



IPv6 over MPLS
Cisco IPv6 Provider
Edge Router (6PE)
Cisco IPv6 VPN
Provider Edge
Router (6VPE)



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IPv6 Deployment Scenario for ISP

	Environment	Scenario	Cisco IOS support
Access	Few customers, no native IPv6 service form the PoP or Data link is not (yet) native IPv6 capable, ie: Cable Docsis (*)	Tunnels	Yes
	Native IPv4-IPv6 services between aggregation and end-users	Dual Stack	Yes
	Dedicated circuits – IPv4 – IPv6	Dual Stack	Yes
Core	Native IP – Core is IPv6 aware	Dual Stack	Yes
	MPLS – Core is IPv6 unaware	6PE/6VPE	Yes

(*) Before DOCSIS 3.0

IPv6 Over MPLS

- Why deploy IPv6 over MPLS ?
- What technology ?
- 6PE deep-dive
- 6VPE deep-dive

Why Deploying IPv6 Over MPLS ?

- Because you already have an MPLS core and want to provide IPv6 access and transit services to your customers
 - IPv6 access to IPv6 services and resources that you provide
 - IPv6 access to IPv6 services and resources reachable via your network
 - VPNv6 services
- Pre-existing MPLS core = IPv4 services; think co-existence
- Because you want to provide IPv6 access and transit services, and MPLS is a cool technology to do so ? (speed, traffic engineering , QoS, VPN, resiliency)

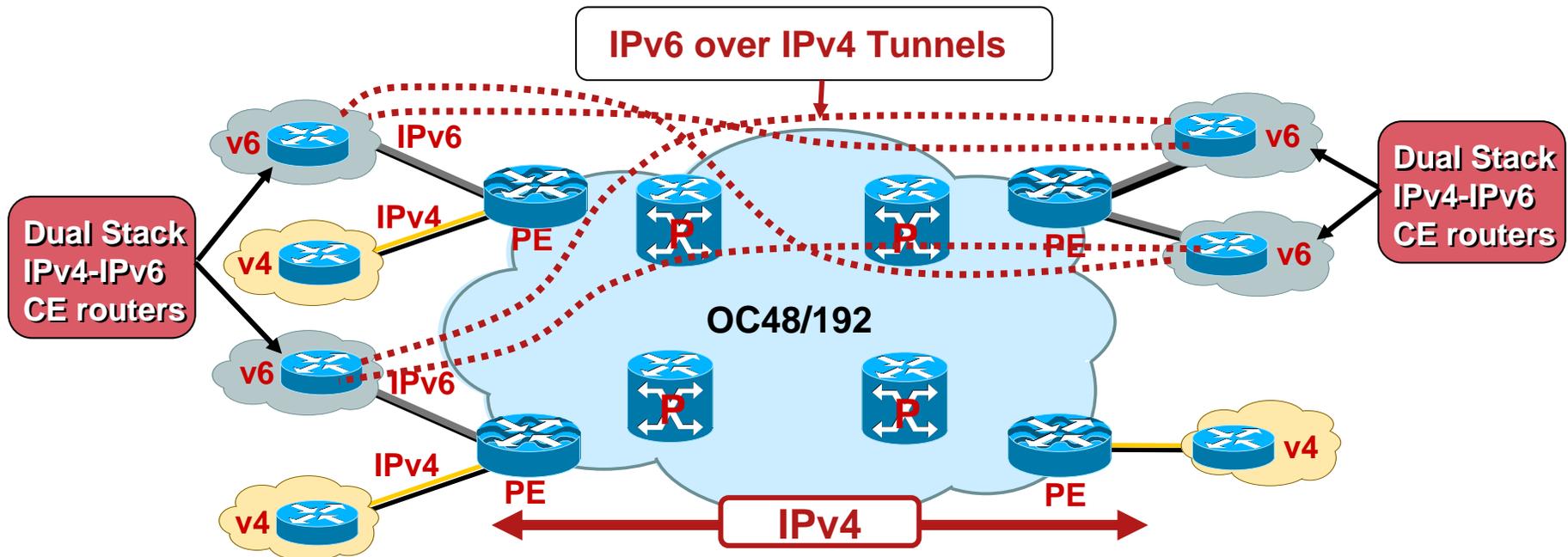
What Core? IPv4 or IPv6 Signaled LSP?

- Pre-existing MPLS core → L2-based or IPv4-based
 - Stick with what you have (L2-based/L3-based, LDP/RSVP, etc.) and use 6PE/6VPE
- New core
 - Providing mixed (IPv4/IPv6) services → IPv4-based (“4PE” is a challenge)
 - IPv6-only → No LDPv6 availability yet
 - Your “only” option today is to go with a v4-based core

What Technology?

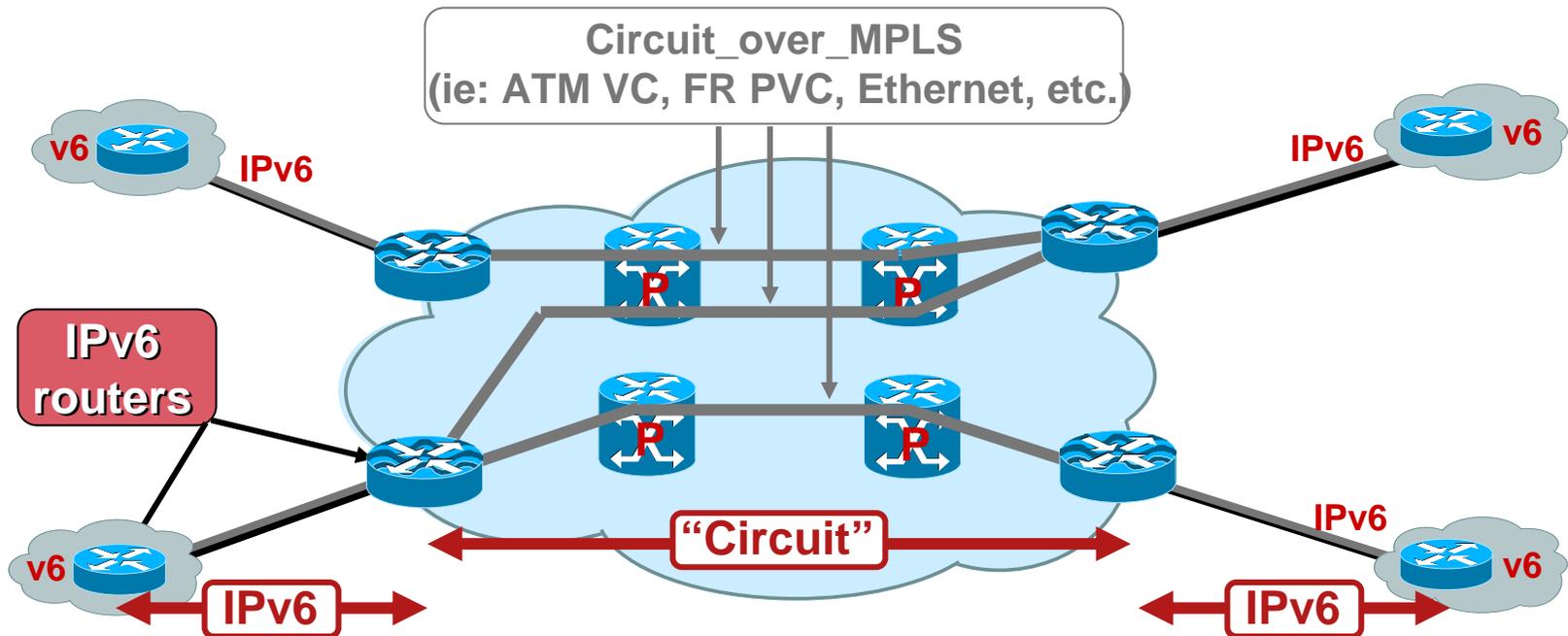
Mechanism	Primary Use	Benefits	Limitations
IPv6 over a circuit transport over MPLS	SP with circuit to the CE (ATM, Ethernet, etc.)	Transparent to the SP	Scalability
IPv6 over IPv4 tunnels over MPLS	SP willing to offer IPv6 service on top of an existing IPv4 MPLS service	Impact limited to PE	Tunnel overhead Configuration
IPv6 MPLS with IPv4-based core (6PE/6VPE)	SP willing to offer IPv6 service on top of an existing IPv4 MPLS service	Impact limited to PE	Core is unaware of IPv6: limitations in load-balancing and troubleshooting
IPv6 MPLS with IPv6-based core	SP willing to offer MPLS services in an IPv6-only context	Full MPLS-IPv6 functionality	Impact on entire MPLS Infrastructure Complexity if coexistence with an IPv4-MPLS service

IPv6 Tunnels Configured on CE



- No impact on existing IPv4 or MPLS Core (IPv6 unaware)
- Only CEs have to be IPv6-aware (Dual stack)
- Mesh of IPv6 over IPv4 Tunnels CE-to-CE
- Overhead: IPv4 header + MPLS header
- MPLS/VPN support IPv4-native and IPv6 tunnels
- Service Provider can't delegate his IPv6 prefix to the CE routers

IPv6 Over “Circuit_over_MPLS”



- No impact on existing IPv4 or MPLS Core (IPv6 unaware)
- Edge MPLS Routers need to support “Circuit_over_MPLS”
- Mesh of “Circuit_Over_MPLS” PE-to-PE
- PE routers can also be regular IPv6 Routers (IPv6 over ATM, IPv6 over FR, IPv6 over Ethernet, etc.) to aggregate Customers IPv6 routers

IPv6 Over MPLS (v4-Signalled LSP) 6PE/6VPE

```
Interface Ethernet 1/0
 ip address 40.1.1.2 255.255.255.0
 ip router isis
 mpls is
```

MPLS label (LDP)	BGP label	IPv6 packet
---------------------	--------------	----------------

IPv6 network

2001:100:1000::/48



PE1

200.10.10.1

PE2

200.11.11.1

CE2

IPv6 network

2001:100:1100::/48



LSP setup: iGP + LDP

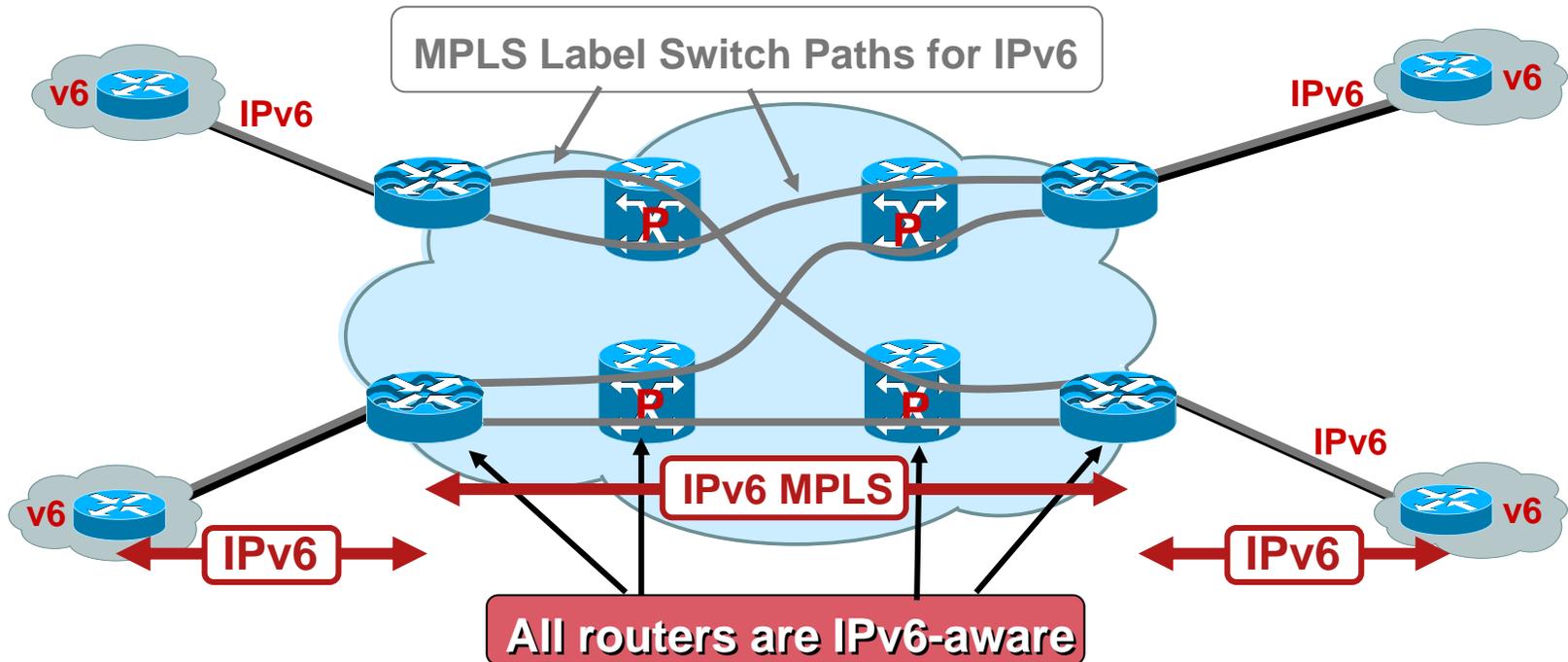
MP-iBGP peering

IPv6+label
VPNv6

```
router bgp 100
  bgp log-neighbor-changes
  neighbor 200.11.11.1 remote-as 100
  !
  address-family ipv6
    neighbor 200.11.11.1 activate
    neighbor 200.11.11.1 send-label
  !
  address-family vpnv6
    neighbor 200.11.11.1 activate
```

```
router bgp 100
  bgp log-neighbor-changes
  neighbor 200.10.10.1 remote-as 100
  !
  address-family ipv6
    neighbor 200.10.10.1 activate
    neighbor 200.10.10.1 send-label
  !
  address-family vpnv6
    neighbor 200.10.10.1 activate
```

IPv6 Over MPLS (v6-Signalled LSP)



- Core Infrastructure requires full Control Plane upgrade to IPv6
 - IPv6 Routing in core
 - IPv6 Label Distribution Protocol in core
- Dual Control Plane management if IPv4 and IPv6 services or a need for “4PE” design – based on IETF Softwire WG?

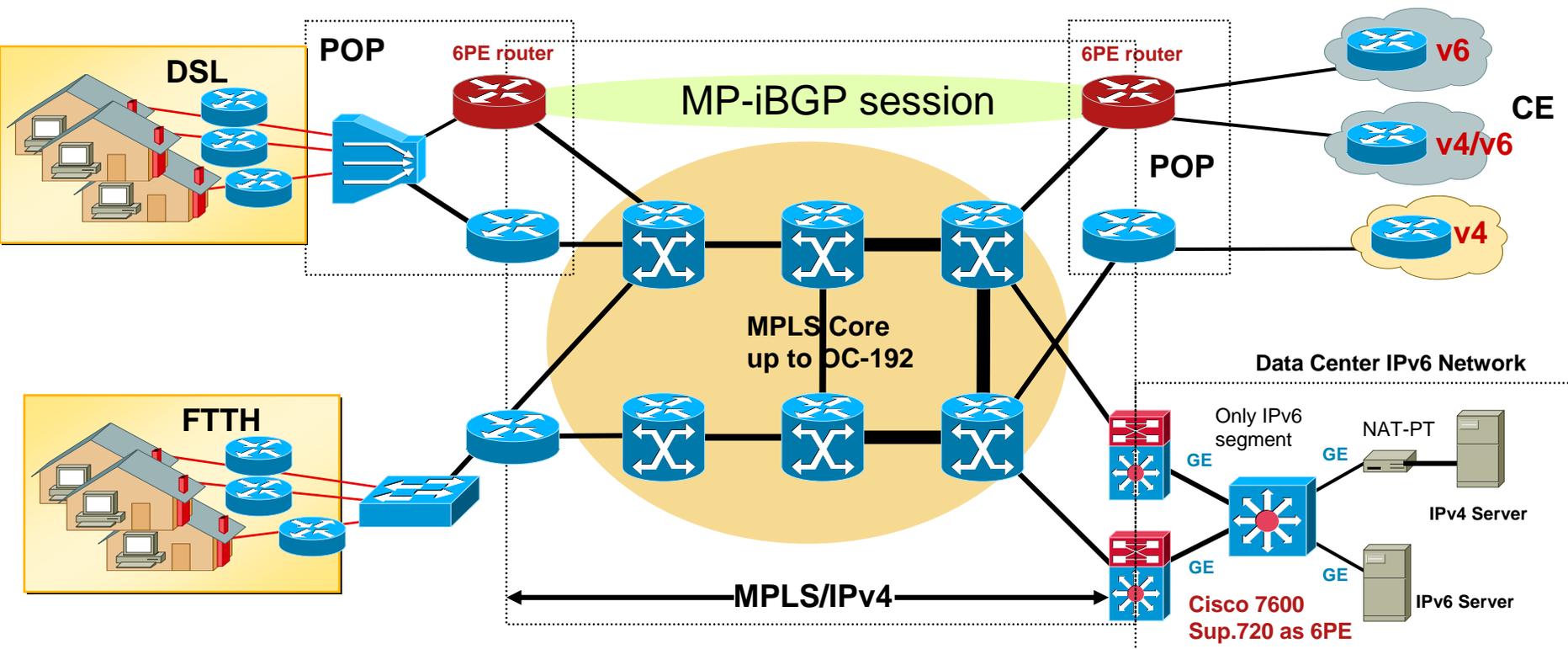
IPv6 Over MPLS

- Why deploy IPv6 over MPLS ?
- What technology ?
- 6PE deep-dive
- 6VPE deep-dive

6PE (RFC 4798) —What is it?

- Provides IPv6 global connectivity over an IPv4-MPLS core
- Transitioning mechanism for providing unicast IPv6 access over IPv4-signaled MPLS
- Coexistence mechanism for combining IPv4 and IPv6 services over an MPLS backbone
- As other IPv6 “tunnel” technologies, it enables services such as
 - “IPv6 Internet Access”
 - Peer-to-peer connectivity
 - Access to IPv6 services supplied by the SP itself

Minimum Infrastructure Upgrade for 6PE

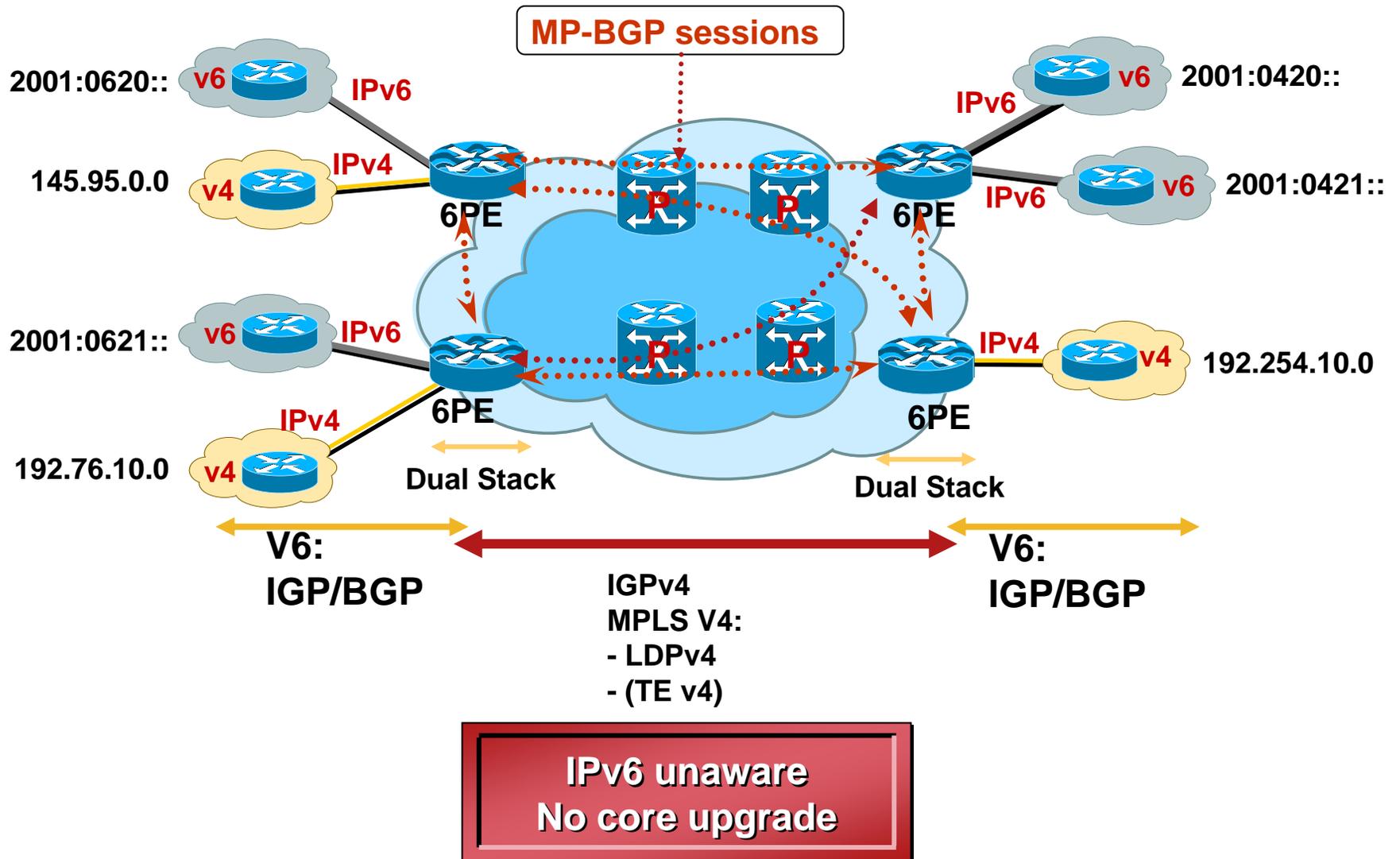


- 6PE – RFC 4798 – defined by Cisco and available from IOS
- MPLS/IPv4 Core Infrastructure is IPv6-unaware
- PEs are updated to support Dual Stack/6PE
- IPv6 reachability exchanged among 6PEs via iBGP (MP-BGP)
- IPv6 packets transported from 6PE to 6PE inside MPLS

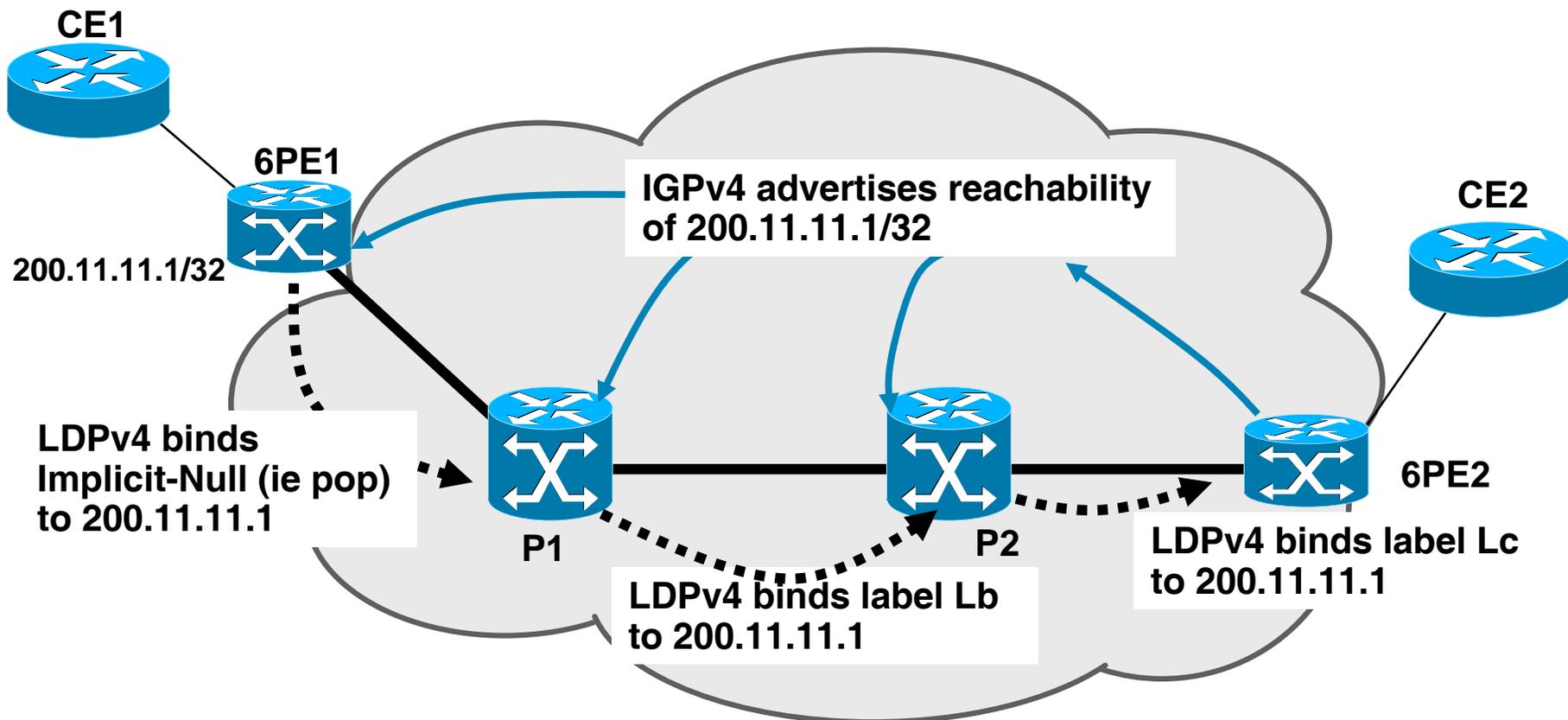
6PE: The Technology

- It's an implicit method to tie-up a v4-signalled Label Switch Path with IPv6 routes announced via MP-BGP
- Apply RFC2547bis architecture to IPv6
 - IPv4/MPLS Core Infrastructure remains IPv6-unaware
 - PEs are updated to support Dual Stack/6PE
 - IPv6 reachability exchanged among 6PEs via MP-iBGP
 - IPv6 packets transported from 6PE to 6PE inside IPv4 LSPs

6PE Overview

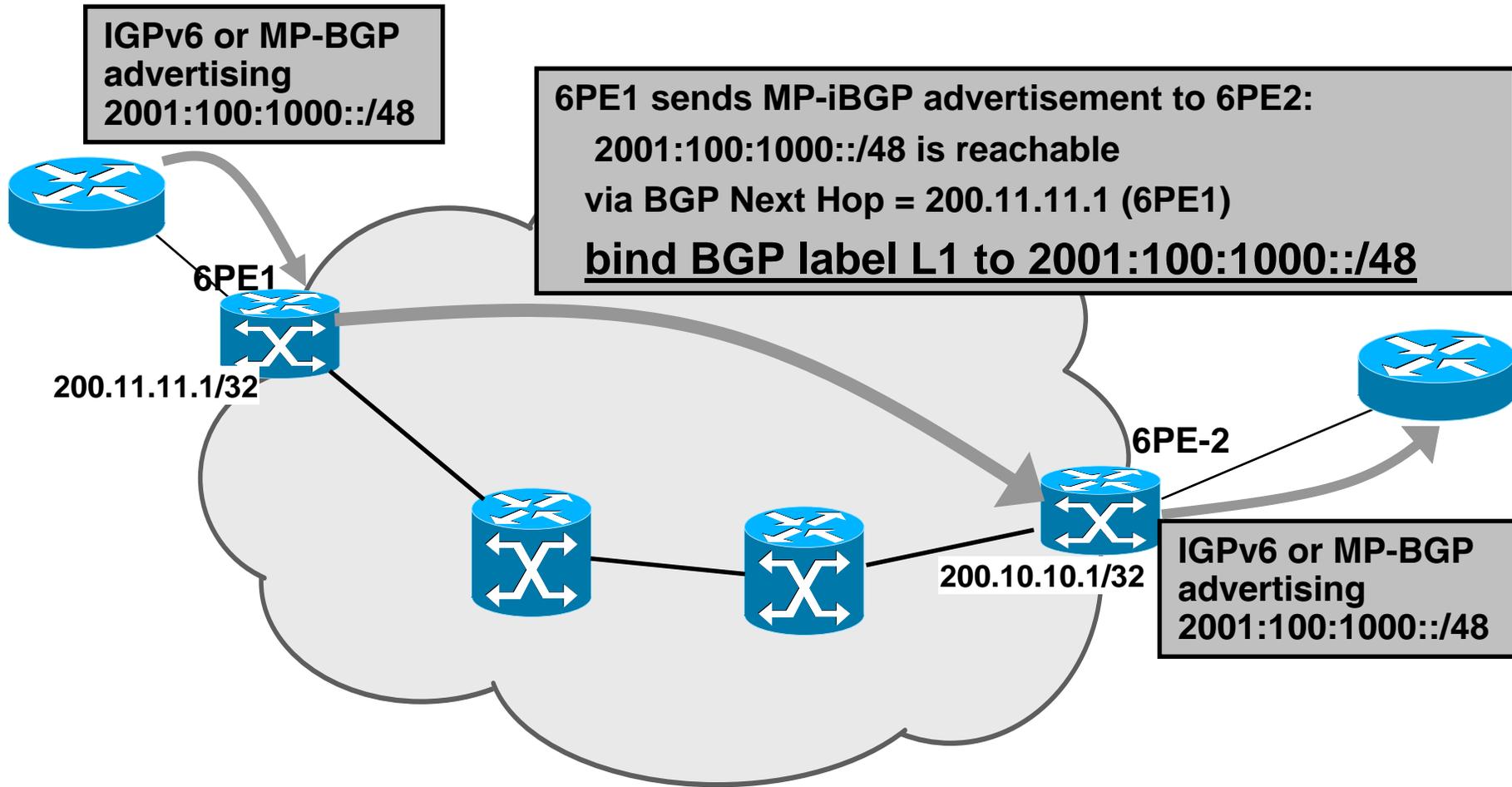


6PE LSP Setup

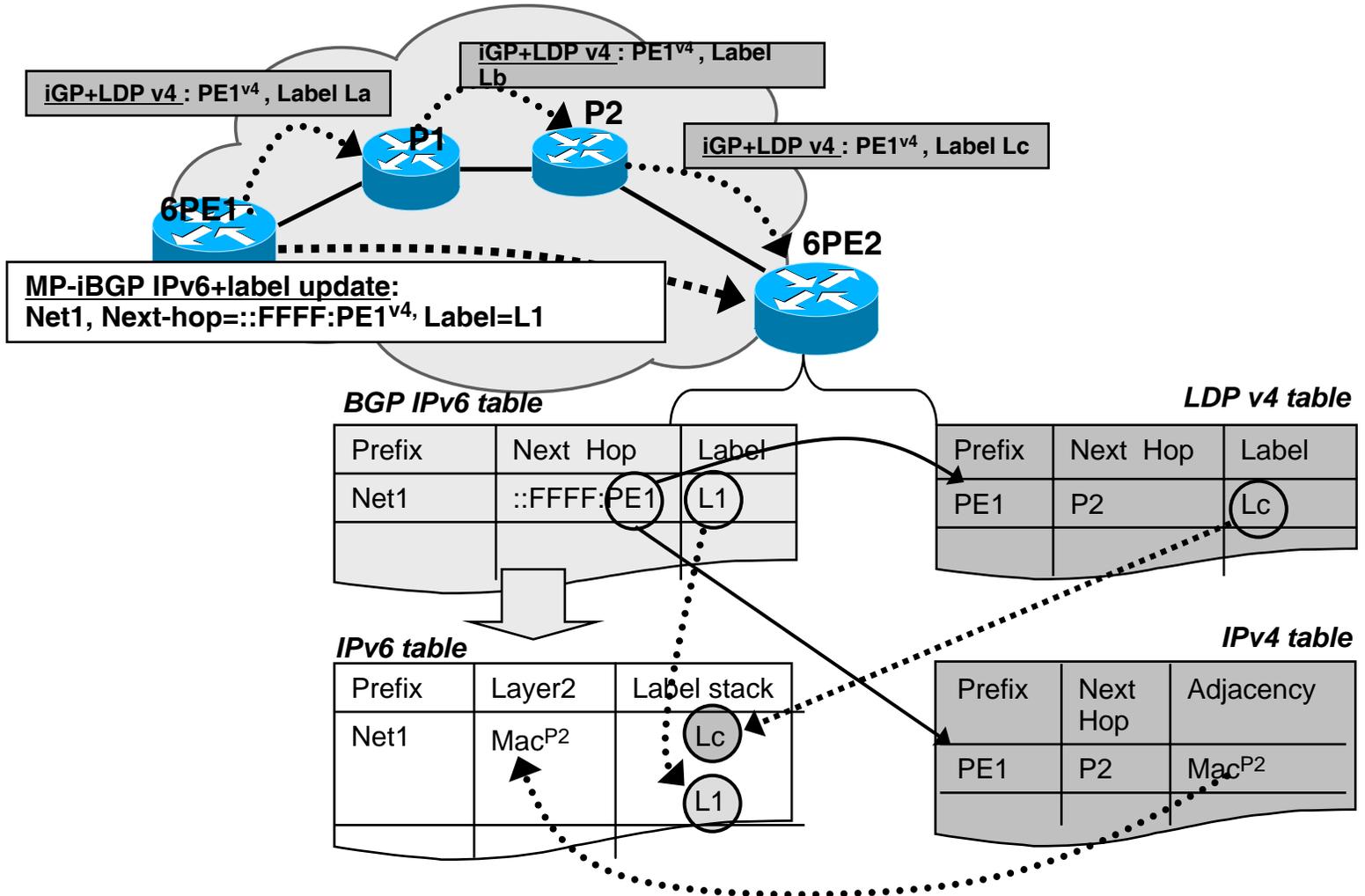


Regular IPv4 Routing and IPv4 Label Distribution

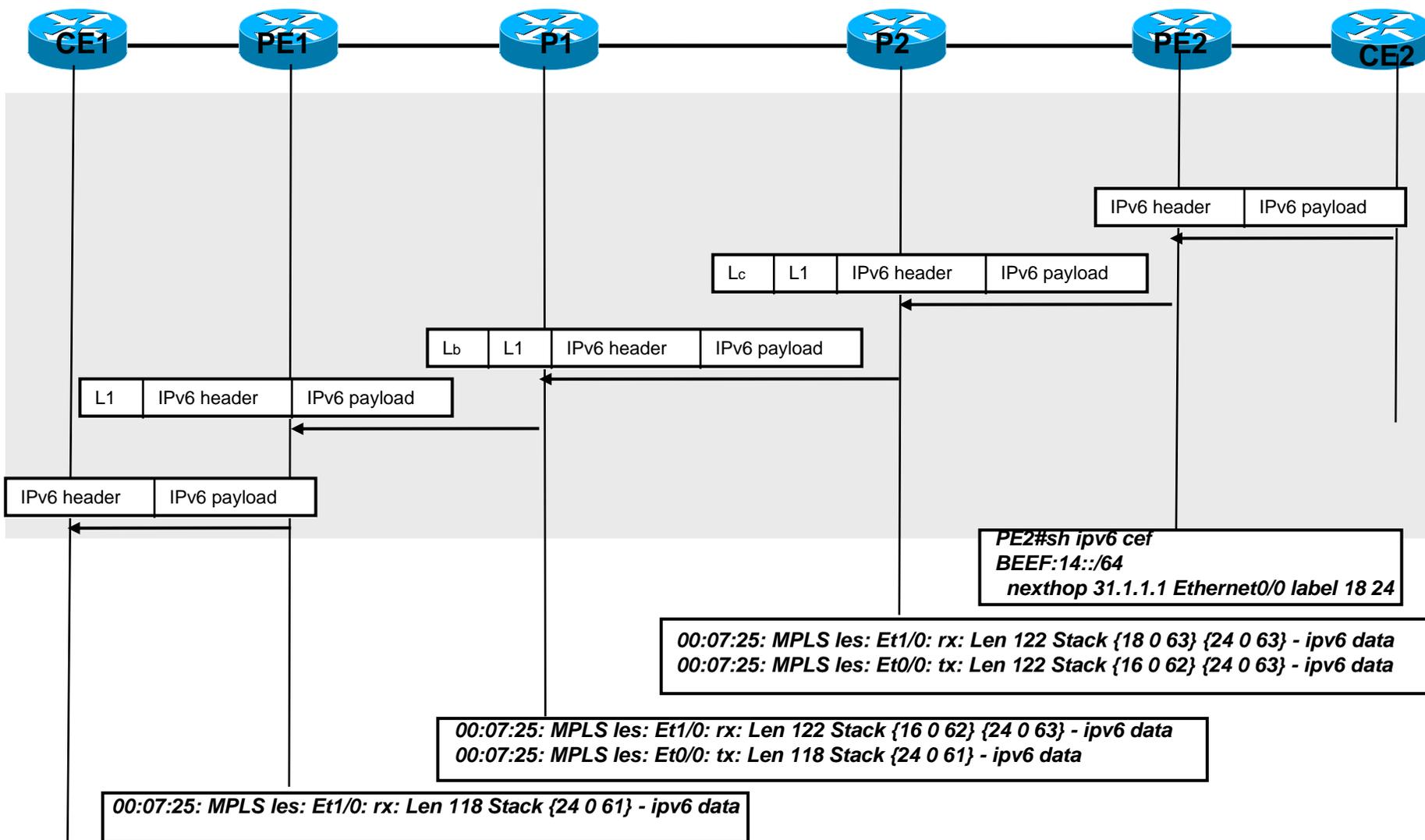
6PE: Routing



6PE: Building the Label Stack



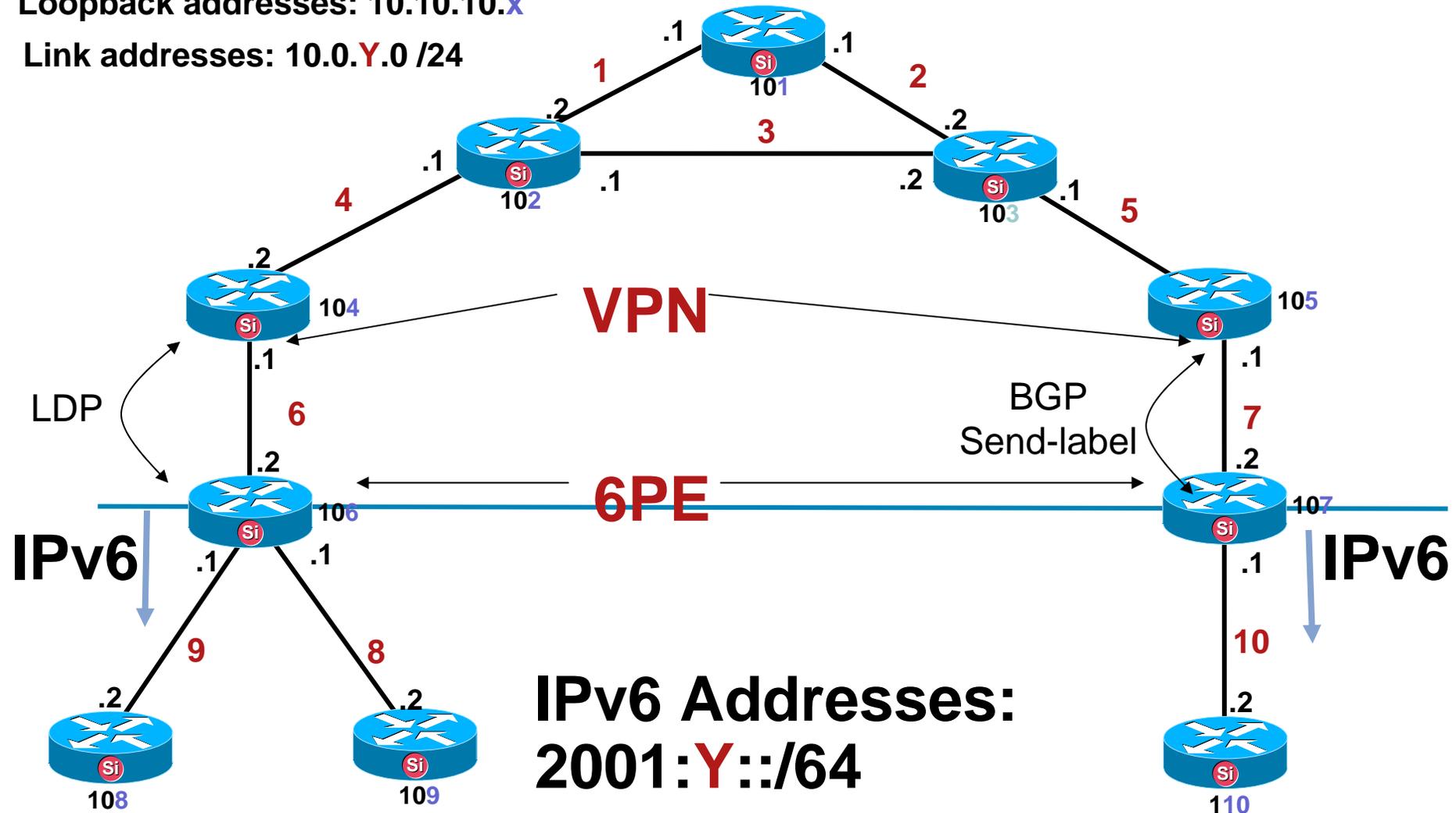
Forwarding



6PE + CsC – To Include IPv6 on Existing VPN

Loopback addresses: 10.10.10.x

Link addresses: 10.0.Y.0 /24



Cisco IOS Software Releases for 6PE

- IPv6 Start Here
- http://www.cisco.com/en/US/products/sw/iosswrel/ps5187/products_configuration_guide_chapter09186a00801d65ed.html
- Since Release 12.0(22)S on Cisco 12000 Series
 - Release 12.0(25)S for 6PE Hardware Assistance on Engine 3
 - Release 12.0(27)S 6PE Hardware Acceleration on Engine 4/4+
 - Release 12.0(31)S 6PE Hardware Acceleration on Engine 5
- Available on Cisco 7600, Release 12.2SR and Catalyst 6500, Release 12.2SX
 - Initially available from Release 12.2(14)S on Cisco 7200/7400/7500 Series

Cisco IOS Software Releases for 6PE (Cont.)

- Introduced on Cisco IOS Software Release 12.2(15)T, then Release 12.3 mainline and later releases
- Since Cisco IOS Software Release 12.2(31)SB on Cisco 10000

IPv6 over MPLS

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- What technology ?
- 6PE deep-dive
- 6VPE deep-dive

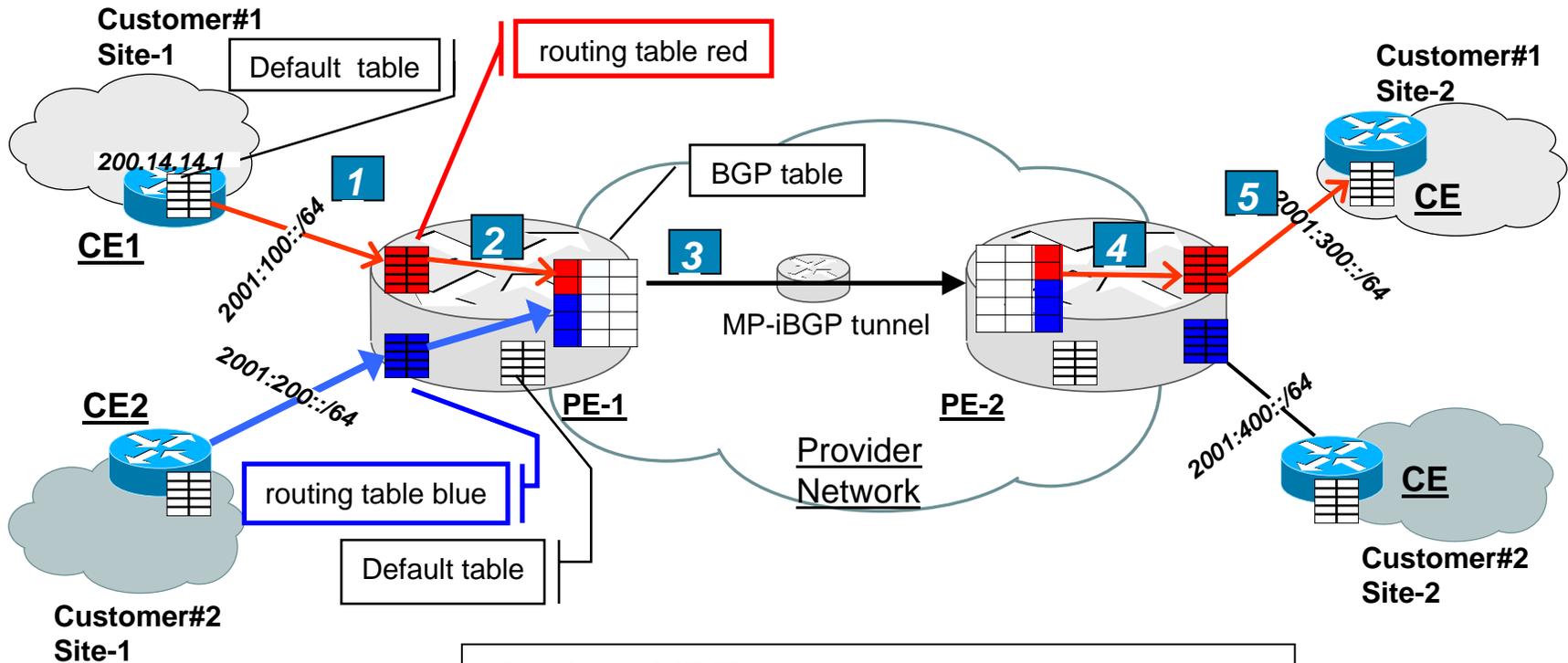
6VPE (RFC 4659) —What Is It?

- For VPN customers, IPv6 VPN service is exactly the same as IPv4 VPN service
- Current 6PE is “like VPN” but this is NOT VPN – ie: global reachability
- Coexistence mechanism for combining IPv4 and IPv6 VPN services over an MPLS backbone
- It enables services such as
 - “IPv6 VPN Access”
 - Carriers Supporting Carriers
 - Access to IPv6 services supplied by the SP itself

6VPE—The Technology

	VPNv4	6VPE
RD	2bytes:6bytes TYPE:VALUE	2bytes:6bytes TYPE:VALUE
RT (extended community)	2bytes:6bytes TYPE:VALUE	2bytes:6bytes TYPE:VALUE
VPN address	<u>8bytes:4bytes</u> <u>RD:IPv4-address</u>	<u>[8bytes]16bytes</u> <u>[RD]IPv6-address</u>
MP_REACH-NLRI	AFI=1 SAFI=128	AFI=2 SAFI=128
NLRI	<length, IPv4-prefix, label>	<length, IPv4-prefix, label>
VRF (Virtual Routing & forwarding instance)	1 VRF = 1 RIB + 1 FIB	MP-VRF
Nexthop	0:IPv4-address	[0>::FFFF:IPv4-address [0]:IPv6-address [0]:IPv6-LL-address
Peering	IPv4-address	IPv4-address IPv6-address IPv6-LL-address

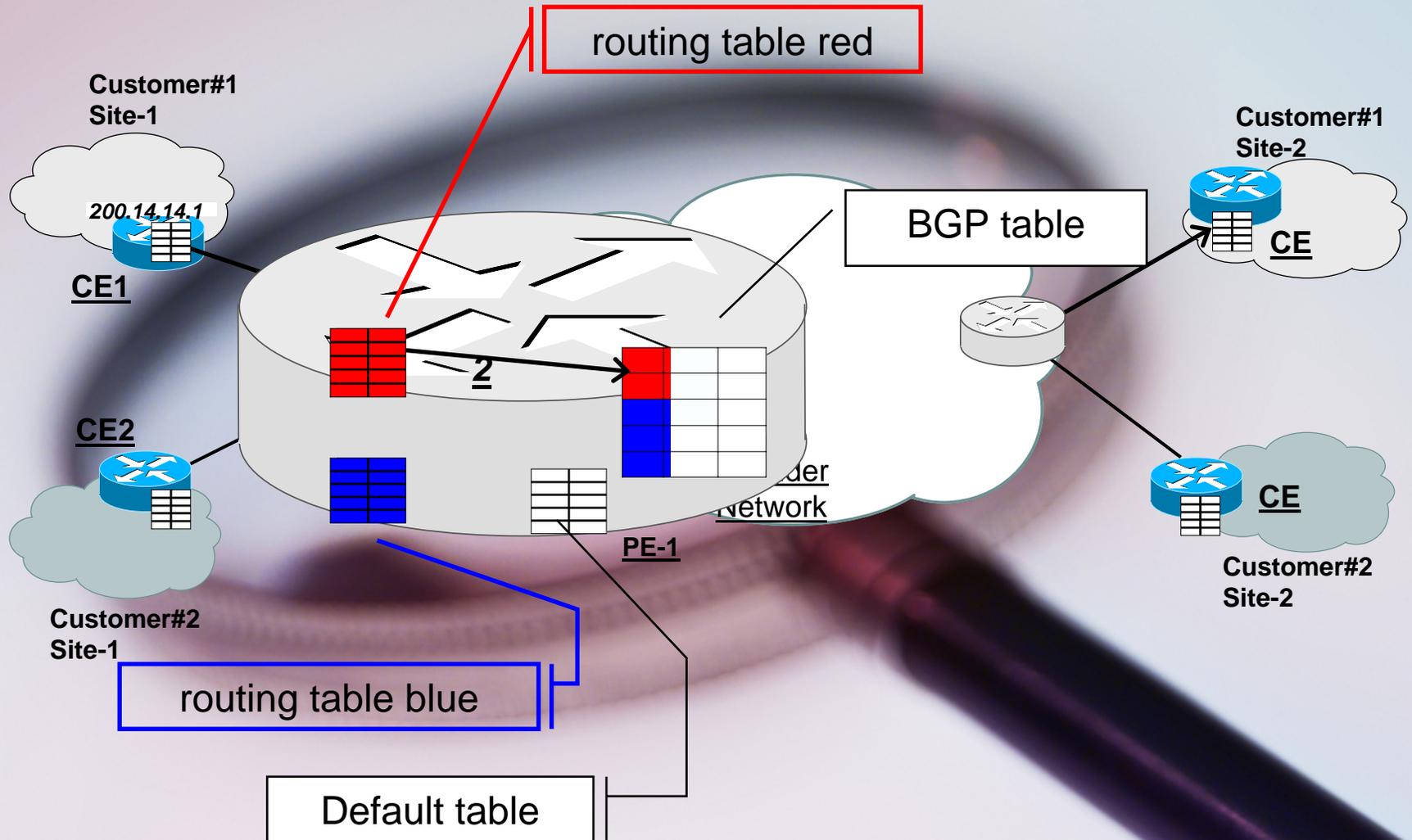
Routing Tables



At the 6VPE

- A set of private IPv6 routing tables (red, blue)
- A default routing table (IPv4 or IPv6)
- A BGP table (AF VPNv6)

Routing Tables: Details



Routing Tables: Examples

```
PE1#show ipv6 route vrf blue
```

```
IPv6 Routing Table - blue - 7 entries
```

```
C 2001:100::/64 [0/0]
   via Ethernet4/0, directly connected
B 2001:300::/64 [200/0]
   via 200.10.10.1%Default-IP-Routing-Table, indirectly connected
```

```
PE1#show ipv6 route vrf red
```

```
IPv6 Routing Table - red - 10 entries
```

```
C 2001:200::/64 [0/0]
   via Ethernet0/0, directly connected
B 2001:400::/64 [200/0]
   via 200.10.10.1%Default-IP-Routing-Table, indirectly connected
```

```
PE1#show ip route
```

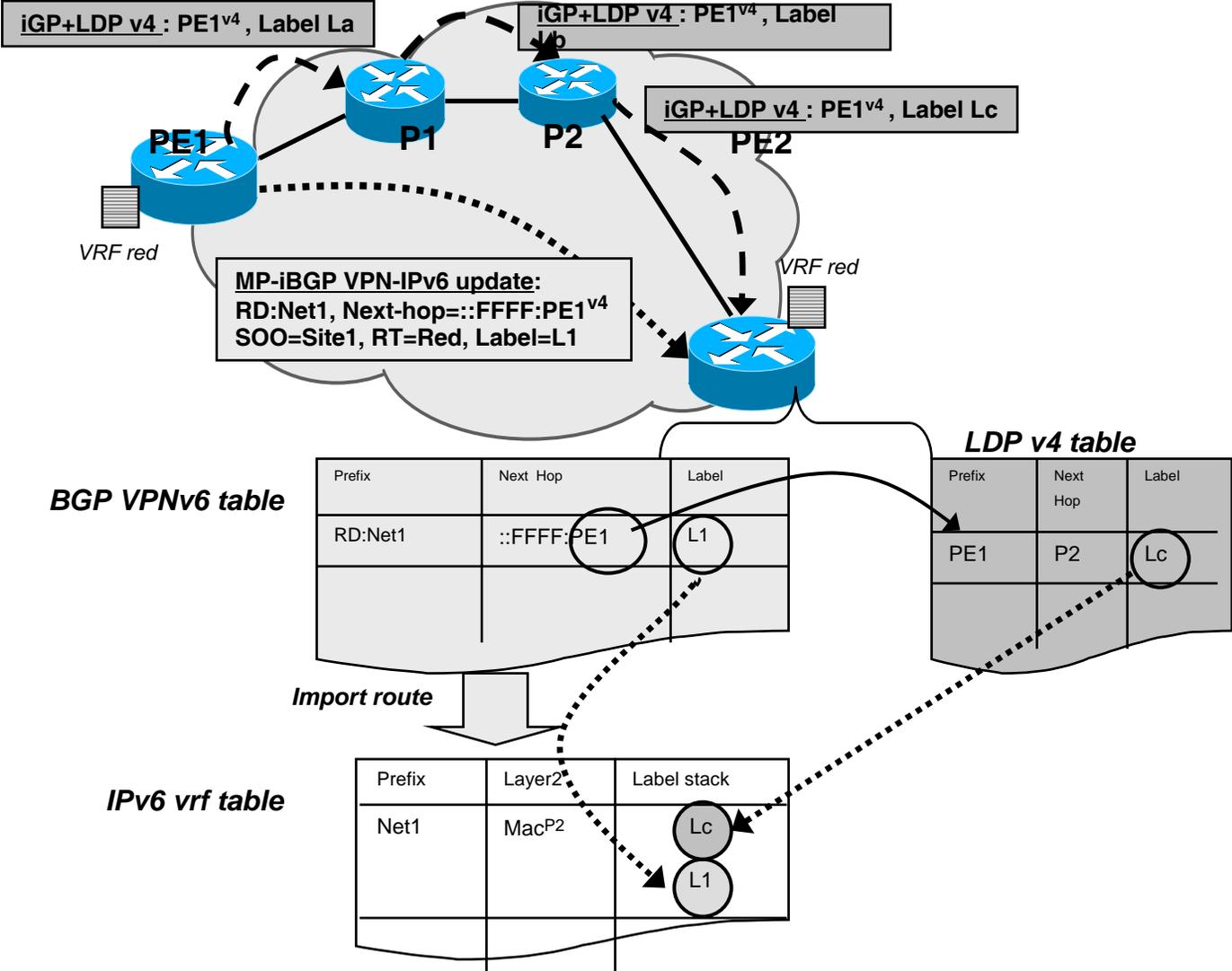
```
200.10.10.0/32 is subnetted, 1 subnets
i L1 200.10.10.1 [115/30] via 40.1.1.3, Ethernet1/0
31.0.0.0/24 is subnetted, 1 subnets
i L1 31.1.1.0 [115/30] via 40.1.1.3, Ethernet1/0
200.11.11.0/32 is subnetted, 1 subnets
C 200.11.11.1 is directly connected, Loopback0
```

BGP VPNv6 Table Example

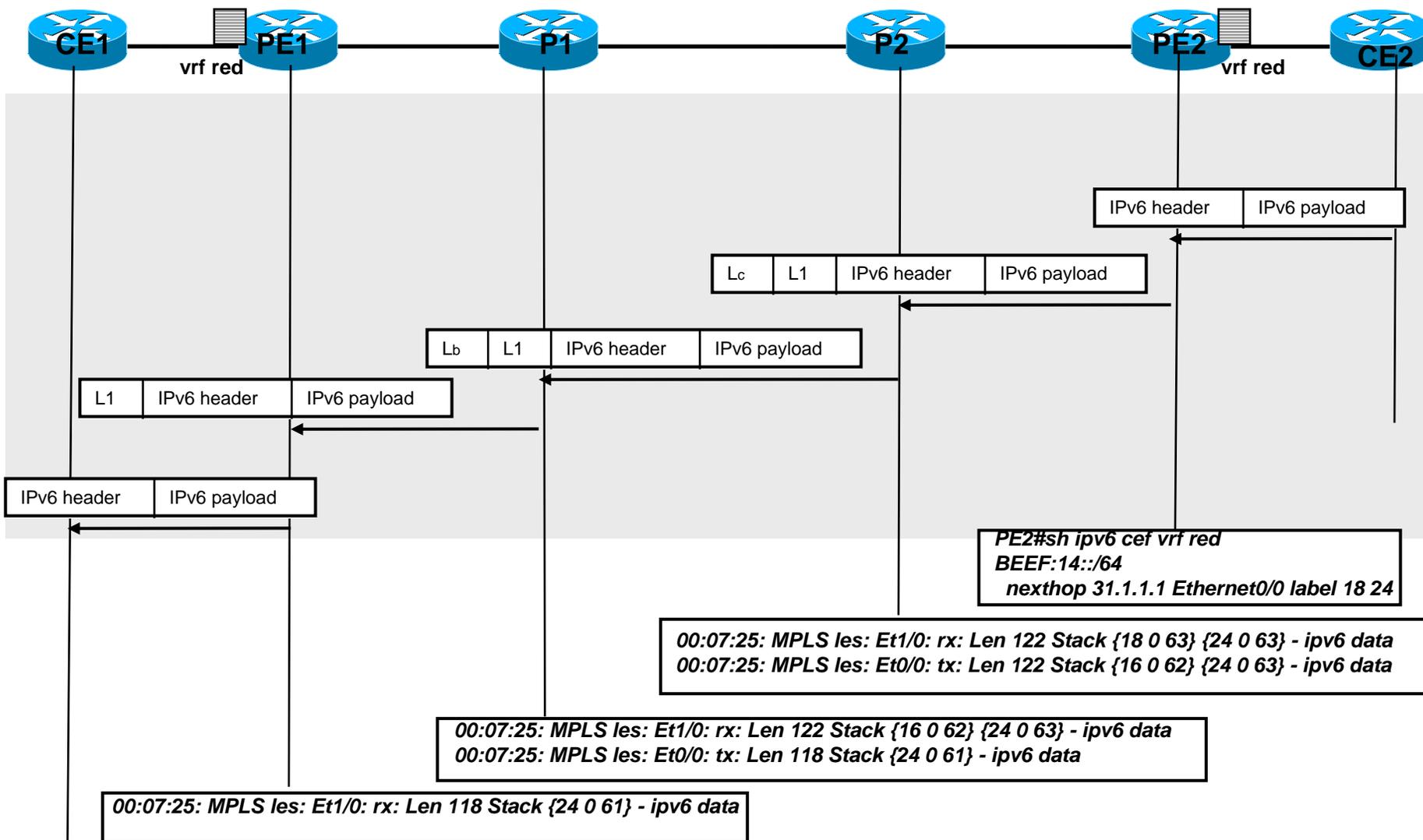
```
PE1#show bgp vpnv6 unicast all
```

Network	Next Hop	Metric
Route Distinguisher: 100:1 (default for vrf blue)		
* 2001:100::/64	2001:100::72a	0
*>	::	0
*>i2001:300::/64	::FFFF:200.10.10.1	0
Route Distinguisher: 200:1 (default for vrf red)		
*> 2001:200::/64	::	0
*> 2001:400::/64	::FFFF:200.10.10.1	0

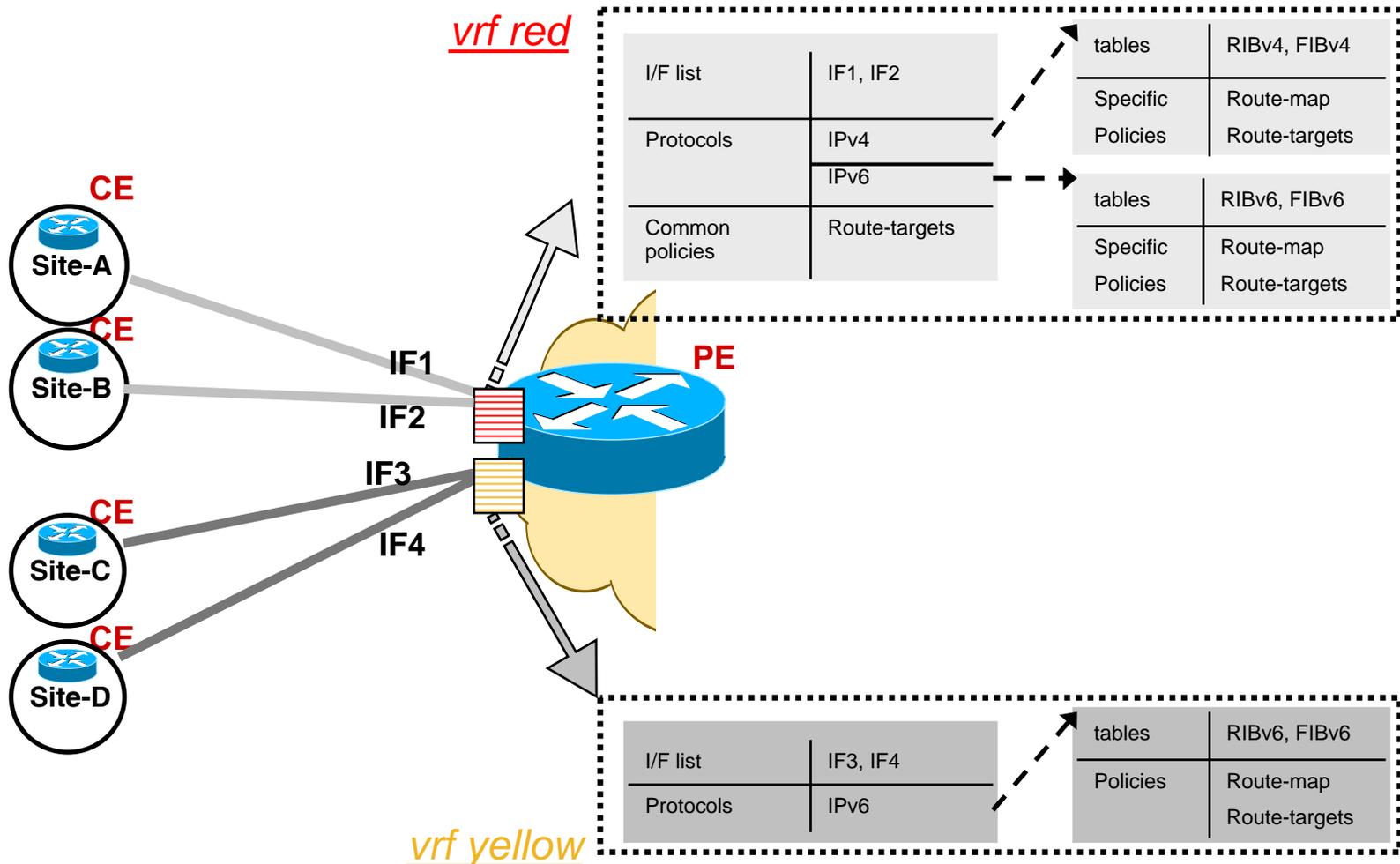
Building the Label Stack for 6VPE



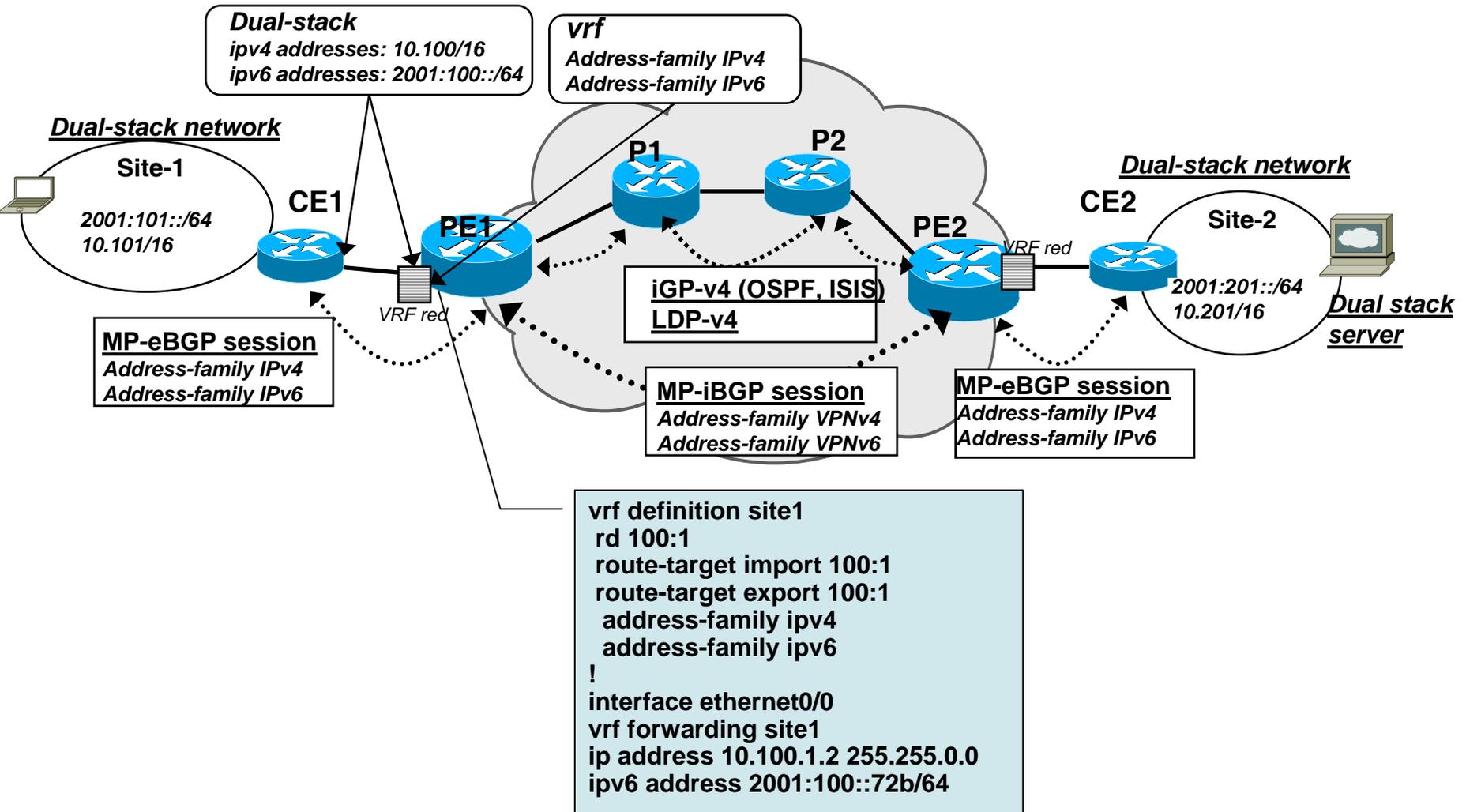
Forwarding



Multi-Protocol VRF



Multi-Protocol VRF Deployment



6VPE Configuration Examples—IPv6 VRF

```
vrf definition site1
rd 1000:1
route-target export 1000:1
address-family ipv4
address-family ipv6
```

VRF Configuration

```
interface Ethernet0/0
vrf forwarding site1
ipv6 address 2001:100::72b/64
ip address 10.100.1.2 255.255.255.0
```

Interface Configuration

```
router bgp 100
neighbor 200.10.10.1 remote-as 100
neighbor 200.10.10.1 update-source Loopback0
!
address-family ipv4 vrf site1
neighbor 10.100.1.1 remote-as 200
neighbor 10.100.1.1 activate
!
address-family ipv6 vrf site1
neighbor 2001:100::72a remote-as 200
neighbor 2001:100::72a activate
!
address-family vpnv4
neighbor 200.10.10.1 activate
neighbor 200.10.10.1 send-community extended
!
address-family vpnv6
neighbor 200.10.10.1 activate
neighbor 200.10.10.1 send-community extended
```

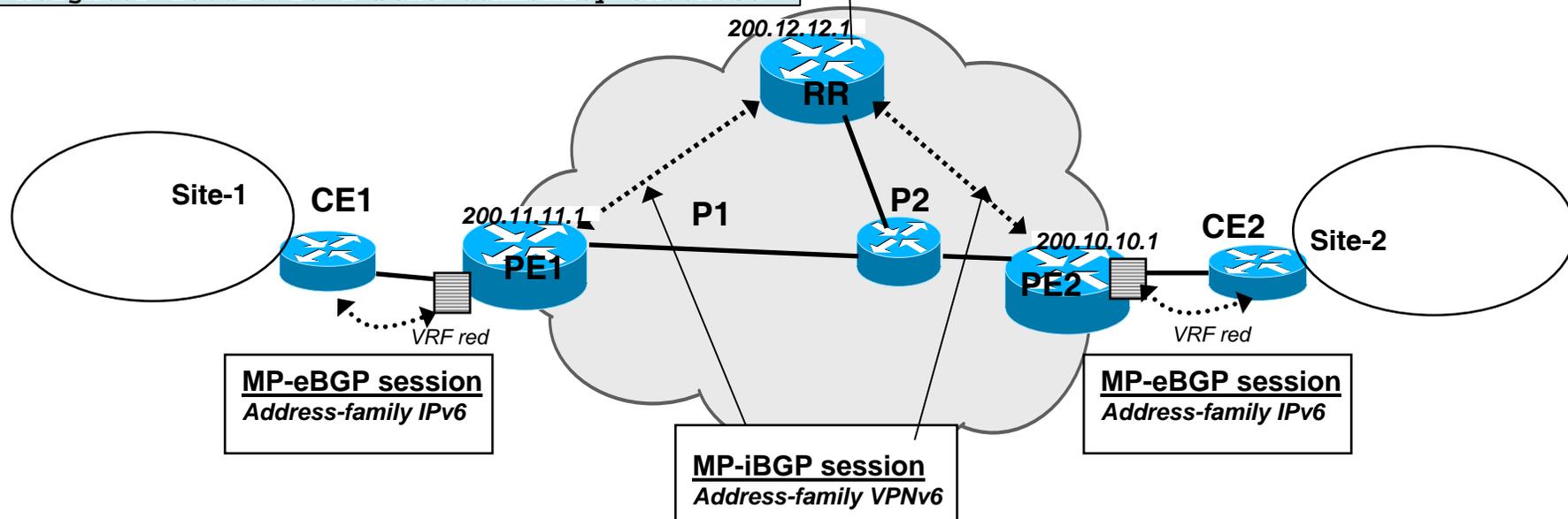
BGP Configuration

6VPE Deployment Scaling Considerations

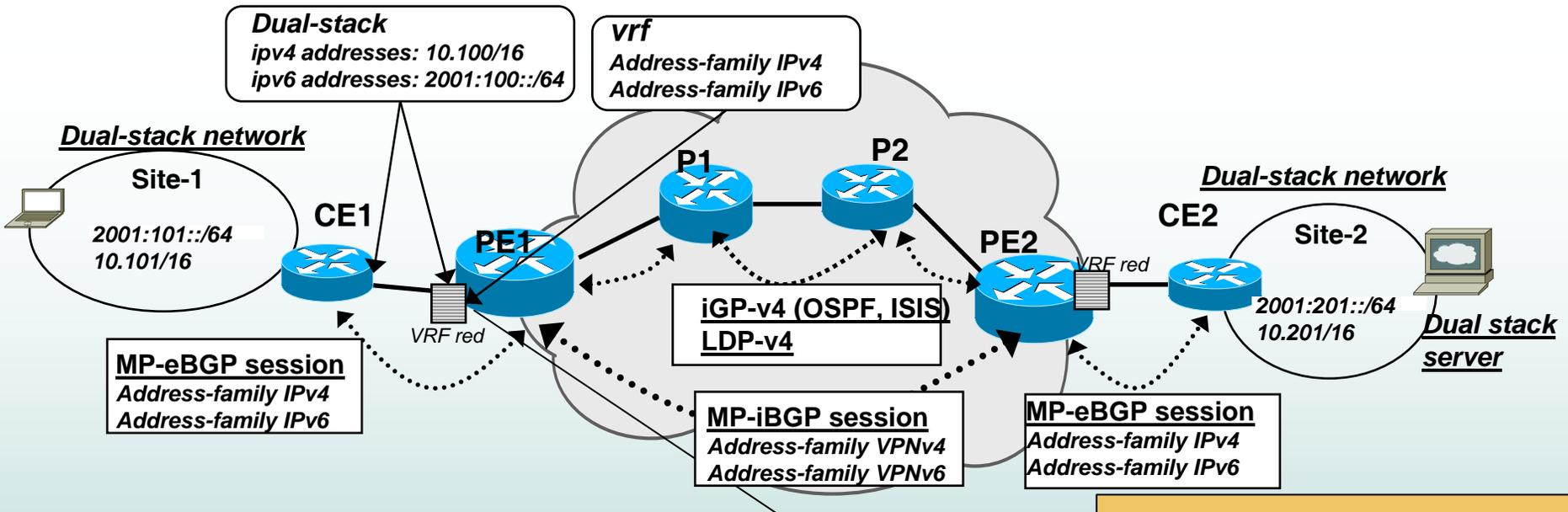
- Route Reflectors
- Route Refresh and Automatic Route Filtering
- Outbound Route Filtering (ORF)

Route-Reflector Based 6VPE Example

```
router bgp 101
no bgp default route-target filter
 neighbor 200.11.11.1 remote-as 101
 neighbor 200.10.10.1 remote-as 101
 neighbor 200.11.11.1 update-source Loopback0
 neighbor 200.10.10.1 update-source Loopback0
!
address-family vpnv6
 neighbor 200.11.11.1 activate
 neighbor 200.11.11.1 route-reflector-client
 neighbor 200.11.11.1 send-community extended
 neighbor 200.10.10.1 activate
 neighbor 200.10.10.1 route-reflector-client
 neighbor 200.10.10.1 send-community extended
```



IPv6 Integration on MPLS VPN Infrastructure



```

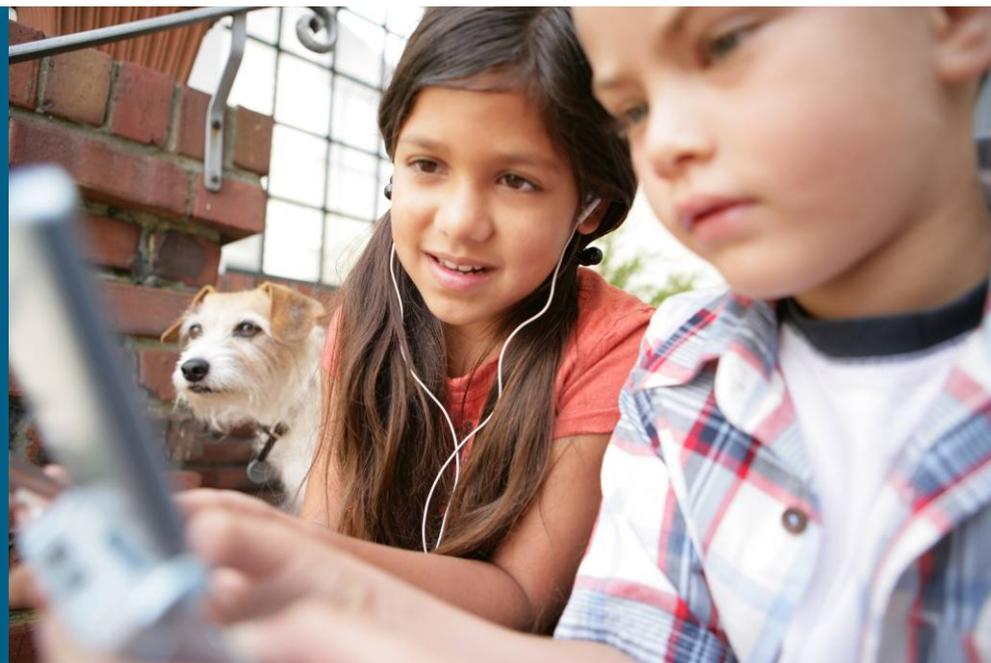
vrf definition site1
rd 100:1
route-target import 100:1
route-target export 100:1
address-family ipv4
address-family ipv6
!
interface ethernet0/0
vrf forwarding site1
ip address 10.100.1.2 255.255.0.0
ipv6 address 2001:100::72b/64
  
```

- **MPLS/IPv4 Core Infrastructure is IPv6-unaware**
- **PEs are updated to support Dual Stack/6VPE**
- **IPv6 VPN can co-exist with IPv4 VPN – same scope and policies**
- **6VPE – RFC 4659 – Cisco authored for IPv6 VPN over MPLS/IPv4 infrastructure**
- **Cisco IOS Release 12.2(33)SRB on Cisco 7600, IOS-XR 3.5 on Cisco 12000**

Conclusions

- IPv6 migration does not “need” MPLS but, where MPLS is deployed, it enables attractive approaches for IPv6 integration
- Cisco IPv6 and MPLS solutions provides the broadest deployment scenario feature set
- Cisco 6PE & 6VPE are ones such IPv6 integration approach over IPv4 MPLS, which offers IPv6 deployment at marginal cost/risk
 - No upgrade/reconfiguration in IPv4/MPLS core
 - IPv6 simultaneously with IPv4, IPv4 VPNs, L2 services, etc.

Q and A





More Information

- CCO IPv6 - <http://www.cisco.com/ipv6>
- Cisco IPv6 Solutions - http://www.cisco.com/en/US/tech/tk872/technologies_white_paper09186a00802219bc.shtml
- Deployment Guides - http://www.cisco.com/en/US/products/ps6553/products_data_sheets_list.html
- IPv6 Application Notes - http://www.cisco.com/warp/public/732/Tech/ipv6/ipv6_techdoc.shtml
- Cisco IOS IPv6 Manuals - http://www.cisco.com/en/US/products/ps6441/products_configuration_guide_book09186a008049e1d7.html

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