Configuring IPv6 Provider Edge over MPLS (6PE)

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Configuring 6PE

Information About 6PE

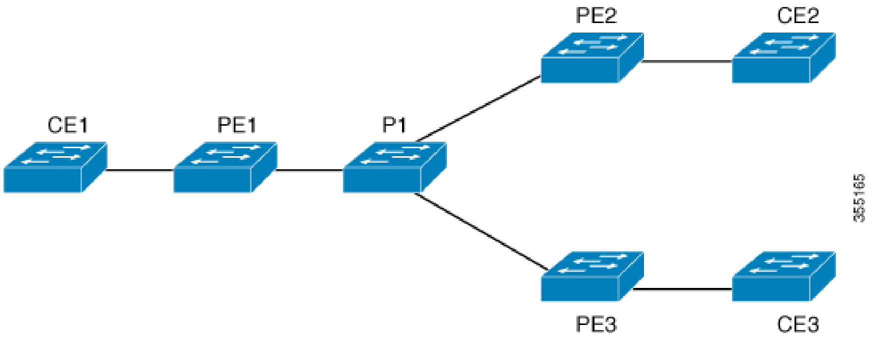
6PE is a technique that provides global IPv6 reachability over IPv4 MPLS. It allows one shared routing table for all other devices. 6PE allows IPv6 domains to communicate with one another over the IPv4 without an explicit tunnel setup, requiring only one IPv4 address per IPv6 domain.

While implementing 6PE, the provider edge routers are upgraded to support 6PE, while the rest of the core network is not touched (IPv6 unaware). This implementation requires no reconfiguration of core routers because forwarding is based on labels rather than on the IP header itself. This provides a cost-effective strategy for deploying IPv6.The IPv6 reachability information is exchanged by PE routers using multiprotocol Border Gateway Protocol (mp-iBGP) extensions.

6PE relies on mp-iBGP extensions in the IPv4 network configuration on the PE router to exchange IPv6 reachability information in addition to an MPLS label for each IPv6 address prefix to be advertised. PE routers are configured as dual stacks, running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange. The next hop advertised by the PE router for 6PE and 6VPE prefixes is still the IPv4 address that is used for IPv4 L3 VPN routes. A value of ::FFFF: is prepended to the IPv4 next hop, which is an IPv4-mapped IPv6 address.

The following figure illustrates the 6PE topology.

Figure 1: 6PE Topology



For scale information related to this feature, see Cisco Catalyst 3650 Series Switches Data Sheet.

Prerequisites for 6PE

Redistribute PE-CE IGP IPv6 routes into core BGP and vice-versa

Restrictions for 6PE

eBGP as CE-PE is not supported. Static Routes, OSPFv3, ISIS, RIPv2 are supported as CE-PE.

Configuring 6PE

Ensure that you configure 6PE on PE routers participating in both the IPv4 cloud and IPv6 clouds.

BGP running on a PE router should establish (IPv4) neighborhood with BGP running on other PEs. Subsequently, it should advertise the IPv6 prefixes learnt from the IPv6 table to the neighbors. The IPv6 prefixes advertised by BGP would automatically have IPv4-encoded-IPv6 addresses as the nexthop-address in the advertisement.

To configure 6PE, complete the following steps:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

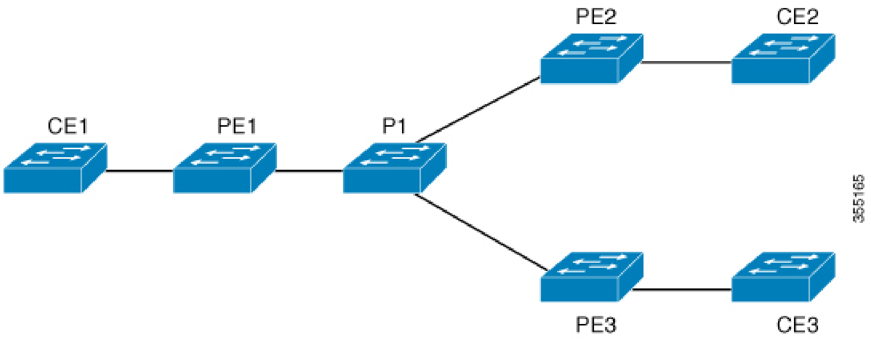
	Command or Action	Purpose
Step 3	**ipv6 unicast-routing** **Example:** `Device(config)# ipv6 unicast-routing`	Enables the forwarding of IPv6 unicast datagrams.
Step 4	**router bgp** *as-number* **Example:** `Device(config)# router bgp 65001`	Enters the number that identifies the autonomous system (AS) in which the router resides. *as-number*—Autonomous system number. Range for 2-byte numbers is 1 to 65535. Range for 4-byte numbers is 1.0 to 65535.65535.
Step 5	**bgp router-id interface** *interface-id* **Example:** `Device(config-router)# bgp router-id interface Loopback1`	Configures a fixed router ID for the local Border Gateway Protocol (BGP) routing process.
Step 6	**bgp log-neighbor-changes** **Example:** `Device(config-router)# bgp log-neighbor-changes`	Enables logging of BGP neighbor resets.
Step 7	**bgp graceful-restart** **Example:** `Device(config-router)# bgp graceful-restart`	Enables the Border Gateway Protocol (BGP) graceful restart capability globally for all BGP neighbors.
Step 8	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **remote-as** *as-number* **Example:** `Device(config-router)# neighbor 33.33.33.33 remote-as 65001`	Adds an entry to the BGP or multiprotocol BGP neighbor table. • *ip-address*—IP address of a peer router with which routing information will be exchanged. • *ipv6-address*—IPv6 address of a peer router with which routing information will be exchanged. • *peer-group-name*—Name of the BGP peer group. • *remote-as*—Specifies a remote autonomous system. • *as-number*—Number of an autonomous system to which the neighbor belongs, ranging from 1 to 65535.

	Command or Action	Purpose
Step 9	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **update-source** *interface-type interface-number* **Example:** `Device(config-router)# neighbor 33.33.33.33 update-source Loopback1`	Configures BGP sessions to use any operational interface for TCP connections.
Step 10	**address-family ipv6** **Example:** `Device(config-router)# address-family ipv6`	Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard IPv6 address prefixes.
Step 11	**redistribute** *protocol as-number* **match** { **internal | external 1 | external 2** **Example:** `Device(config-router-af)# redistribute ospf 11 match internal external 1`	Redistributes routes from one routing domain into another routing domain.
Step 12	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **activate** **Example:** `Device(config-router-af)# neighbor 33.33.33.33 activate`	Enables the exchange of information with a BGP neighbor.
Step 13	**neighbor** { *ip-address* | *ipv6-address* | *peer-group-name* } **send-label** **Example:** `Device(config-router-af)#  neighbor 33.33.33.33 send-label`	Sends MPLS labels with BGP routes to a neighboring BGP router.
Step 14	**exit-address-family** **Example:** `Device(config-router-af)# exit-address-family`	Exits BGP address-family submode.

Step 15	**end**
	Example:
	`Device(config)# end`
		Returns to privileged EXEC mode.

Configuration Examples for 6PE

Figure 2: 6PE Topology



PE Configuration	CE Configuration
address-family ipv6 unicast redistribute bgp 65001 exit-address-family ! router bgp 65001 bgp router-id interface Loopback1 bgp log-neighbor-changes bgp graceful-restart neighbor 33.33.33.33 remote-as 65001 neighbor 33.33.33.33 update-source Loopback1 ! address-family ipv4 neighbor 33.33.33.33 activate ! address-family ipv6 redistribute ospf 11 match internal external 1 external 2 include-connected neighbor 33.33.33.33 activate neighbor 33.33.33.33 send-label !	ipv6 unicast-routing ! interface vlan4 no ip address ipv6 address 10:1:1:2::2/64 ipv6 enable ospfv3 11 ipv6 area 0 ! router ospfv3 11 address-family ipv6 unicast exit-address-family !

The following is a sample output of **show bgp ipv6 unicast summary** :

```
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 34, main routing table version 34
4 network entries using 1088 bytes of memory
4 path entries using 608 bytes of memory
4/4 BGP path/bestpath attribute entries using 1120 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 2816 total bytes of memory
BGP activity 6/2 prefixes, 16/12 paths, scan interval 60 secs

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down
  State/PfxRcd
2.2.2.2         4          100      21      21       34    0    0 00:04:57
```

```
        2

sh ipv route
IPv6 Routing Table - default - 7 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP
external
      ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect

       RL - RPL, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       la - LISP alt, lr - LISP site-registrations, ld - LISP dyn-eid lA
 - LISP away
C   10:1:1:2::/64 [0/0]
     via Vlan4, directly connected
L   10:1:1:2::1/128 [0/0]
     via Vlan4, receive
LC  11:11:11:11::11/128 [0/0]
     via Loopback1, receive
B   30:1:1:2::/64 [200/0]
     via 33.33.33.33%default, indirectly connected
B   40:1:1:2::/64 [200/0]
     via 44.44.44.44%default, indirectly connected
```

The following is a sample output of **show bgp ipv6 unicast** command :

```
BGP table version is 112, local router ID is 11.11.11.11
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f
RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
              t secondary path,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
     Network          Next Hop            Metric LocPrf Weight Path
 *>   10:1:1:2::/64    ::                       0         32768 ?
 *>i  30:1:1:2::/64    ::FFFF:33.33.33.33
                                                0    100      0 ?
 *>i  40:1:1:2::/64    ::FFFF:44.44.44.44
                                                0    100      0 ?
 *>i  173:1:1:2::/64   ::FFFF:33.33.33.33
                                                2    100      0 ?
```

The following is a sample output of **show ipv6 cef 40:1:1:2::0/64 detail** command :

```
40:1:1:2::/64, epoch 6, flags [rib defined all labels]
  recursive via 44.44.44.44 label 67
    nexthop 1.20.4.2 Port-channel103 label 99-(local:147)
```