBR: Address Family Border Router Provider Edge (PE).

Edge: PE-CE Edge Network Provider Edge - Customer Edge

Core: P Core Network Provider (P)

4to6 Softwire : IPv4 edge over an IPv6-Only core

6to4 Softwire: IPv6 edge over an IPv4-Only core

E2E: End to End

## **4. IPv6-Only Edge Peering Architecture**

### **4.1. Problem Statement**

This specification addresses a real world issue that has been discussed at many operator groups around the world related to IXP

major peering points where hundreds of AS's have both IPv4 and IPv6 dual stacked peering. IPv4 address depletion have been a major issue for many years now. Operators around the world are clamoring for a solution that can help solve issues related to IPv4 address depletion at these large IXP peering points. With this solution IXPs as well as all infrastructure networks such as Core networks, DC networks, Access networks as well as any PE-CE public or private network can now utilize this IPv6-Only Edge solution and reap the benefits immediately on IPv4 address space saving.

### IXP Problem Statement

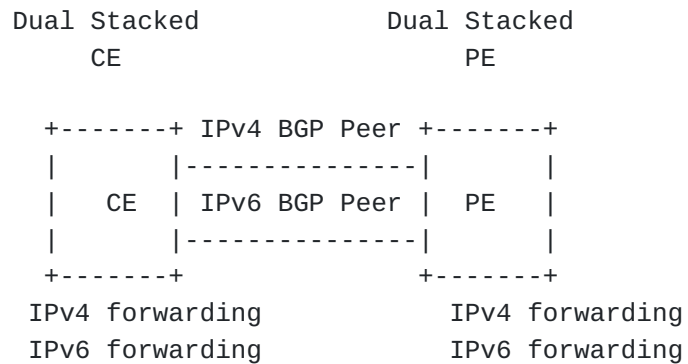


Figure 1: Problem Statement - IXP Dual Stack Peering

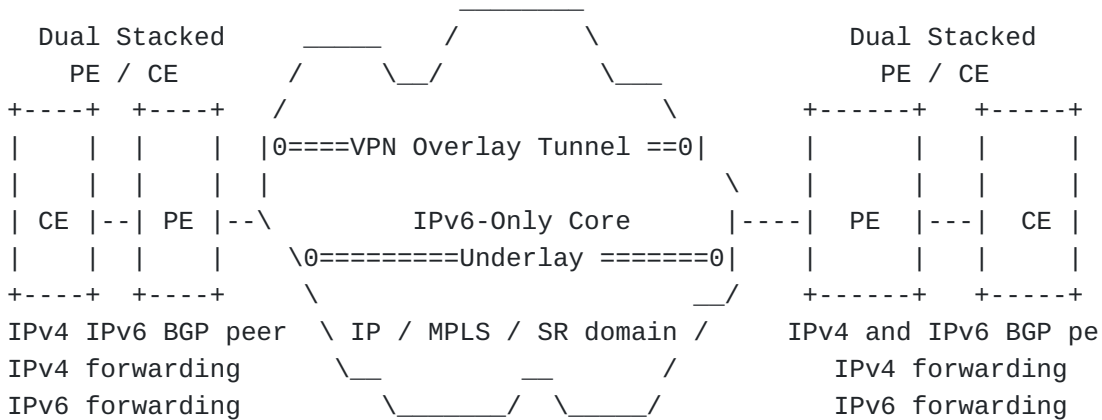


Figure 2: Problem Statement - E2E Dual Stack Edge





### **4.3. IPv6-Only Edge Peering Design**

#### **4.3.1. IPv6-Only Edge Peering Packet Walk**

The IPv6-Only Edge Peering design utilizes two key E2E Software Mesh Framework scenario's, 4to6 software and 6to4 software. The Software mesh framework concept is based on the overlay and underlay MPLS or SR based technology framework, where the underlay is the transport layer and the overlay is a Virtual Private Network (VPN) layer, and is the the tunneled virtualization layer containing the customer payload. The concept of a 6to4 Software is based on transmission of IPv6 packets at the edge of the network by tunneling the IPv6 packets over an IPv4-Only Core. The concept of a 4to6 Software is also based on transmission of IPv4 packets at the edge of the network by tunneling the IPv4 packets over an IPv6-Only Core.

This document describes End to End (E2E) test scenarios that follow a packet flow from IPv6-Only attachment circuit from ingress PE-CE to egress PE-CE tracing the routing protocol control plane and data plane forwarding of IPv4 packets in a 4to6 software or 6to4 software within the IPv4-Only or IPv6-Only Core network. In both scenarios we are focusing on IPv4 packets and the control plane and data plane forwarding aspects of IPv4 packets from the PE-CE Edge network over an IPv6-Only P (Provider) core network or IPv4-Only P (Provider) core network. With this IPv6-Only Edge peering design, the Software Mesh Framework is not extended beyond the Provider Edge (PE) and continues to terminate on the PE router.

#### **4.3.2. 6to4 Software IPv4-Only Core packet walk**

6to4 software where IPv6-Edge eBGP IPv6 peering where IPv4 packets at network Edge traverse a IPv4-Only Core

In the scenario where IPv4 packets originating from a PE-CE edge are tunneled over an MPLS or Segment Routing IPv4 underlay core network, the PE and CE only have an IPv6 address configured on the interface. In this scenario the IPv4 packets that ingress the CE from within the CE AS are over an IPv6-Only interface and are forwarded to an IPv4 NLRI destination prefix learned from the Pure Transport Single IPv6 BGP Peer. In the IPv6-Only Edge peering architecture the PE is IPv6-Only as all PE-CE interfaces are IPv6-Only. However, on the CE, the PE-CE interface is the only interface that is IPv6-Only and all other interfaces may or may not be IPv6-Only. Following the data plane packet flow, IPv4 packets are forwarded from the ingress CE to the IPv6-Only ingress PE where the VPN label imposition push per prefix, per-vrf, per-CE occurs and the labeled packet is forwarded over a 6to4 software IPv4-Only core, to the egress PE where the VPN label disposition pop occurs and the native IPv4 packet is forwarded to the egress CE. In the reverse direction IPv4 packets are

forwarded from the egress CE to egress PE where the VPN label imposition per prefix, per-vrf, per-CE push occurs and the labeled packet is forwarded back over the 6to4 software IPv4-Only core, to the ingress PE where the VPN label disposition pop occurs and the native IPv4 packet is forwarded to the ingress CE. . The functionality of the IPv4 forwarding plane in this scenario is identical from a data plane forwarding perspective to Dual Stack IPv4 forwarding scenario.

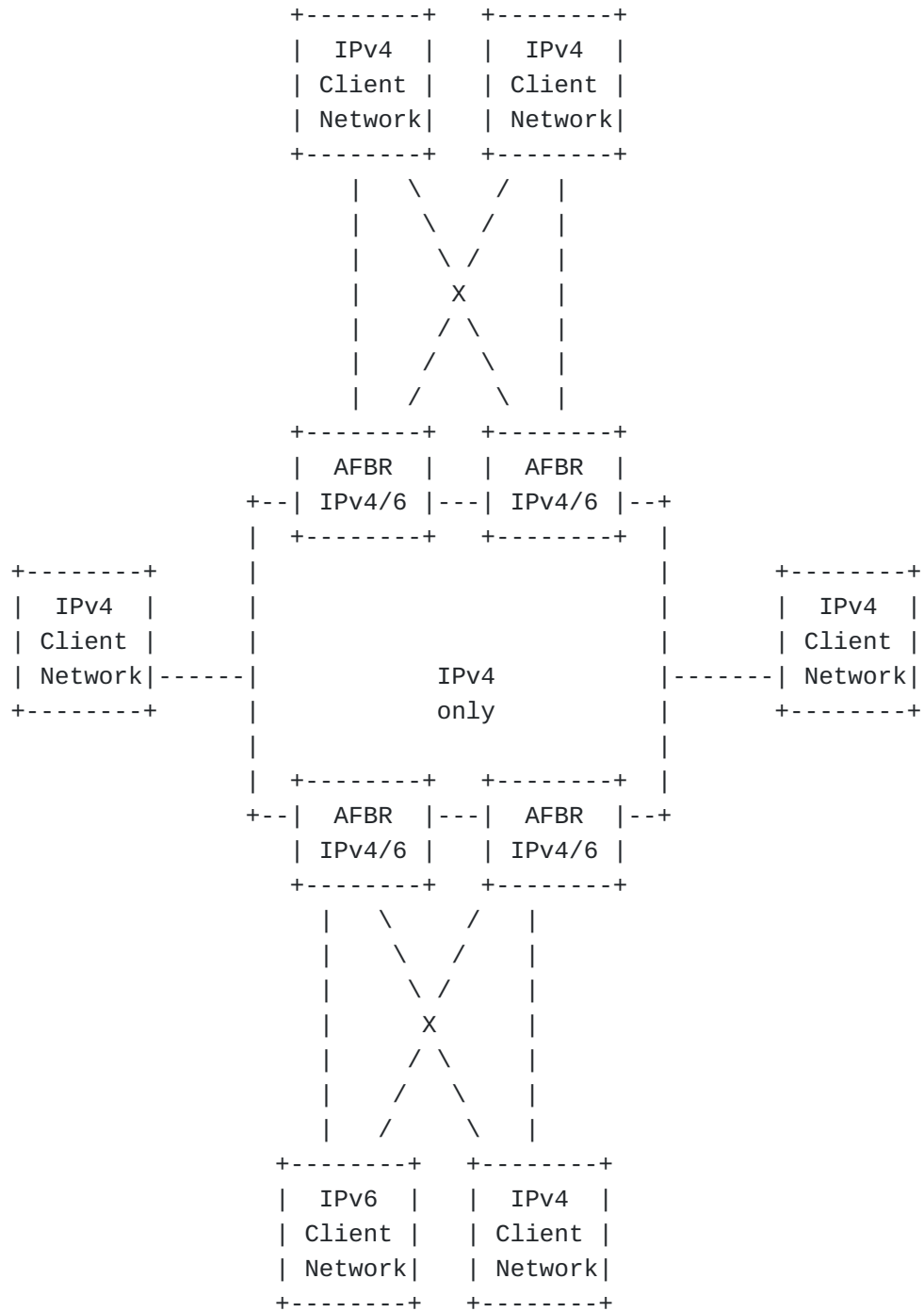


Figure 5: 6to4 Software - IPv6 Edge over an IPv4-Only Core

**4.3.3. 4to6 Software IPv6-Only Core packet walk**

4to6 software where IPv6-Edge eBGP IPv6 peering where IPv4 packets at network Edge traverse a IPv6-Only Core

In the scenario where IPv4 packets originating from a PE-CE edge are tunneled over an MPLS or Segment Routing IPv4 underlay core network, the PE and CE only have an IPv6 address configured on the interface. In this scenario the IPv4 packets that ingress the CE from within the CE AS are over an IPv6-Only interface and are forwarded to an IPv4 NLRI destination prefix learned from the Pure Transport Single IPv6 BGP Peer. In the IPv6-Only Edge peering architecture the PE is IPv6-Only as all PE-CE interfaces are IPv6-Only. However, on the CE, the PE-CE interface is the only interface that is IPv6-Only and all other interfaces may or may not be IPv6-Only. Following the data plane packet flow, IPv4 packets are forwarded from the ingress CE to the IPv6-Only ingress PE where the VPN label imposition push per prefix, per-vrf, per-CE occurs and the labeled packet is forwarded over a 4to6 softwire IPv6-Only core, to the egress PE where the VPN label disposition pop occurs and the native IPv4 packet is forwarded to the egress CE. In the reverse direction IPv4 packets are forwarded from the egress CE to egress PE where the VPN label imposition per prefix, per-vrf, per-CE push occurs and the labeled packet is forwarded back over the 4to6 softwire IPv6-Only core, to the ingress PE where the VPN label disposition pop occurs and the native IPv4 packet is forwarded to the ingress CE. . The functionality of the IPv4 forwarding plane in this scenario is identical from a data plane forwarding perspective to Dual Stack IPv4 forwarding scenario.

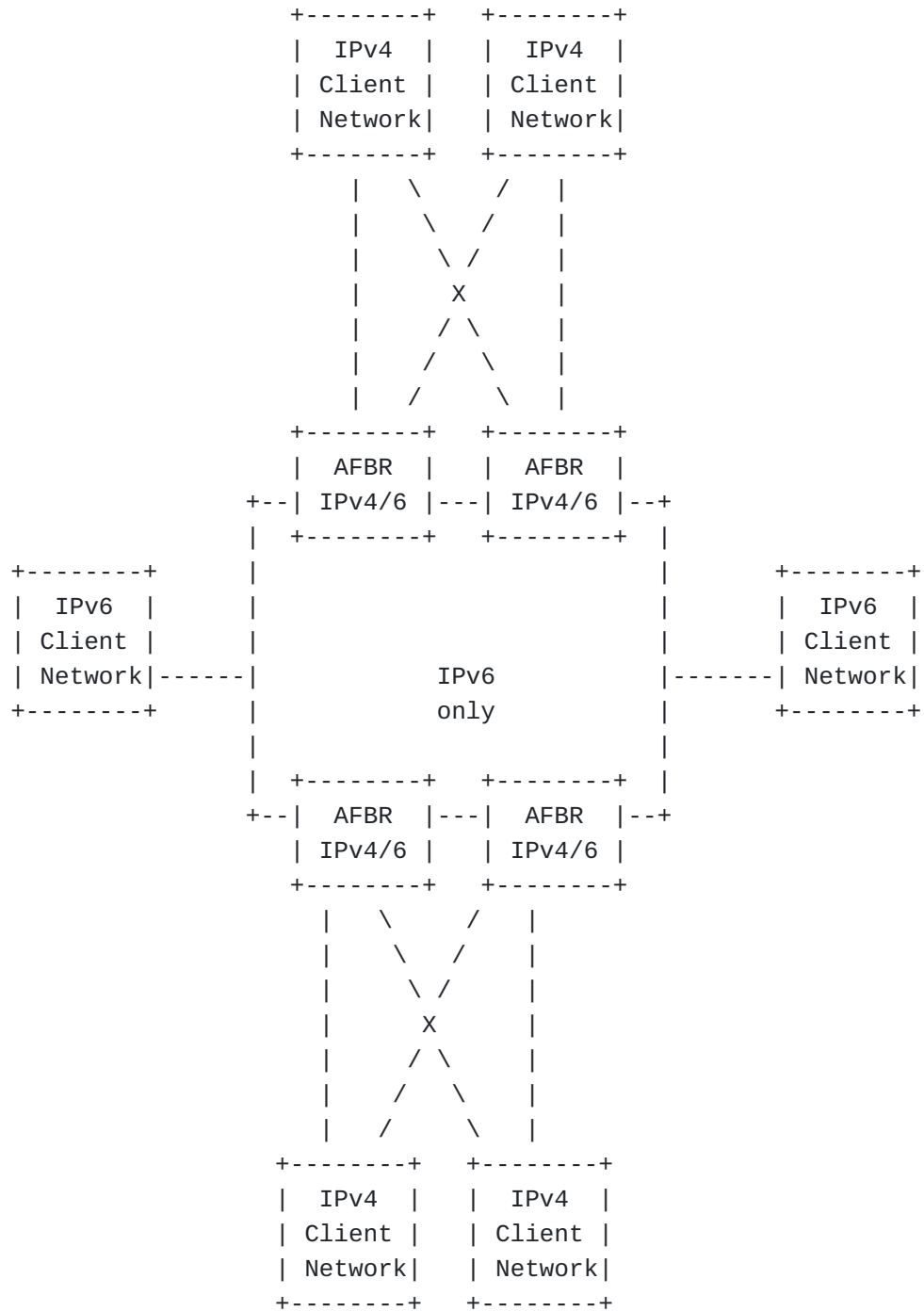


Figure 6: 4to6 Software - IPv4 Edge over an IPv6-Only Core

#### 4.4. RFC5549 and RFC8950 Applicability

##### 4.4.1. IPv6-Only Edge Peering design next-hop encoding

This section describes [RFC8950] next hop encoding updates to [RFC5549] applicability to this specification. IPv6-only eBGP Edge PE-CE peering to carry IPv4 Unicast NLRI <AFI/SAFI> IPv4 <1/1> over an IPv6 next hop BGP capability extended hop encoding IANA capability codepoint value 5 defined in [RFC5549] and [RFC8950] as IPv4 Unicast NLRI <AFI/SAFI> IPv4 <1/1> does not change in the RFC updates.

IPv4 packets over an IPv6-Only core 4to6 Software E2E packet flow is part of the IPv6-Only design vendor interoperability test cases and in that respect is applicable as [RFC8950] updates [RFC5549] for <AFI/SAFI> VPN-IPv4 <1/128>, and Multicast VPN <1/129>

##### 4.4.2. RFC8950 updates to RFC5549 applicability

This section describes the [RFC8950] next hop encoding updates to [RFC5549]

In [RFC5549] when AFI/SAFI 1/128 is used, the next-hop address is encoded as an IPv6 address with a length of 16 or 32 bytes. This document modifies how the next-hop address is encoded to accommodate all existing implementations and bring consistency with VPNv4oIPv4 and VPNv6oIPv6. The next-hop address is now encoded as a VPN-IPv6 address with a length of 24 or 48 bytes [RFC8950] (see Sections 3 and 6.2 of this document). This change addresses Erratum ID 5253 (Err5253). As all known and deployed implementations are interoperable today and use the new proposed encoding, the change does not break existing interoperability. Updates to [RFC8950] is applicable to the IPv6-Only PE-CE edge design for the IPv6 next hop encoding E2E test case of IPv4 packets over and IPv6-Only core 4to6 Software. In this test case IPv4 Unicast NLRI <AFI/SAFI> IPv4 <1/1> is advertised over the PE to RR core peering 4to6 software in <AFI/SAFI> VPN-IPv4 <1/128>. In this test case label allocation mode comes into play which is discussed in section 8.9.

[RFC5549] next hop encoding of MP\_REACH\_NLRI with:

\*NLRI= NLRI as per current AFI/SAFI definition

Advertising with [RFC4760] MP\_REACH\_NLRI with:

\*AFI = 1

\*SAFI = 128 or 129

\*Length of Next Hop Address = 16 or 32

\*NLRI= NLRI as per current AFI/SAFI definition

[RFC8950] next hop encoding of MP\_REACH\_NLRI with:

\*NLRI= NLRI as per current AFI/SAFI definition

Advertising with [RFC4760] MP\_REACH\_NLRI with:

\*AFI = 1

\*SAFI = 128 or 129

\*Length of Next Hop Address = 24 or 48

\*Next Hop Address = VPN-IPv6 address of next hop with an 8-octet RD set to zero (potentially followed by the link-local VPN-IPv6 address of the next hop with an 8-octet RD is set to zero).

\*NLRI= NLRI as per current AFI/SAFI definition

## 5. IPv6-Only PE Design Edge and Inter-AS Options E2E Test Cases

Proof of concept interoperability testing of the 4 test cases between the 5 vendors Cisco, Juniper, Arista, Nokia and Huawei.

Cisco, Juniper, Arista, Nokia, Huawei, platform, code revision and test results for all use cases

Cisco: Edge Router- XR ASR 9910 IOS XR 7.4.1, Core Router- NCS 6000 7.2.2, CRS-X 6.7.4

Juniper: Edge Router- MX platform MX480, MX960, Core Router- PTX Platform PTX5000, PTC10K8 (JUNOS and EVO) Release 20.4R2

Tested v4 edge over v6 core in a virtual setup using vMX platform and 20.4R2 and LDPv6 as underlay, but there were some data plane forwarding issues. Tested same setup on latest release 21.4 and it worked. Investigating what the minimum version is for this setup to work.

Tested on above Juniper platforms. Completed IPv6-Only PE design functionality test with PE-CE IPv6 peer carrying IPv4 and IPv6 prefixes control plane validation and data plane forwarding plane validation and verified end to end reachability CE to CE forwarding plane with Default Per-CE label allocation mode. Tested with IPv4-Only Core and IPv6-Only Core and proved that the IPv6-Only PE design solution works. Both IPv4 and IPv6 packets were forwarded identical functionality of Dual Stack without having IPv4 address configured.

Nokia: Edge and Core-7750 Service Router, Release R21

Huawei: Edge and Core-VRPv8, Release VRP-V800R020C10

Arista:

Intra-AS tests PE-CE Edge Peering IPv4-Only Core, IPv6-Only Core, Global Table (GRT) and IP VPN

AFI/SAFI IPv4-Unicast SAFI IPv6-Unicast SAFI

IPv4 Core:

Test-1 Global table (6PE)

Test-2 IP VPN

Global table IPv6

IPv6 Core:

Test-3 Global table

Test-4 IP VPN

Inter-AS Options tests IPv4-Only Core, IPv6-Only Core, Global Table (GRT) and IP VPN

AFI/SAFI VPN and MVPN

IPv4-Only Core

Test-5 Global table 6PE Option-B (Segmented LSP stitched IPv4 Core - Inter-AS Link IPv6-Only PE - IPv4 Core)

Test-6 Global table 6PE Option-C (Redistribute IPv4 Loopbacks into BGP-LU AFI/SAFI 2/6)

Test-7 IP VPN Inter AS Option-B (Segmented LSP stitched IPv4 Core - Inter-AS Link IPv6-Only PE - IPv4 Core)

Test-8 IP VPN Inter AS Option-C (Redistribute IPv4 Loopbacks into BGP-LU AFI/SAFI 2/6)

IPv6-Only Core

Test-9 Global table Option-B

Test-10 Global table Option-C

Test-11 IP VPN Inter AS Option-B

Test-12 IP VPN Inter AS Option-C



**5.1. Test-1 E2E IPv6-Only PE-CE, Global Table over IPv4-Only Core(6PE), 6to4 software**

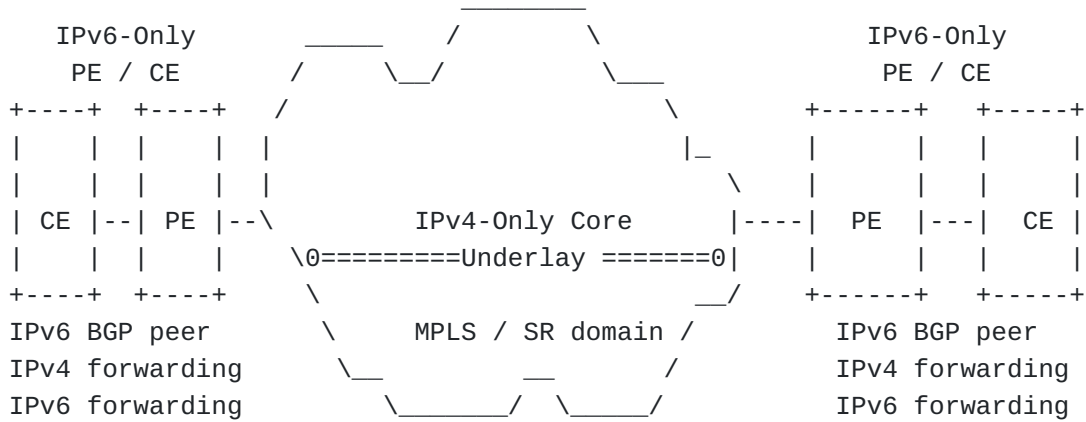


Figure 7: Test-1 E2E IPv6-Only PE-CE, Global Table over IPv4-Only Core (6PE)

**5.2. Test-2 E2E IPv6-Only PE-CE, VPN over IPv4-Only Core, 6to4 Software**

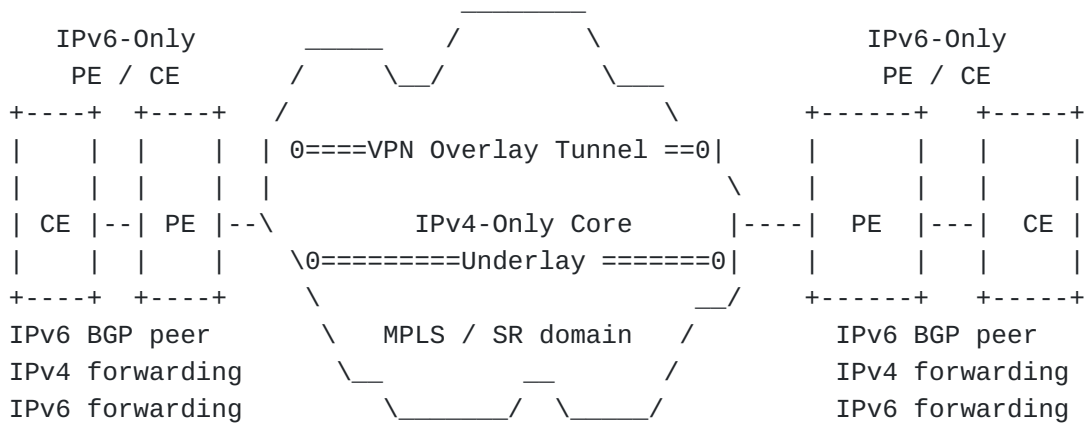


Figure 8: Test-2 E2E IPv6-Only PE-CE, VPN over IPv4-Only Core

**5.3. Test-3 E2E IPv6-Only PE-CE, Global Table over IPv6-Only Core, 4to6 Software**

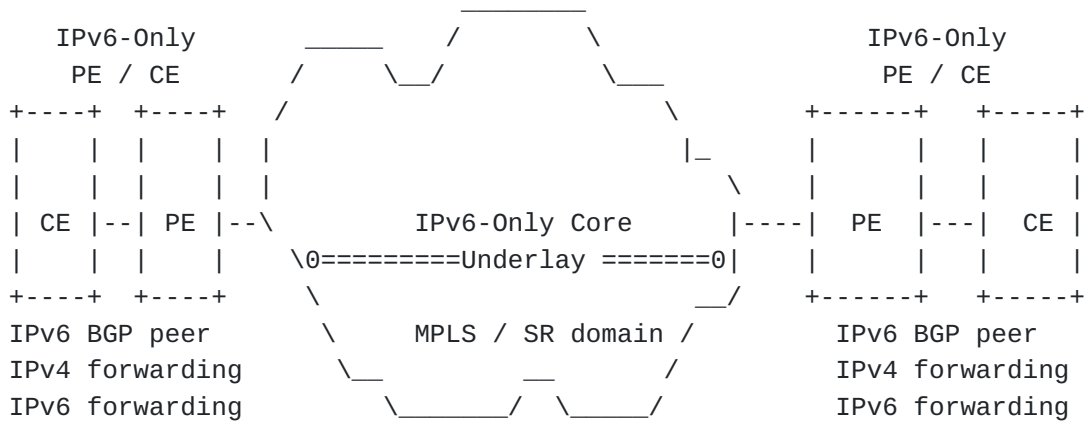


Figure 9: Test-3 E2E IPv6-Only PE-CE, Global Table over IPv6-Only Core

**5.4. Test-4 E2E IPv6-Only PE-CE, VPN over IPv6-Only Core, 4to6 Software**

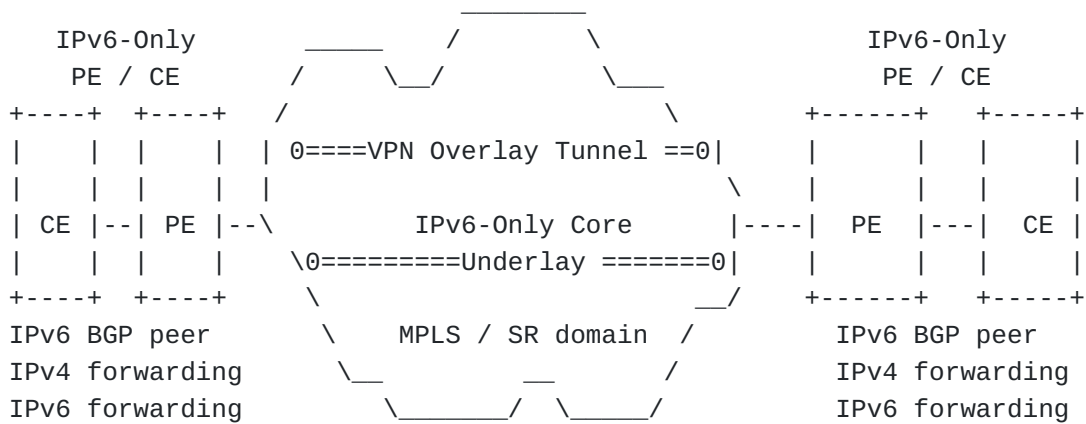


Figure 10: Test-4 E2E IPv6-Only PE-CE, VPN over IPv6-Only Core

**5.5. Test-5 E2E IPv6-Only PE-CE, Global Table over IPv4-Only Core(6PE), 6to4 software -Inter-AS Option-B**

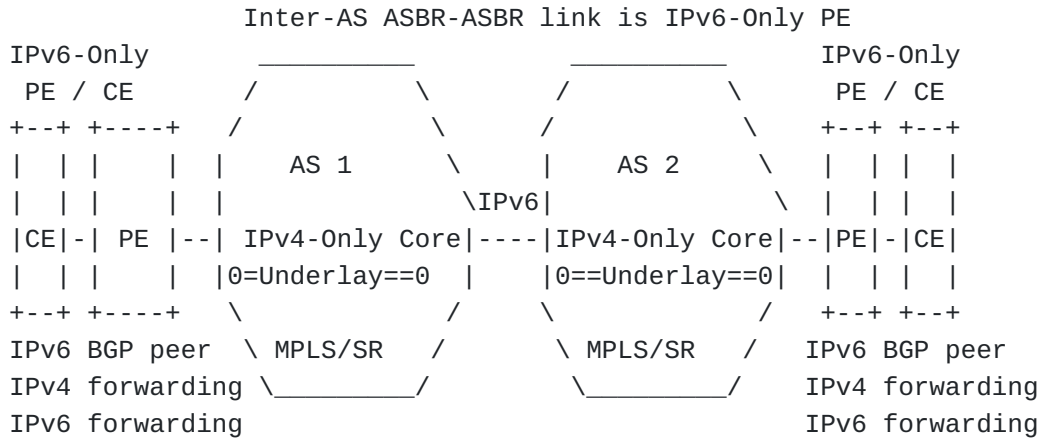


Figure 11: Test-5 E2E IPv6-Only PE-CE, Global Table over IPv4-Only Core (6PE) - Inter-AS Option-B

**5.6. Test-6 E2E IPv6-Only PE-CE, Global Table over IPv4-Only Core(6PE), 6to4 software -Inter-AS Option-C**

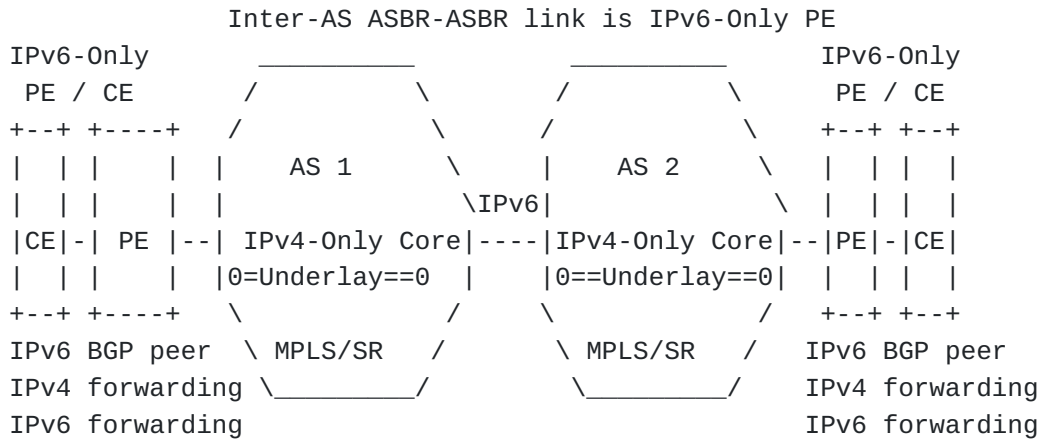


Figure 12: Test-6 E2E IPv6-Only PE-CE, Global Table over IPv4-Only Core (6PE) - Inter-AS Option-C

**5.7. Test-7 E2E IPv6-Only PE-CE, VPN over IPv4-Only, 6to4 software - Inter-AS Option-B**

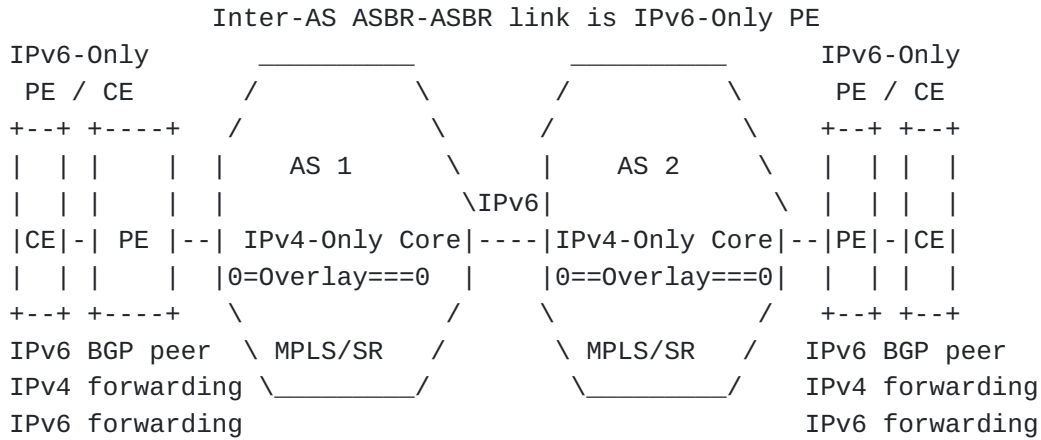


Figure 13: Test-7 E2E IPv6-Only PE-CE, VPN over IPv4-Only Core - Inter-AS Option-B

**5.8. Test-8 E2E IPv6-Only PE-CE, VPN over IPv4-Only Core, 6to4 software -Inter-AS Option-C**

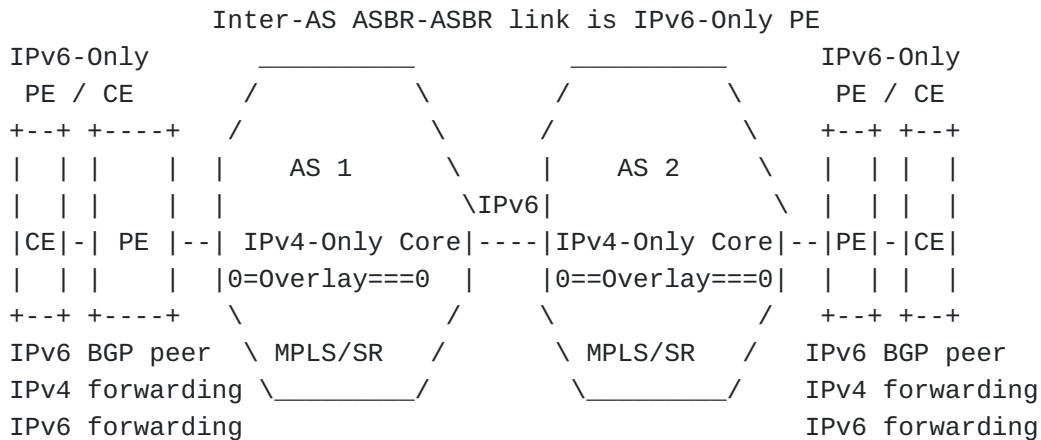


Figure 14: Test-8 E2E IPv6-Only PE-CE, VPN over IPv4-Only Core - Inter-AS Option-C

**5.9. Test-9 E2E IPv6-Only PE-CE, Global Table over IPv6-Only Core, 4to6 software -Inter-AS Option-B**

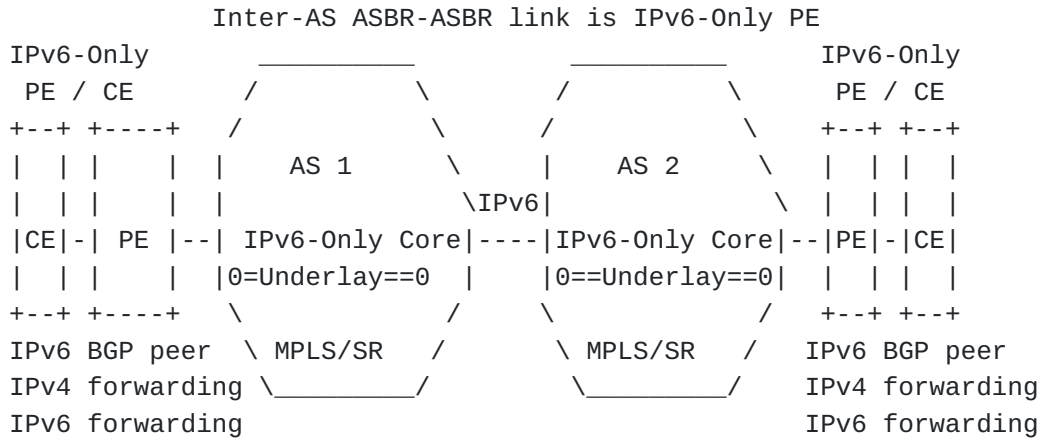


Figure 15: Test-9 E2E IPv6-Only PE-CE, Global Table over IPv6-Only Core - Inter-AS Option-B

**5.10. Test-10 E2E IPv6-Only PE-CE, Global Table over IPv6-Only Core, 4to6 softwire -Inter-AS Option-C**

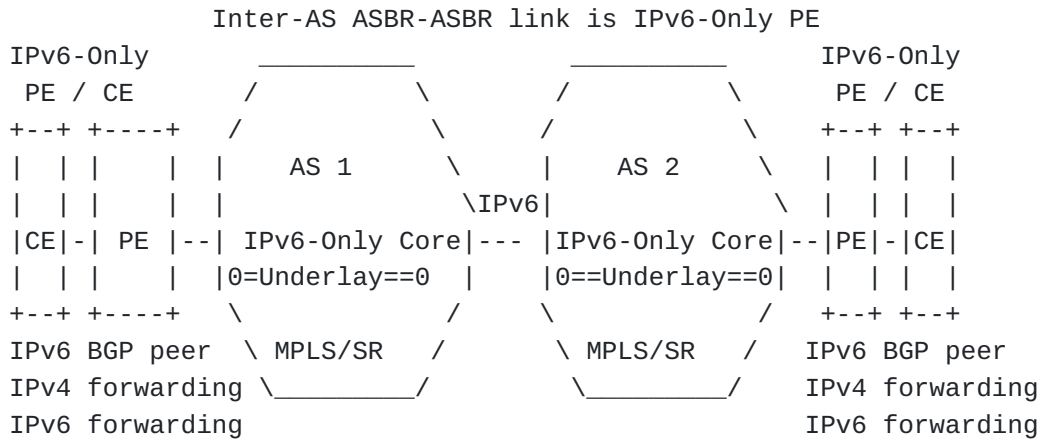


Figure 16: Test-10 E2E IPv6-Only PE-CE, Global Table over IPv6-Only Core - Inter-AS Option-C

**5.11. Test-11 E2E IPv6-Only PE-CE, VPN over IPv6-Only Core, 4to6 softwire -Inter-AS Option-B**

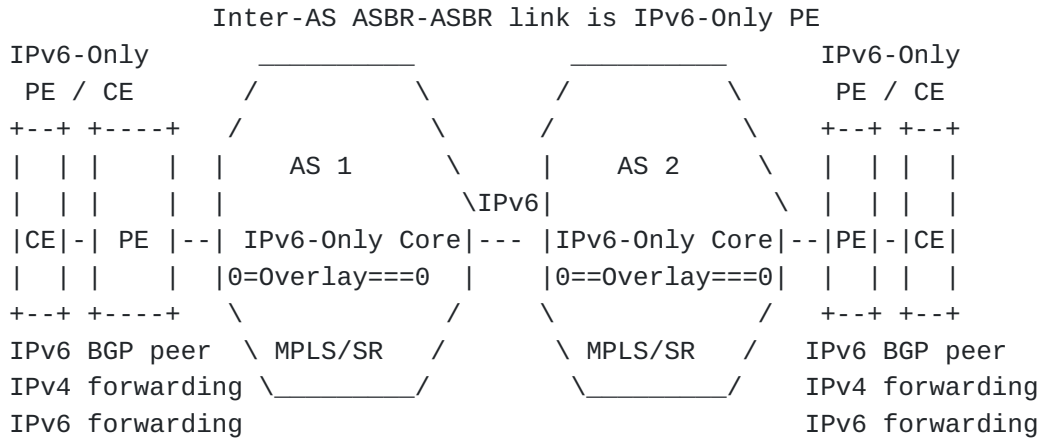


Figure 17: Test-11 E2E IPv6-Only PE-CE, VPN over IPv6-Only Core - Inter-AS Option-B

**5.12. Test-12 E2E IPv6-Only PE-CE, VPN over IPv6-Only Core, 4to6 software -Inter-AS Option-C**

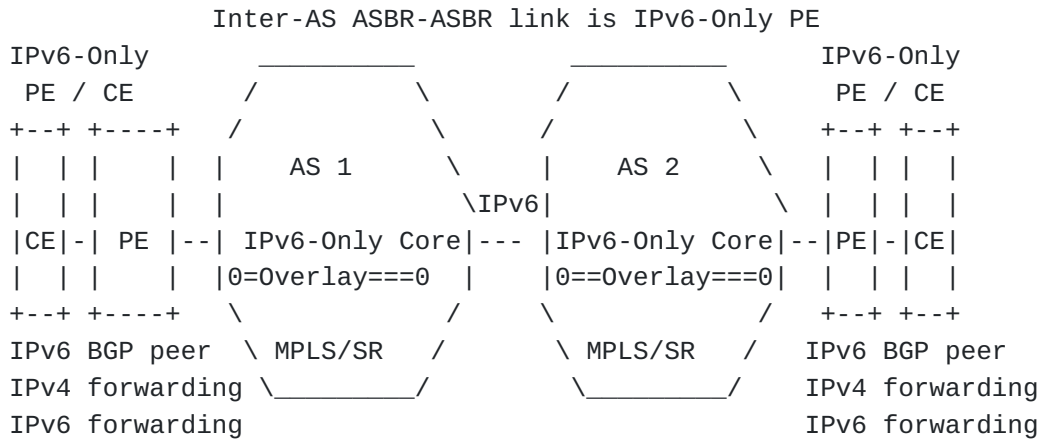


Figure 18: Test-12 E2E IPv6-Only PE-CE, VPN over IPv6-Only Core - Inter-AS Option-C

**5.13. IPv6-Only PE-CE Operational Considerations Testing**

Ping CE to PE when destination prefix is withdraw  
 Traceroute CE to PE and test all ICMPv4 and ICMPv

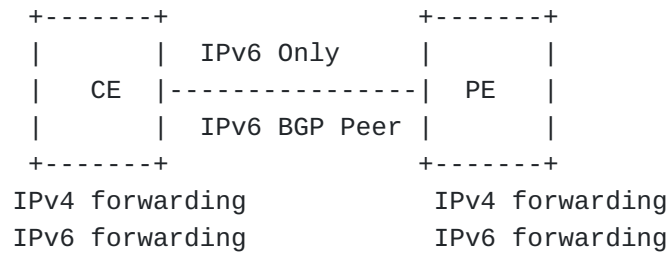


Figure 19: Ping and Trace Test Case

## 6. Operational Considerations

With a single IPv6 Peer carrying both IPv4 and IPv6 NLRI there are some operational considerations in terms of what changes and what does not change.

What does not change with a single IPv6 transport peer carrying IPv4 NLRI and IPv6 NLRI below:

Routing Policy configuration is still separate for IPv4 and IPv6 configured by capability as previously.

Layer 1, Layer 2 issues such as one-way fiber or fiber cut will impact both IPv4 and IPv6 as previously.

If the interface is in the Admin Down state, the IPv6 peer would go down, and IPv4 NLRI and IPv6 NLRI would be withdrawn as previously.

Changes resulting from a single IPv6 transport peer carrying IPv4 NLRI and IPv6 NLRI below:

Physical interface is no longer dual stacked.

Any change in IPv6 address or DAD state will impact both IPv4 and IPv6 NLRI exchange.

Single BFD session for both IPv4 and IPv6 NLRI fate sharing as the session is now tied to the transport, which now is only IPv6 address family.

Both IPv4 and IPv6 peer now exists under the IPv6 address family configuration.

Fate sharing of IPv4 and IPv6 address family from a logical perspective now carried over a single physical IPv6 peer.

From an operations perspective, prior to elimination of IPv4 peers, an audit is recommended to identify and IPv4 and IPv6 peering incongruencies that may exist and to rectify them. No operational impacts or issues are expected with this change.

With MPLS VPN overlay, per-CE next-hop label allocation mode where both IPv4 and IPv6 prefixes have the same label in no table lookup pop-n-forward mode should be taken into consideration.

## **7. IANA Considerations**

There are not any IANA considerations.

## **8. Security Considerations**

The extensions defined in this document allow BGP to propagate reachability information about IPv4 prefixes over an MPLS or SR IPv6-Only core network. As such, no new security issues are raised beyond those that already exist in BGP-4 and the use of MP-BGP for IPv6. Both IPv4 and IPv6 peers exist under the IPv6 address family configuration. The security features of BGP and corresponding security policy defined in the ISP domain are applicable. For the inter-AS distribution of IPv6 routes according to case (a) of Section 4 of this document, no new security issues are raised beyond those that already exist in the use of eBGP for IPv6 [RFC2545].

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