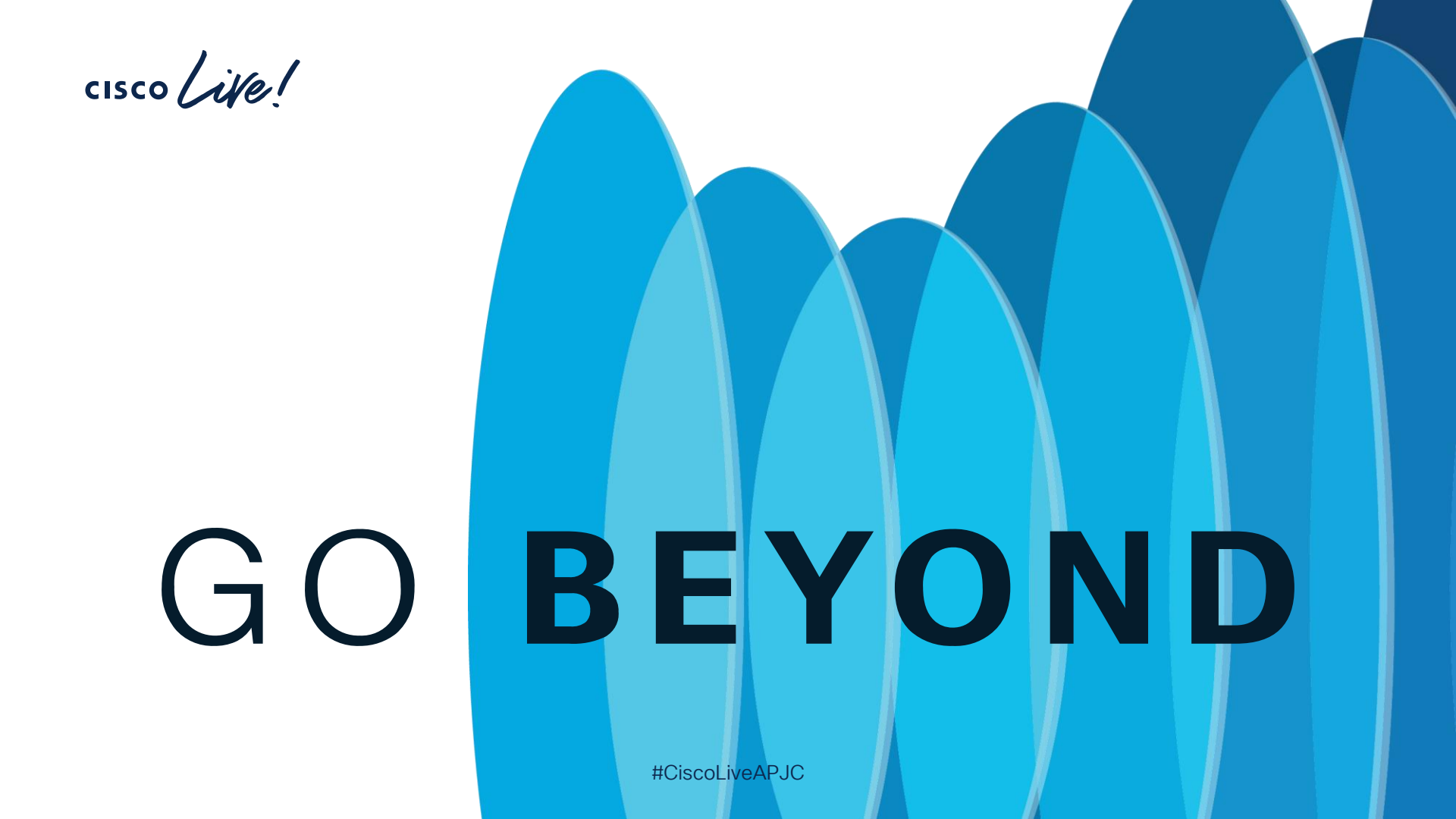
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MPLS to Segment Routing: Migration and Best Practices

Jakub Horn
Principal Technical Marketing Engineer
BRKSPG-1569

Cisco Webex App

https://ciscolive.ciscoevents.com/ciscolivebot/#BRKSPG-1569

Questions?

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Agenda

- Introduction
- Addressing Plan for SRv6
- Services Migration
- MPLS to SRv6 Interworking
- Demonstration
- Conclusion

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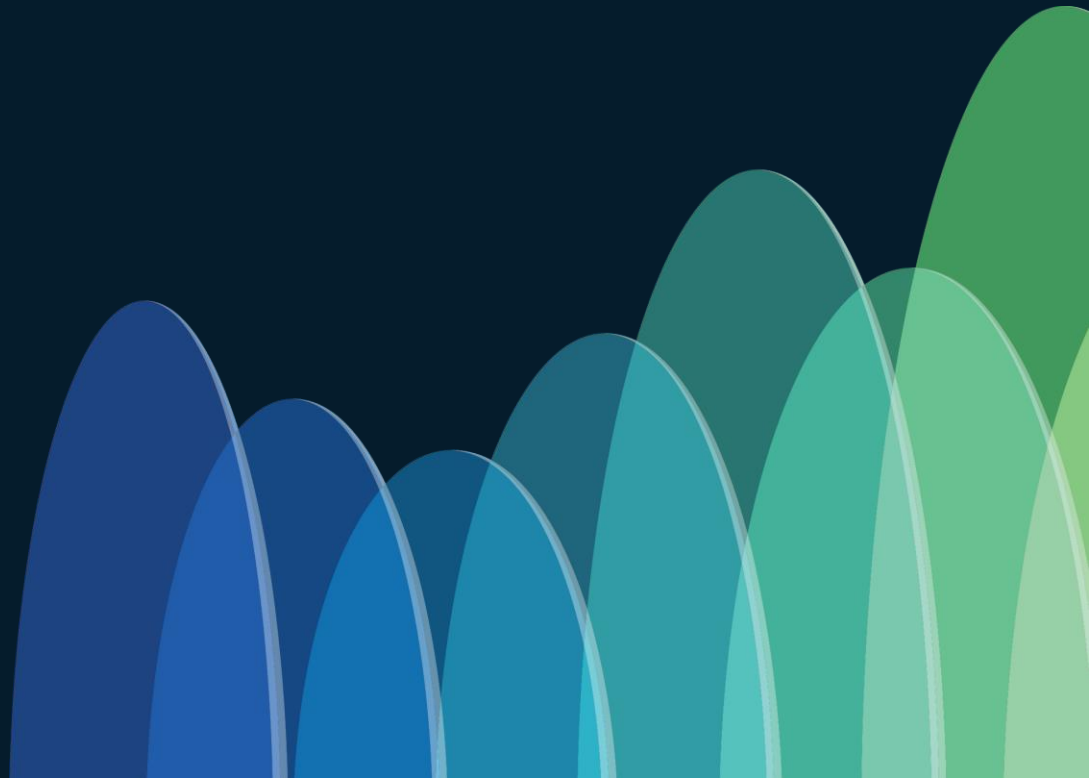
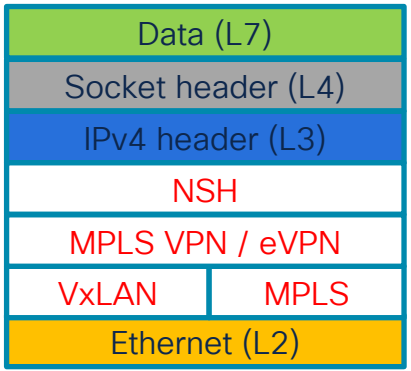
Introduction



IPv4 limitations & work-arounds

Network Functions	IPv4
Reachability	IPv4 Header
Engineered Load Balancing	MPLS Entropy Label, VxLAN UDP
VPN	MPLS VPN's, VxLAN
Traffic Engineering	RSVP-TE, SR-TE MPLS
Source Routing	SR-TE MPLS
Service Chaining	NSH

Address space 32-bit limitation
No optional header
IPv4 header doesn't support
- VPN
- Traffic Engineer
- Service Chaining
- Engineered Flow optimization
- Source-Routing



work-arounds

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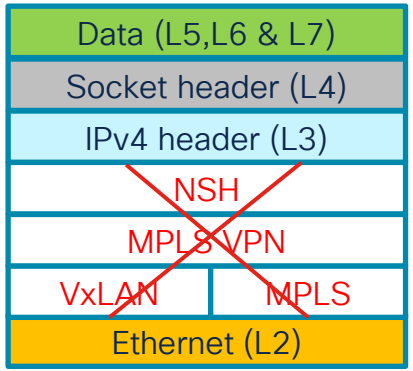
SRv6 Solution

Network Functions	IPv6
Reachability	IPv6 Header
Engineered Load Balancing	IPv6 Header
VPN	IPv6 Header
Traffic Engineering	IPv6 Header
Source Routing	IPv6 Header
Service Chaining	IPv6 Header

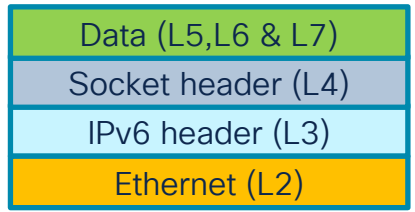
IPv6 Address 128bits
IPv6 Flow Header
- Engineered Flow optimization

SRv6 Header
- Source-Routing
- Traffic Engineering
- VPN
- Service Chaining



SR v6 Segment Routing

Simplicity
(back to OSI model)



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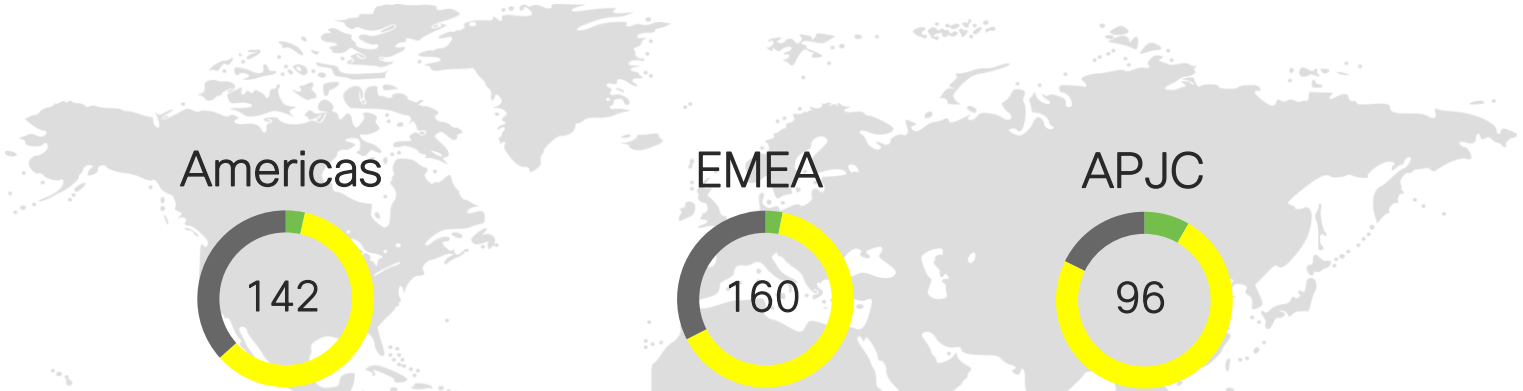
SRv6 deployment status



- Deployed
- Active Testing
- Deployment Planned

SoftBank free LINE indosat ooredoo Rakuten Bell Telefónica T-Mobile

iliad cesnet swisscom Alibaba.com SCHWARZ ITKG XL axiata tpg TELECOM SYMA

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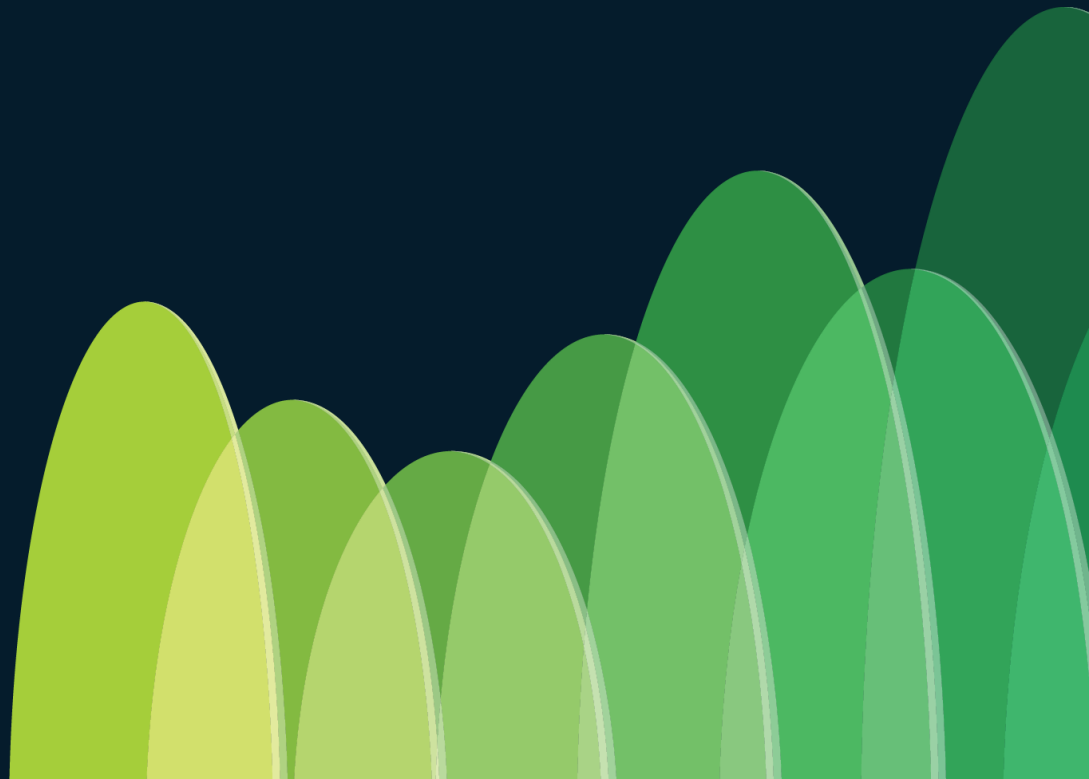
Addressing Plan



Separation between SIDs and addresses

- Infrastructure addressing and SRv6 SID allocation belong to two different planes and are different
  - Infrastructure IP addresses (e.g., link interfaces, loopbacks) are allocated on the management plane
  - SRv6 SIDs are allocated on the service plane
- SRv6 SIDs are assigned to a node independently from the IP addressing of that node
- Even if they are both represented as IPv6 addresses, infrastructure addresses and SIDs cannot be merged and should be allocated off different blocks.

An existing IPv6 address plan is not a constraint for a future SRv6 SID allocation plan.

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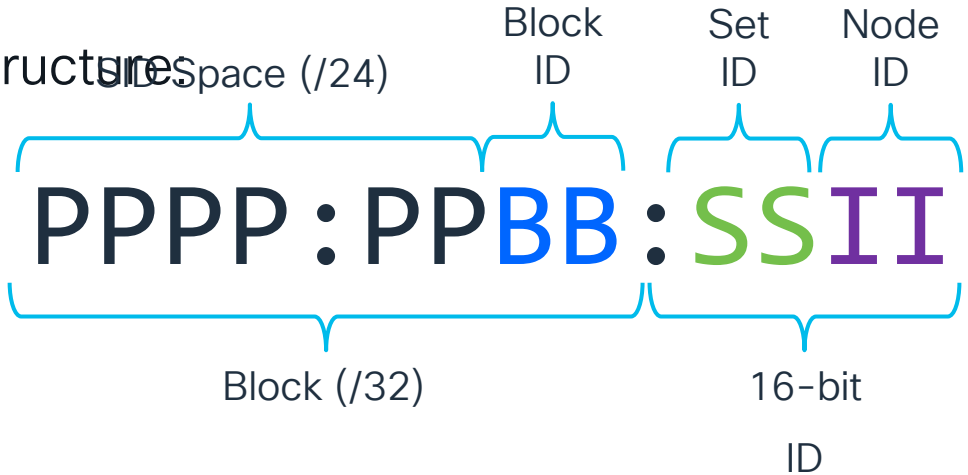
Terminology – uSID F3216

- uSID F3216: uSID format with
  - uSID Block size: 32 bits
  - ID size: 16 bits

- uSID F3216 structures:



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SRv6 Space allocation recommendation

- Private range allocation
  - Recommended allocation
  - Use /24 sub-range from ULA `FC00::/8` space
  - `FCBB:BB00::/24`, with `B` indicating a nibble value picked by operator
- Public range allocation
  - Supported, not advised
  - From allocated public GUA range
- SRv6 range allocation
  - Use /24 sub-range from `5F00::/16`

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uSID Block per slice (Flex Algo) if possible

- 256 Blocks are available in the SRv6 Space:

  `FCBB:BBTT::/32`, with `TT` = slice ID

  - Multiple Blocks can be concurrently used on a node
  - 63 Blocks available on DNX1 platforms (`TT` = 00 to 3E)
- We assume 2 slices (Blocks), e.g.:
  - `FCBB:BB00::/32` Low-cost slice (algo 0) ← focus, other Blocks are similar
  - `FCBB:BB01::/32` Low-delay slice (algo 128)

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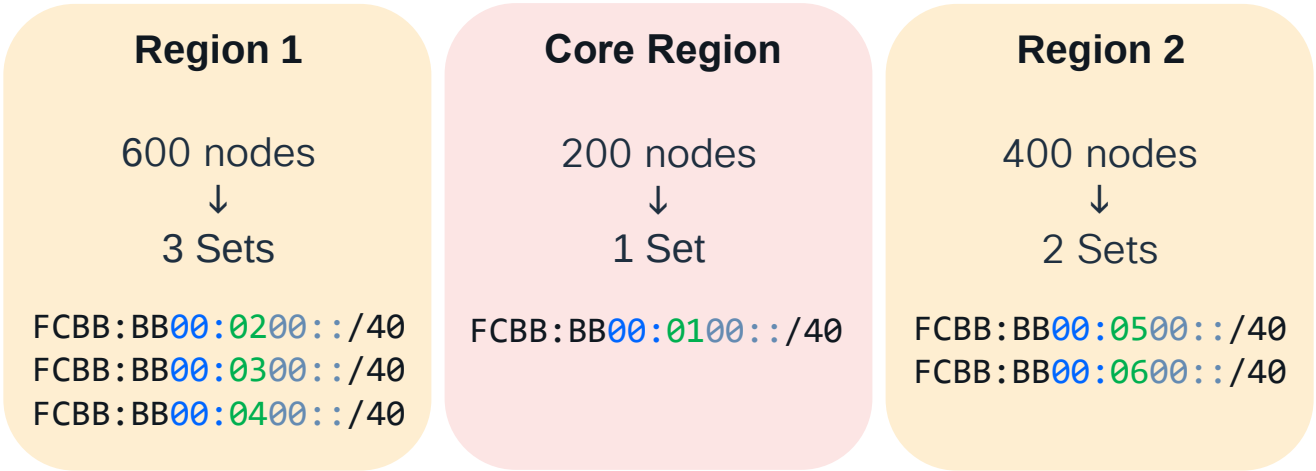
Set Allocation Example

Block: FCBB:BB00::/32



If a region outgrows its allocated Sets, then allocate more Sets to this region

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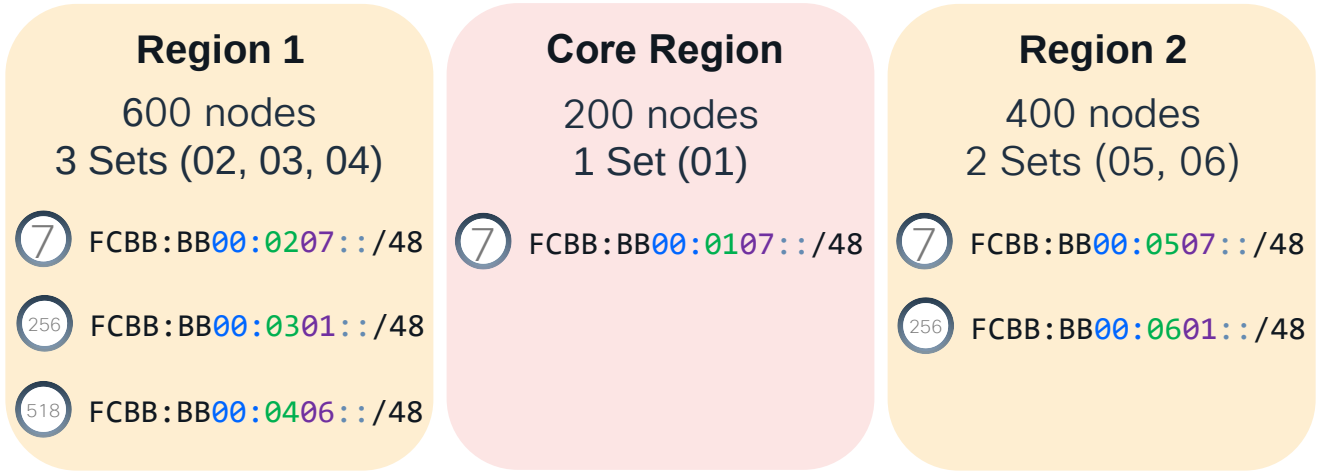
uSID Allocation Example

Block: FCBB:BB00::/32



Remaining unallocated uSIDs in Sets are for future growth

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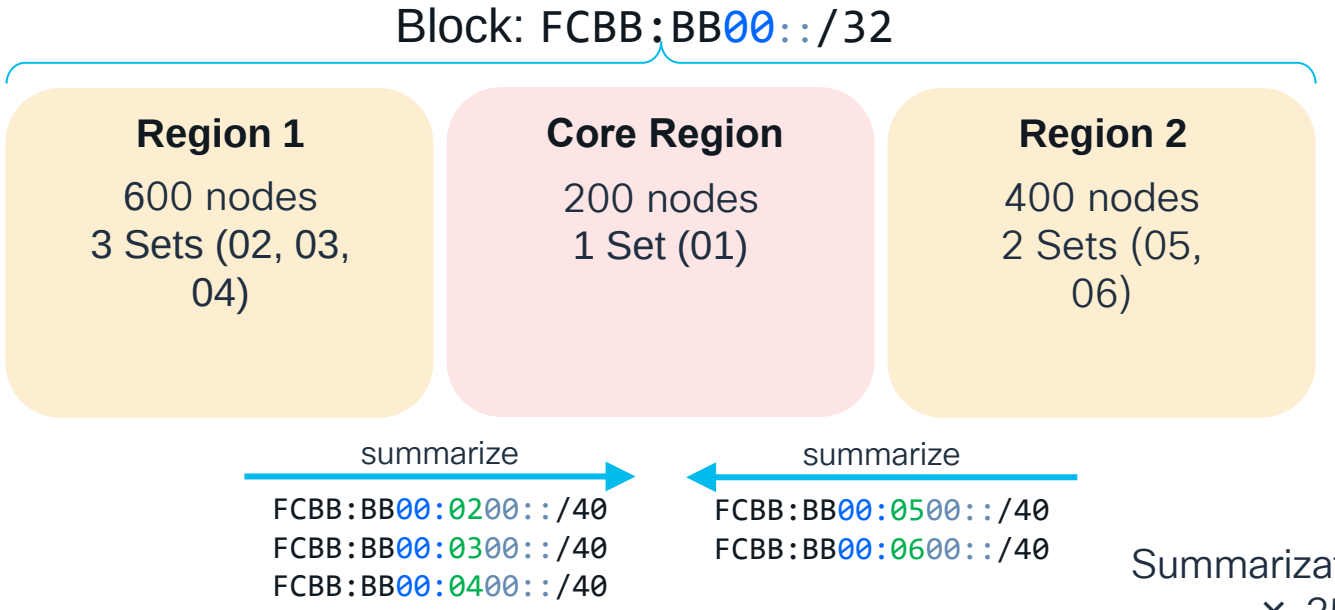
Summarization



Summarization gain:
× 256

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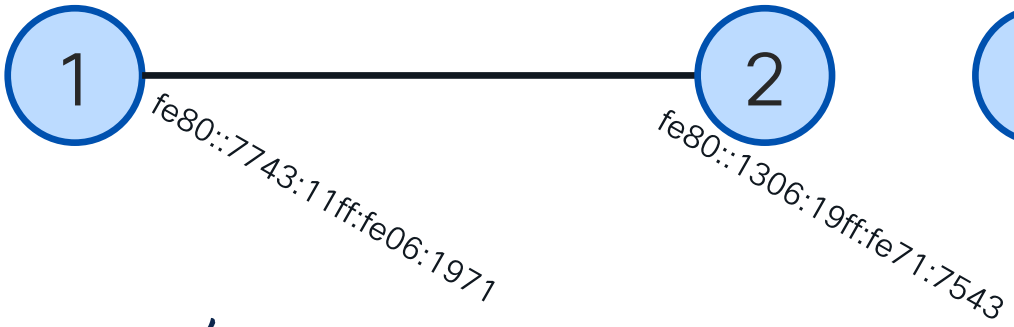
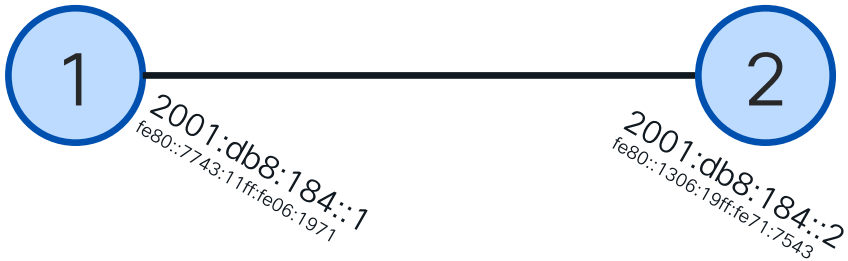
Interface Addressing

- Link Local Only
  - no config
  - no address planning
  - new device insertion
  - smaller LSP
  - Interfaces not remotely reachable
- Global (ULA/GUA)
  - Must be configured
  - Must be planned, maintained
  - Interfaces remotely reachable





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Loopback Addressing

Independent

Locator: fcbb:bb00:3::/48
Lo0: 2001:db8::1/128

From Locator

Locator: fcbb:bb00:3::/48
Lo0: fcbb:bb00:3::1/128

- Smaller LSP
- No loopback addressing planning
- Summarization!!

*Note: only last nibble can be altered!

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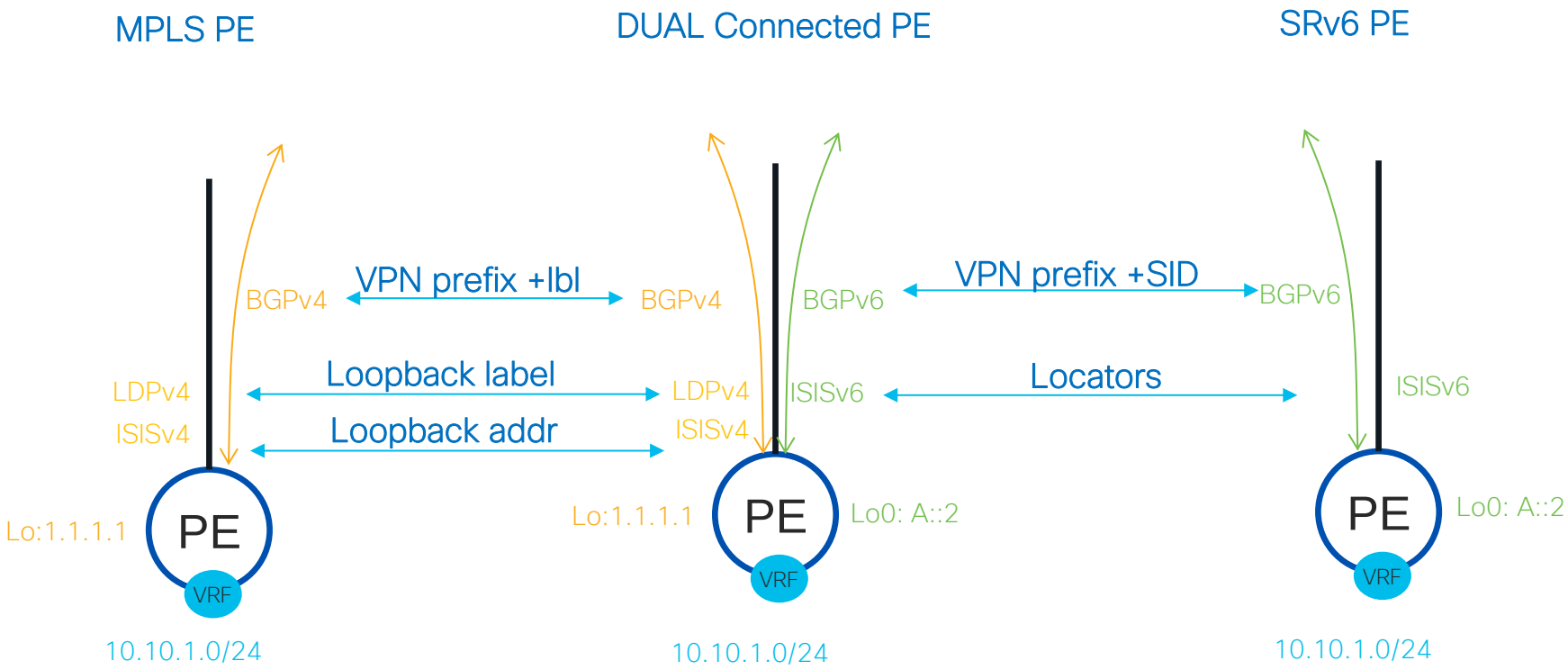
Services Migration

L3 VPN Dual Connected PE



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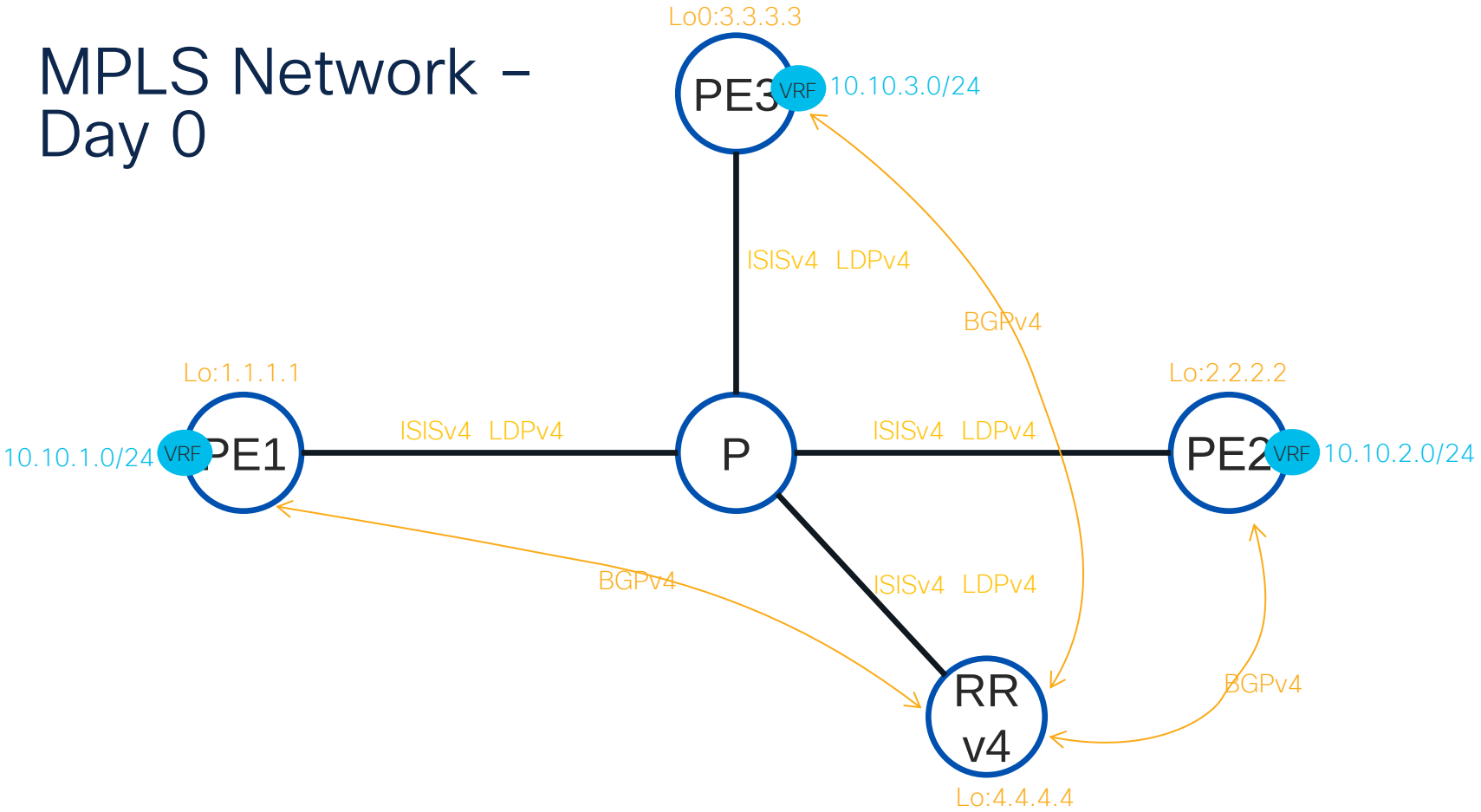
MPLS Network – Day 0



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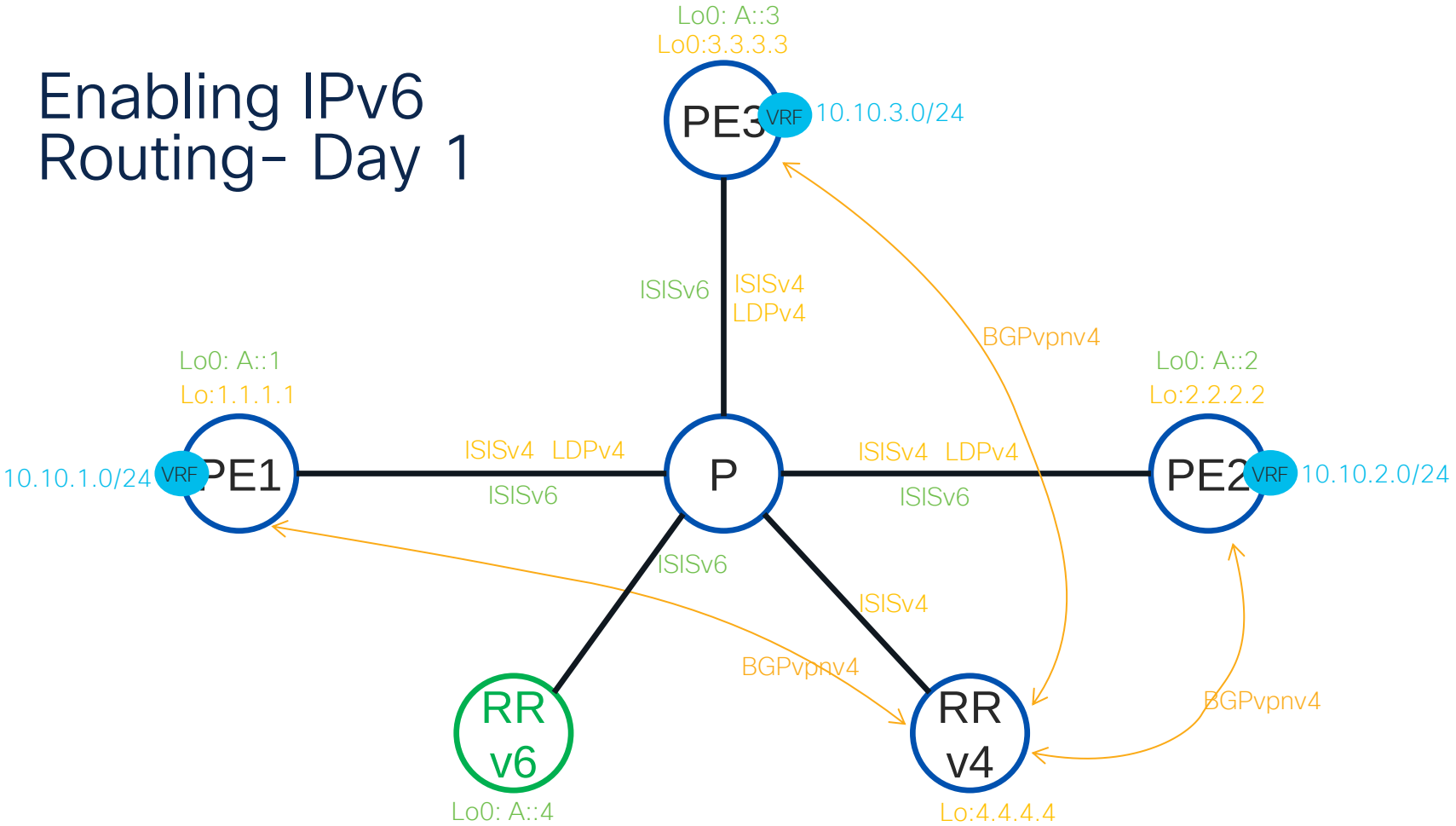
Enabling IPv6 Routing- Day 1



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IPv6 Routing Configuration

```
interface Loopback0
 ipv6 address fcbb:bb00:2::1/128 interface TenGigE 0/0/0/0
  ipv6 enable
router isis 1
 address-family ipv6 unicast
  metric-style wide
  advertise link attributes
  router-id Loopback 0
interface Loopback0
    passive
    address-family ipv6 unicast
  interface TenGigE 0/0/0/1
    circuit-type level-2-only
    point-to-point
    address-family ipv6 unicast
  !
```

Loopback From Locator

LL Only on Interface

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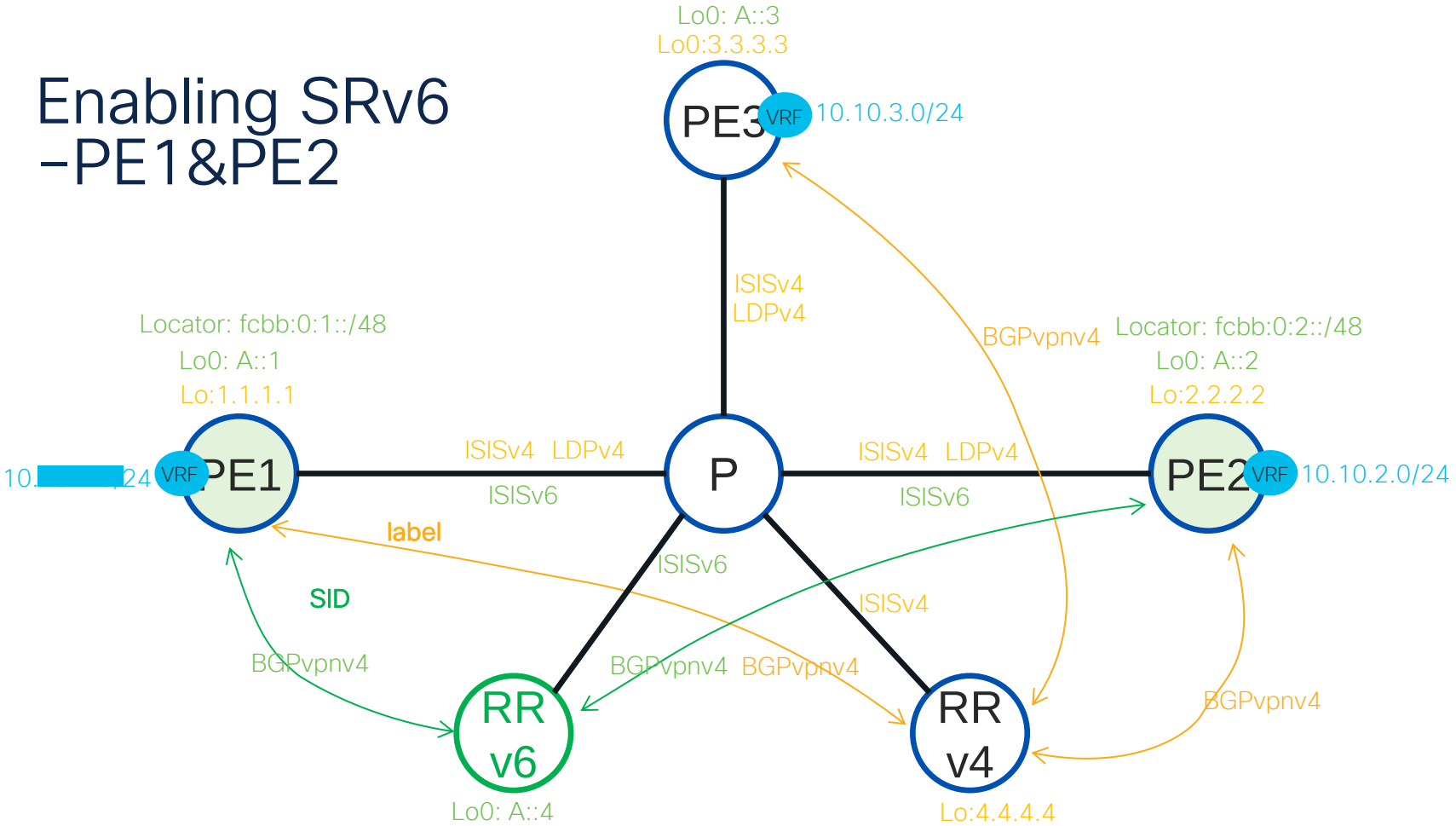
Enabling SRv6 –PE1&PE2



Everything is BGP best path selection driven!! (ie Local Preference)

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Enable SRv6

```
router isis 1
 address-family ipv6 unicast
  segment-routing srv6
   locator MAIN
```

Reference to Locator MAIN

```
segment-routing
 srv6
  locators
   locator MAIN
    micro-segment behavior unode psp-usd
    prefix fcbb:bb00:2::/48
```


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SRv6 Dual PE Configuration

```
router bgp 1
 neighbor A::4
  address-family vpnv4 unicast
   encapsulation-type srv6
   route-policy RRv6 out
 neighbor 4.4.4.4
  address-family vpnv4 unicast
   route-policy RRv4 out
vrf 1
  address-family ipv4 unicast
   mpls alloc enable
   segment-routing srv6
    locator MAIN
    alloc mode per-vrf
```

Policy towards v6 RR

Policy towards v4 RR

Allocates Labels for all prefixes in VRF

Allocates SIDs for all prefixes in VRF from Locator MAIN

Via RPL we set specific BGP attributes to to prefixes ie Local Preference towards RRv6 and RRv4

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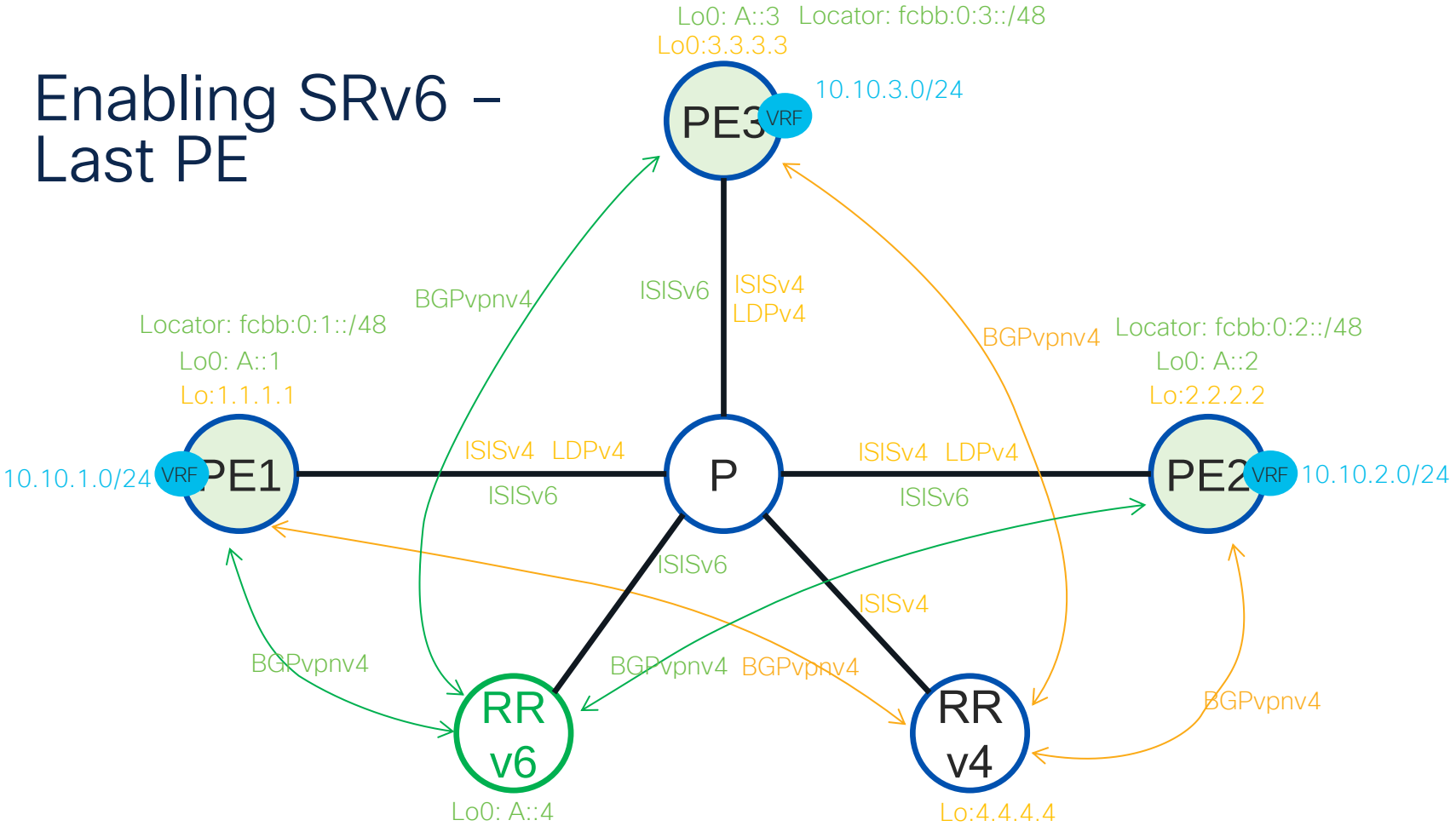
Enabling SRv6 – Last PE



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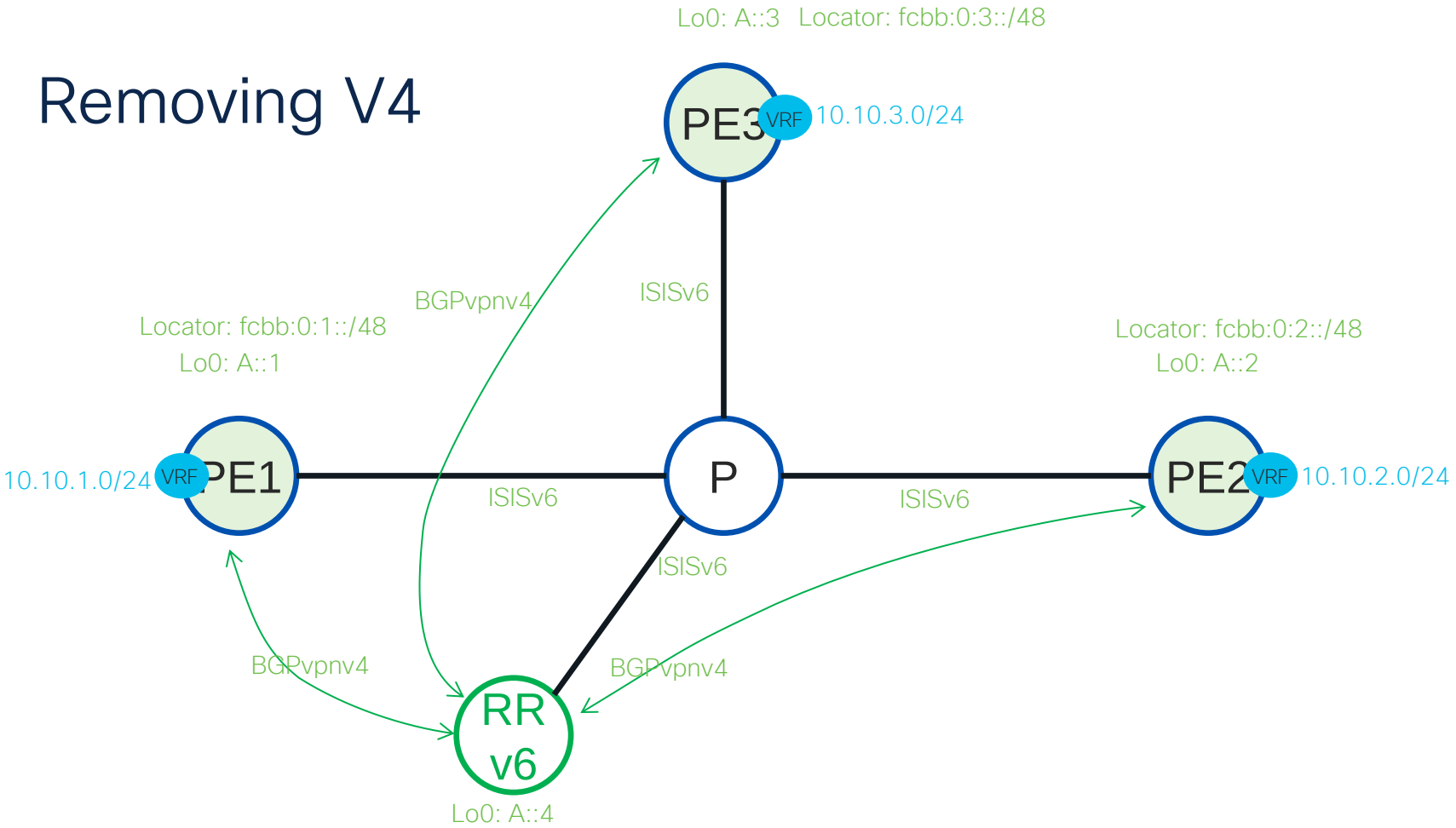
Removing V4



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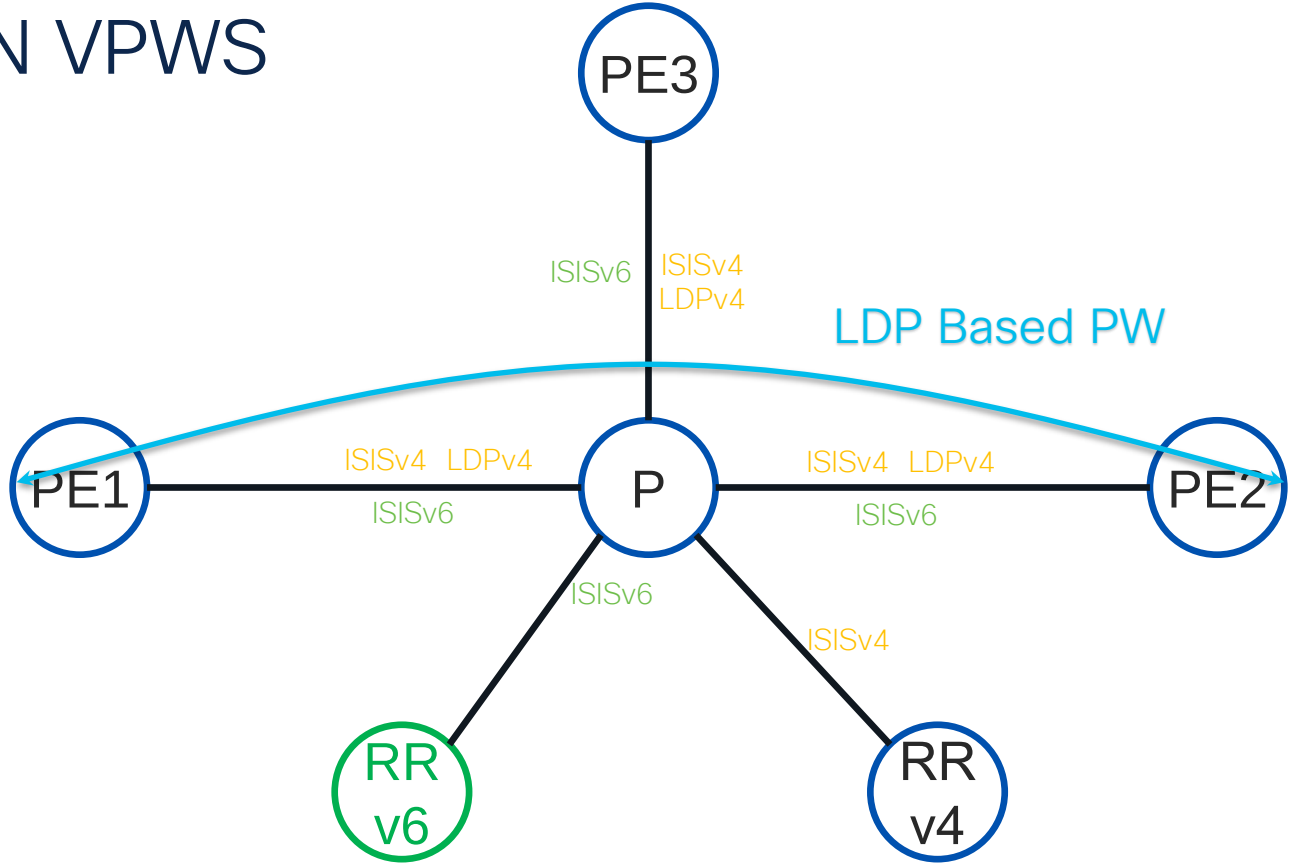
EVPN VPWS



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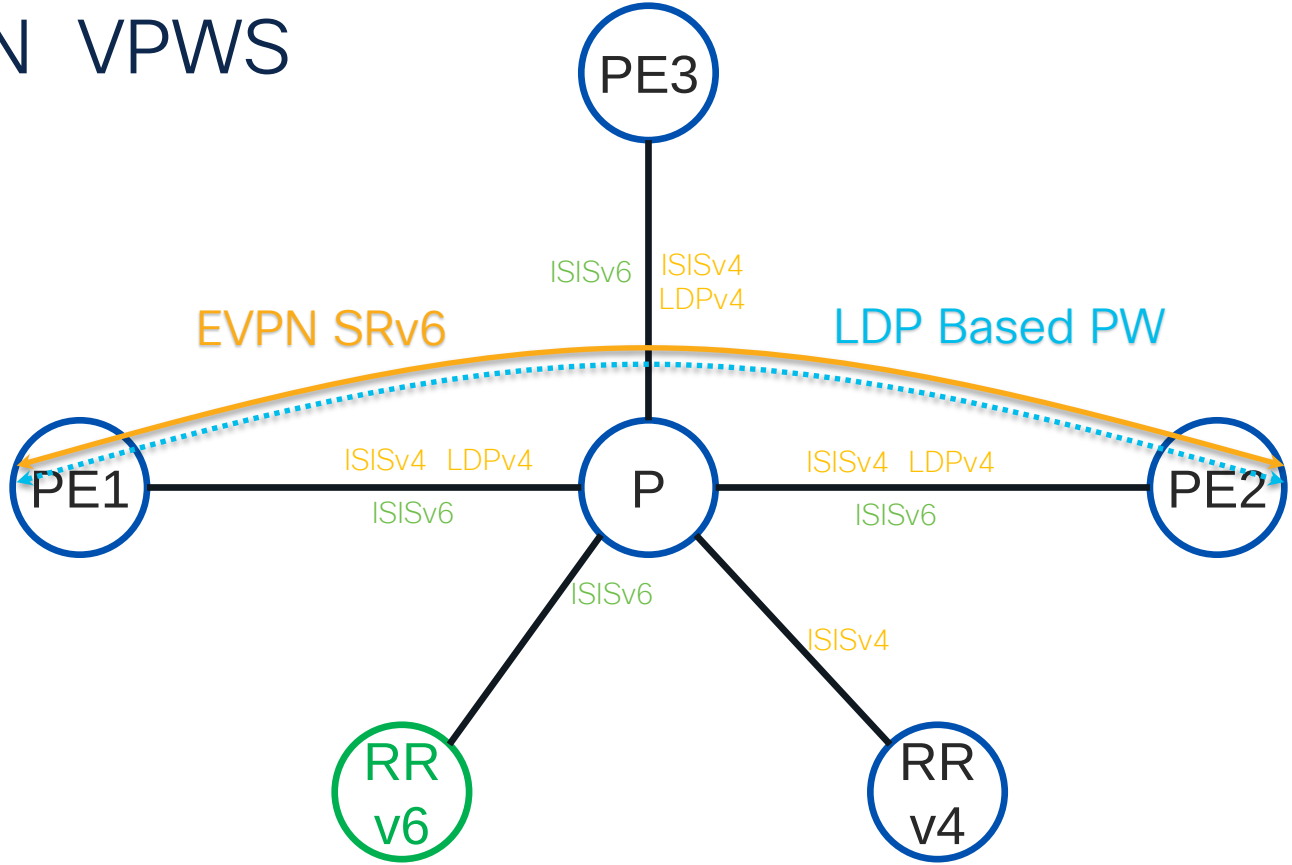
EVPN VPWS



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EVPN VPWS + PW configuration

```
l2vpn
 xconnect group 2000
  p2p 2000
   vpws-seamless-integration
   interface TenGigE0/0/0/1.2000
   neighbor ipv4 2.2.2.2 pw-id 1971
 p2p 2000-evpn
   interface TenGigE0/0/0/1.252
   neighbor evpn evi 2000 service 2000 segment-routing srv6
!
evpn
 evi 2002 segment-routing srv6
  locator MAIN
 segment-routing srv6
  locator MAIN
```

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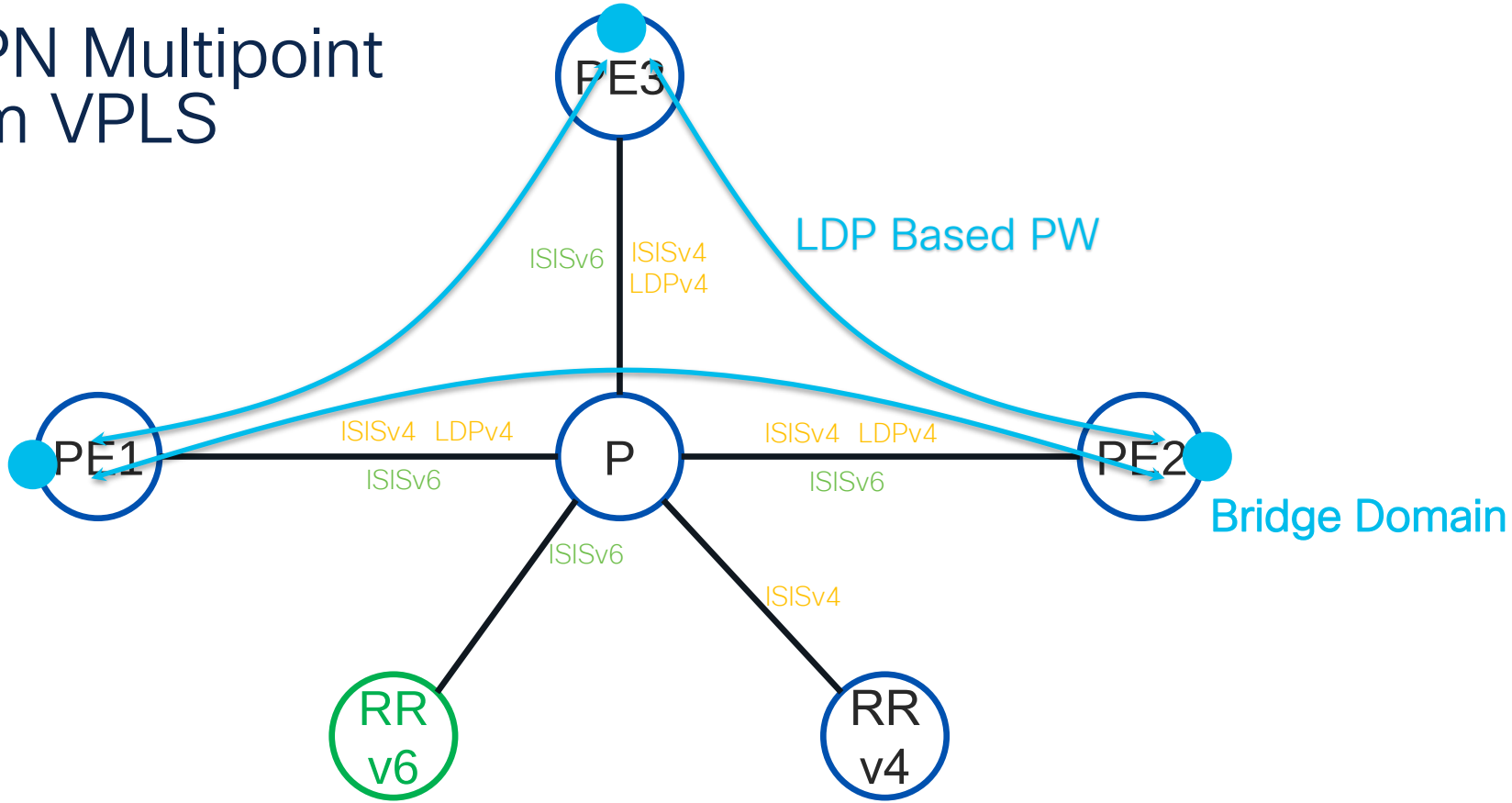
EVPN Multipoint from VPLS



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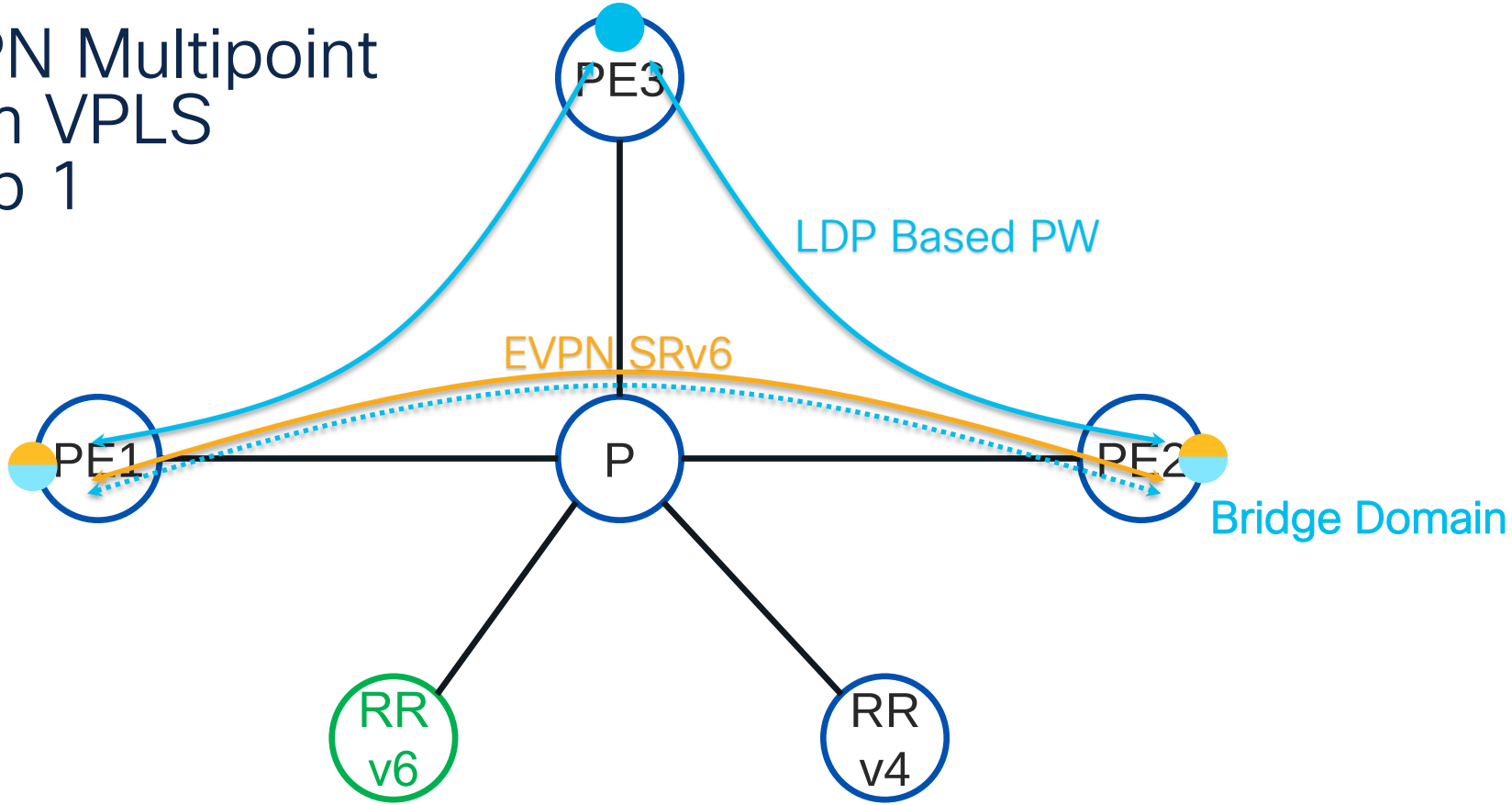
EVPN Multipoint from VPLS Step 1



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EVPN Multiopint + VPLS Configuration

```
l2vpn
 bridge group 2001
  bridge-domain 2001
   interface TenGigE0/0/0/1.268
   vfi 2001
    neighbor 2.2.2.2 pw-id 7543
    neighbor 3.3.3.3 pw-id 1106
   evi 2001 segment-routing srv6

evpn
 evi 2001 segment-routing srv6
  advertise-mac
  locator MAIN
 segment-routing srv6
  locator MAIN
 !
```

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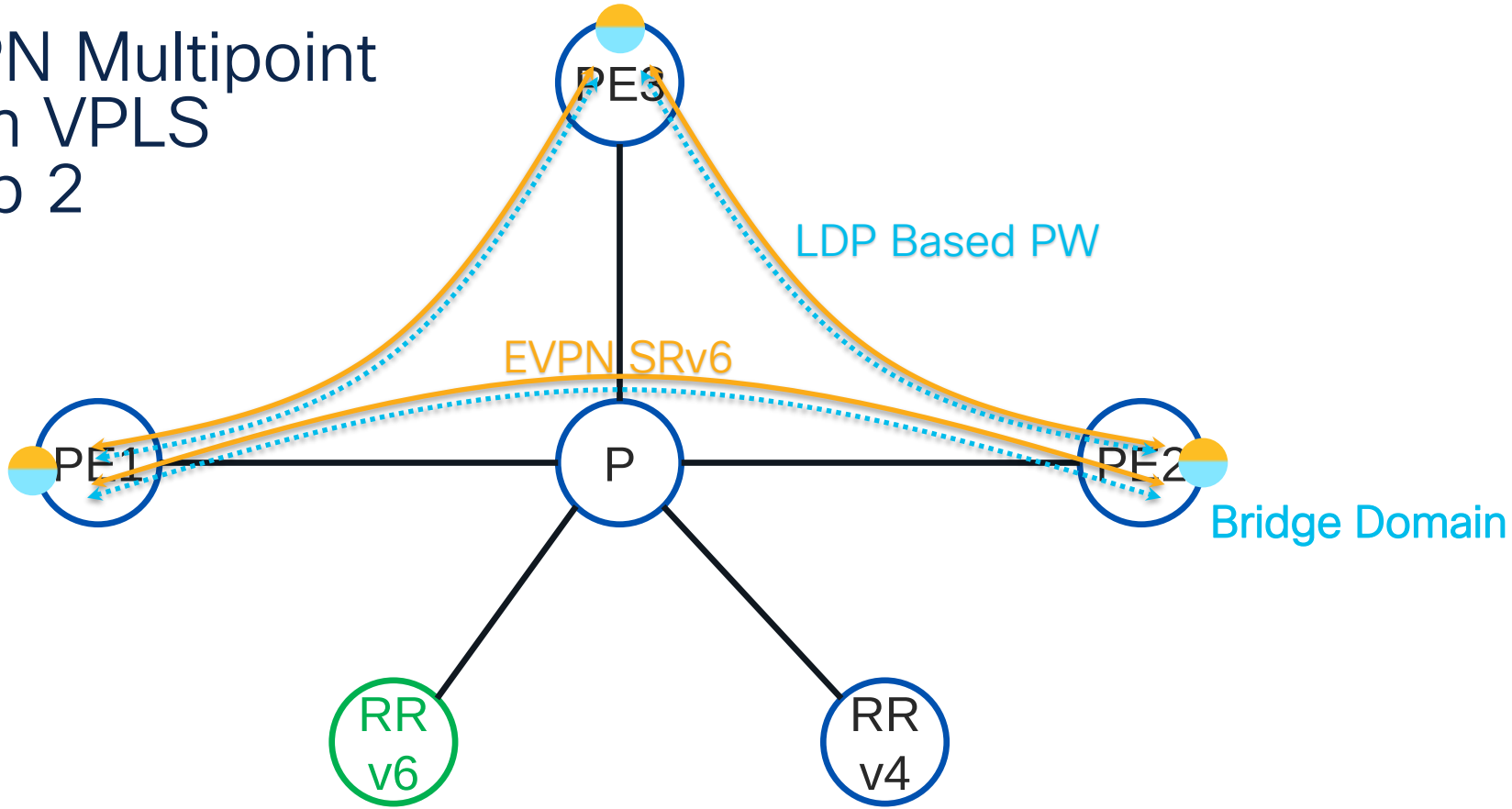
EVPN Multipoint from VPLS Step 2



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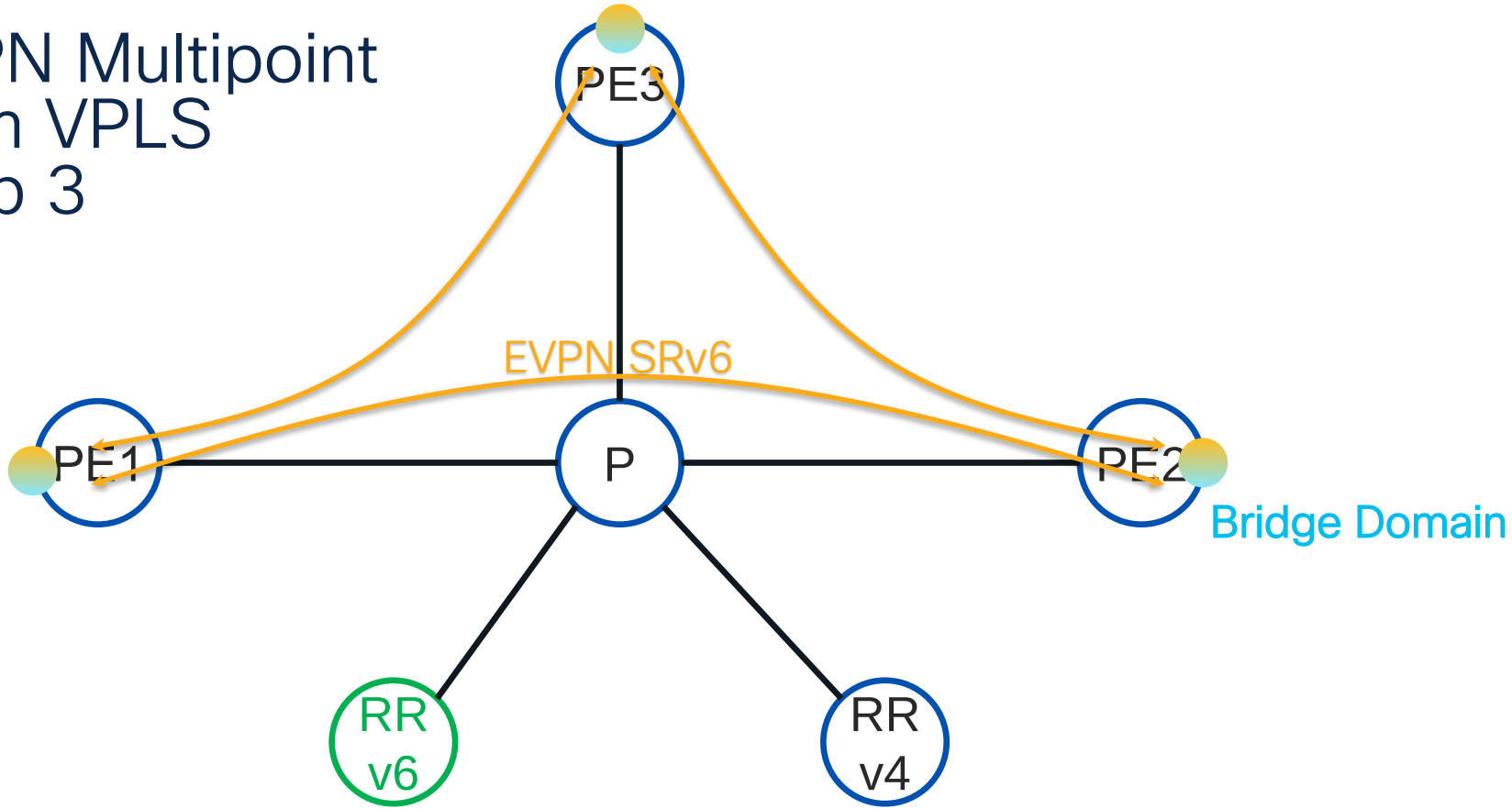
EVPN Multipoint from VPLS Step 3



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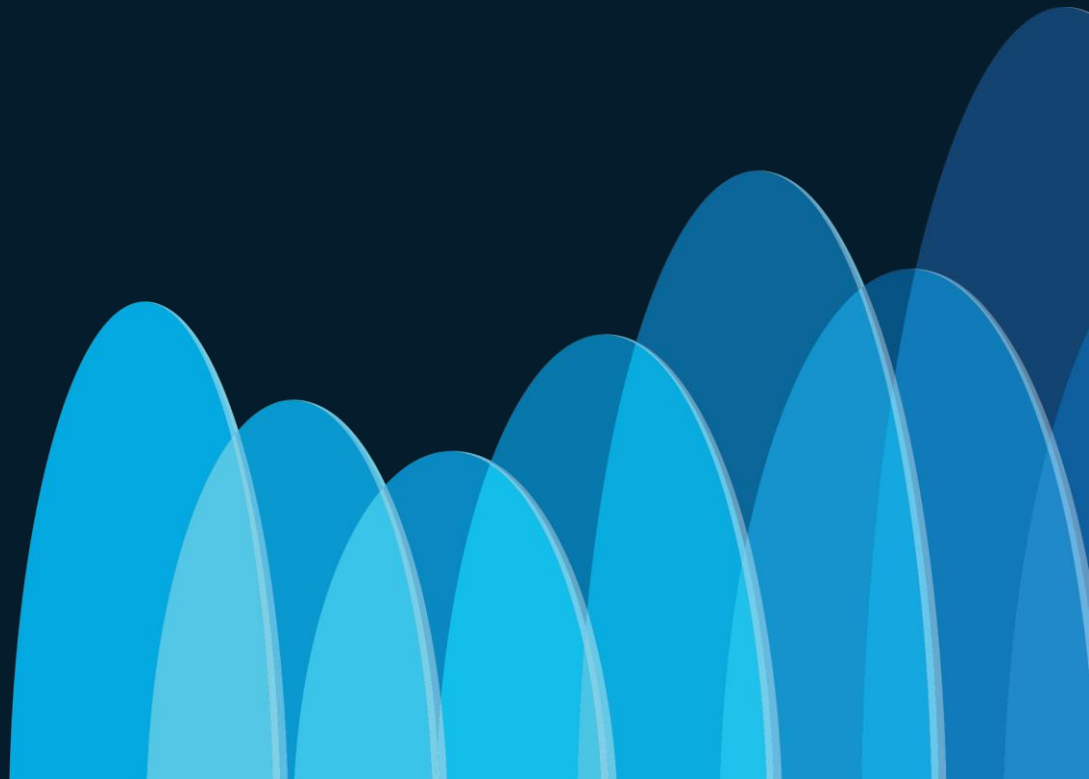
MPLS to SRv6 Interworking



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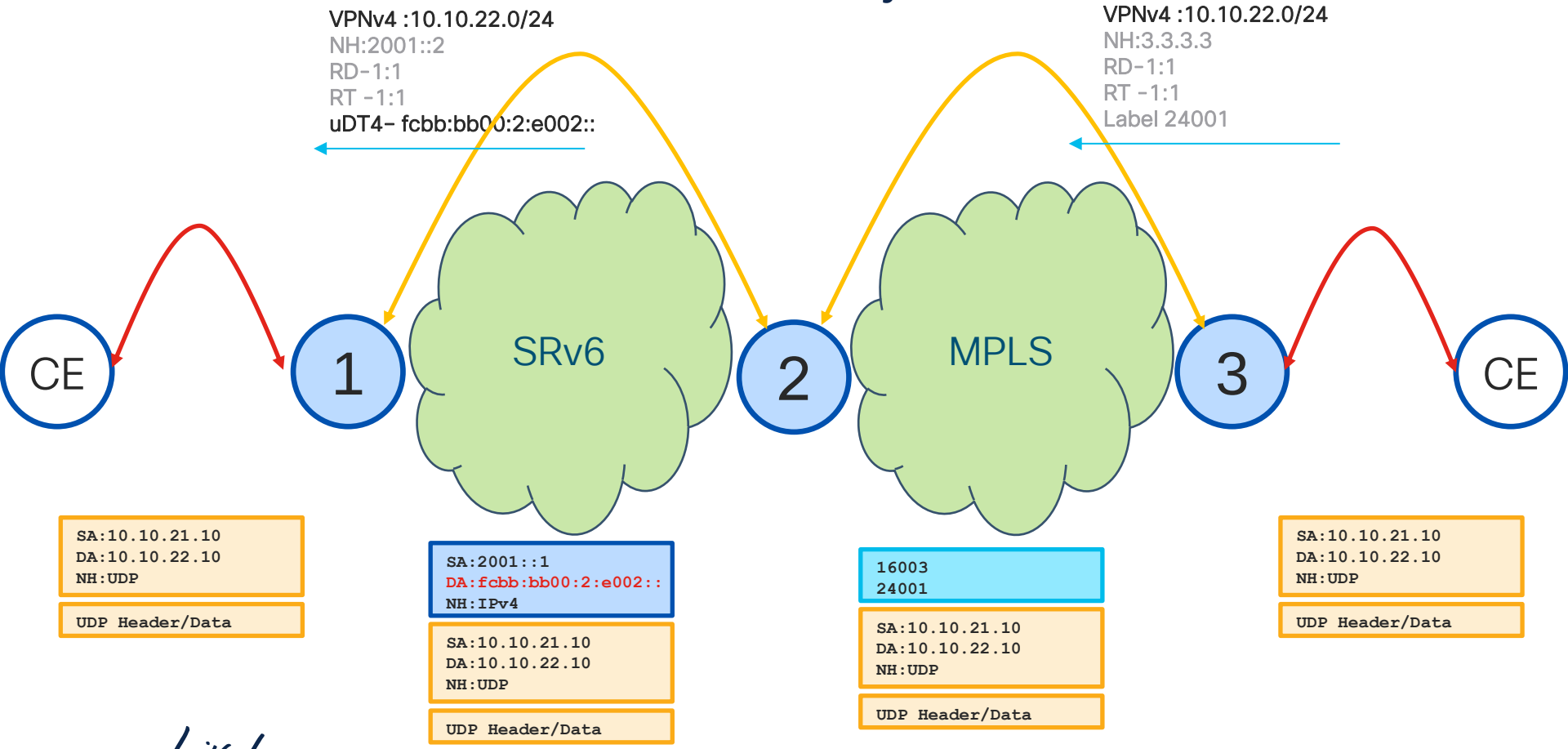
L3 VPN SRv6 MPLS Gateway



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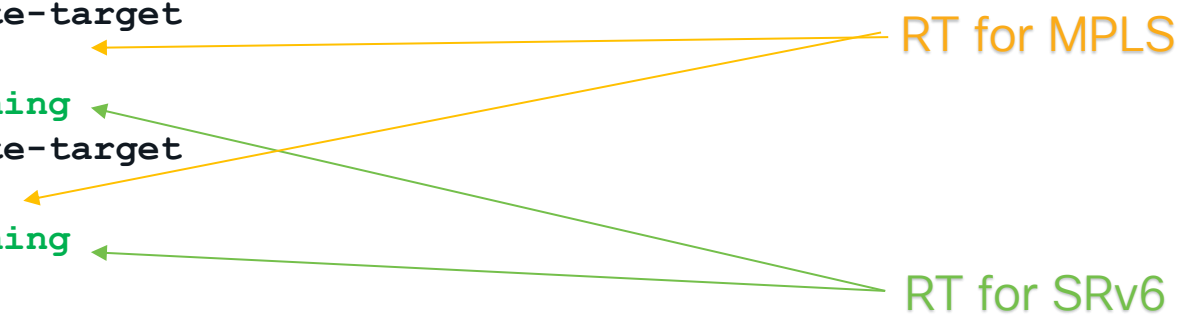
L3VPN SRv6 to MPLS Gateway Configuration – VRF

```
vrf 1
  address-family ipv4 unicast
   import route-target
    1:1
    2:1 stitching
   export route-target
    1:1
    2:1 stitching
```



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L3VPN SRv6 to MPLS Gateway Configuration – BGP

```
router bgp 1
 neighbor 4::4
  address-family vpnv4 unicast
   encapsulation-type srv6
   import reoriginate stitching-rt
   advertise vpnv4 unicast re-originated
 neighbor 3.3.3.3
  address-family vpnv4 unicast
   import stitching-rt reoriginate
   advertise vpnv4 unicast re-originated stitching-rt

  vrf 1
   address-family ipv4 unicast
    mpls alloc enable
    segment-routing srv6
     locator MAIN
```

v6 RR

v4 RR

Allocates Labels for all prefixes in VRF

Allocates SIDs for all prefixes in VRF from Locator MAIN

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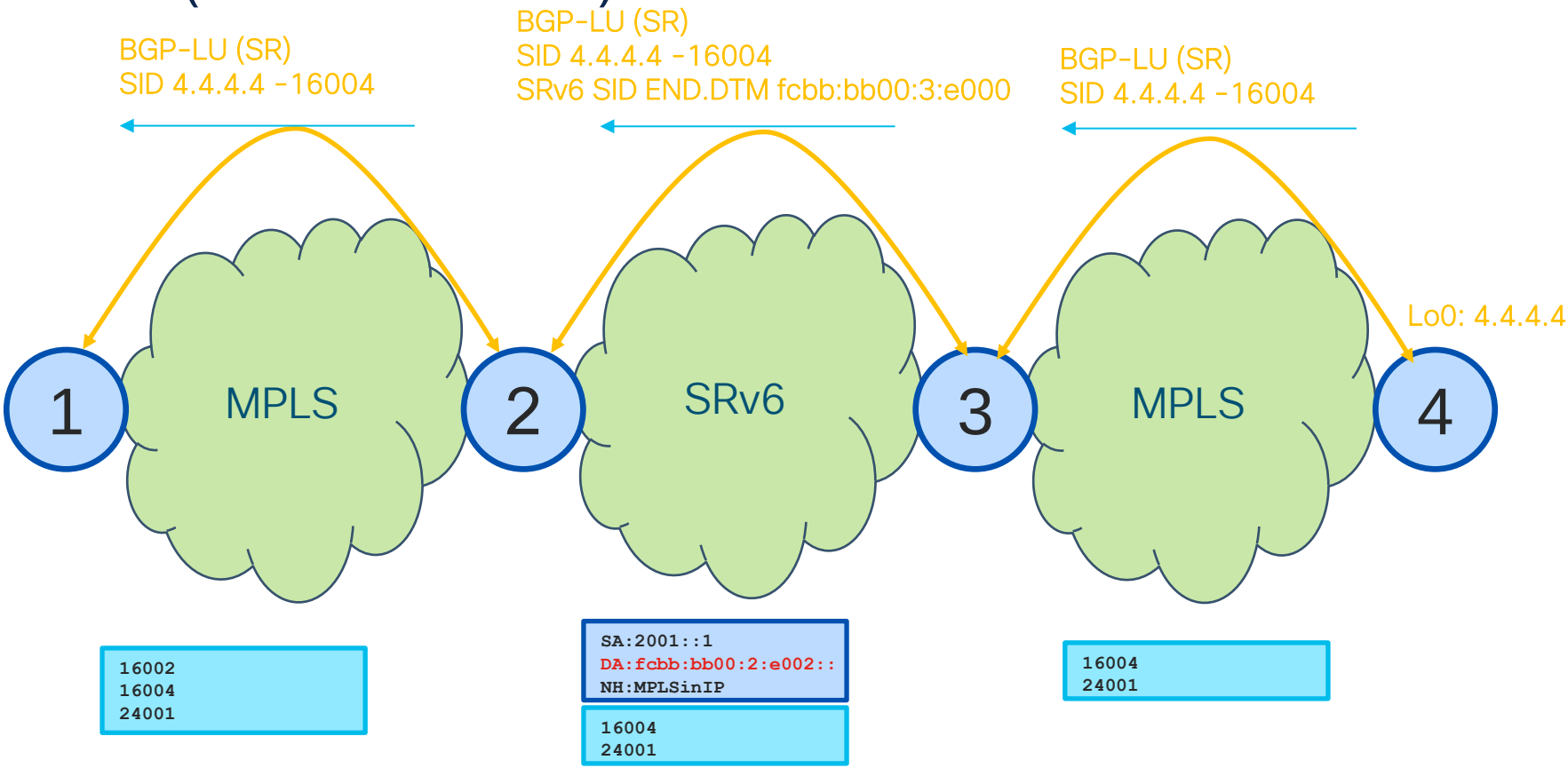
Mo6 – (BGP-LU+SID)



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Mo6 ABR Configuration

```
router bgp 1
 address-family ipv4 unicast
  segment-routing srv6
   locator MAIN
  labeled-unicast
!
 neighbor 1::1
  address-family ipv4 labeled-unicast
   encapsulation-type srv6
```

Allocates SRv6 SID

Allocate Label

Advertises SID in LU AF

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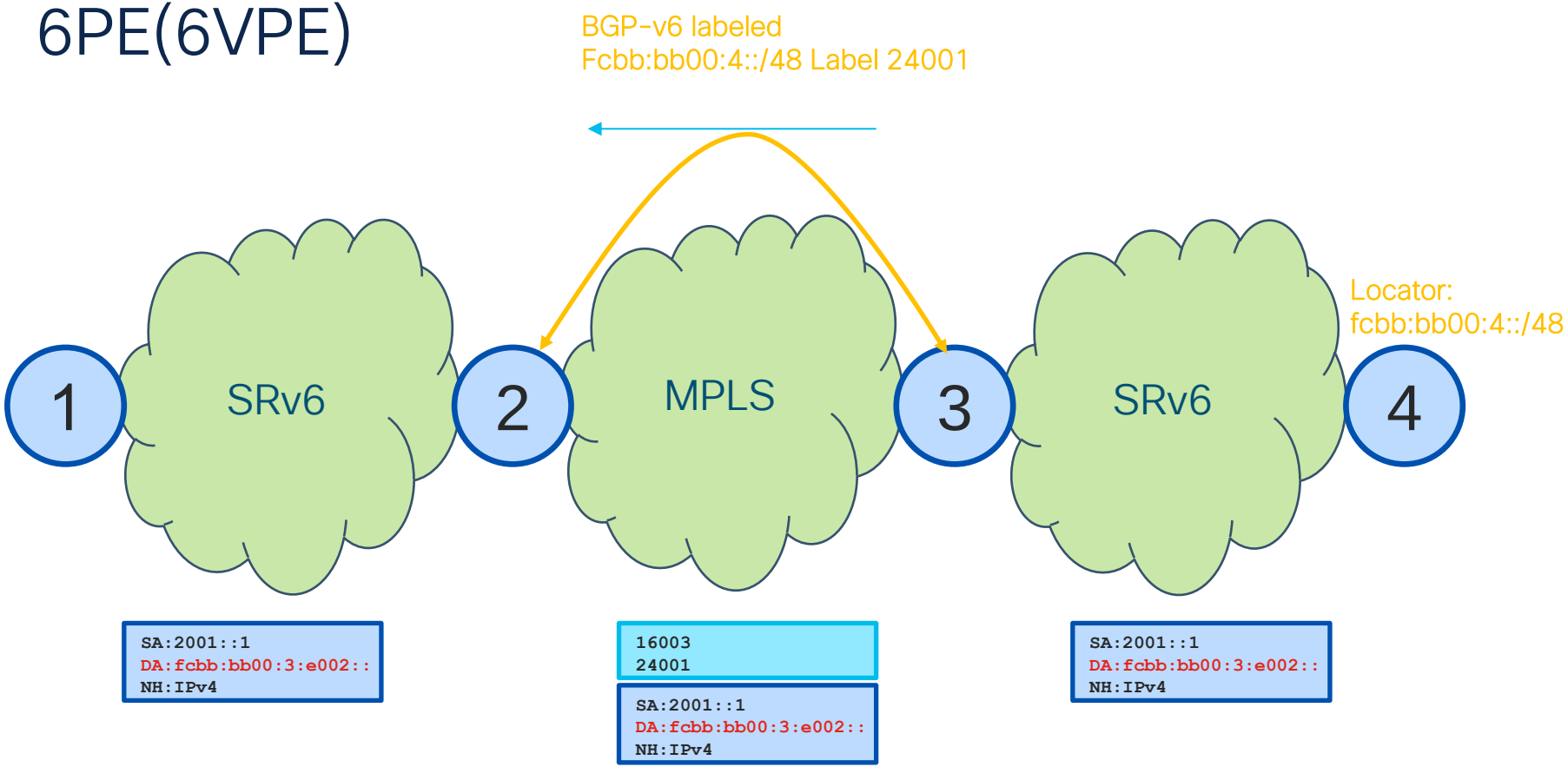
6PE(6VPE)



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Demo:
Using Crosswork to Migrate to SRv6

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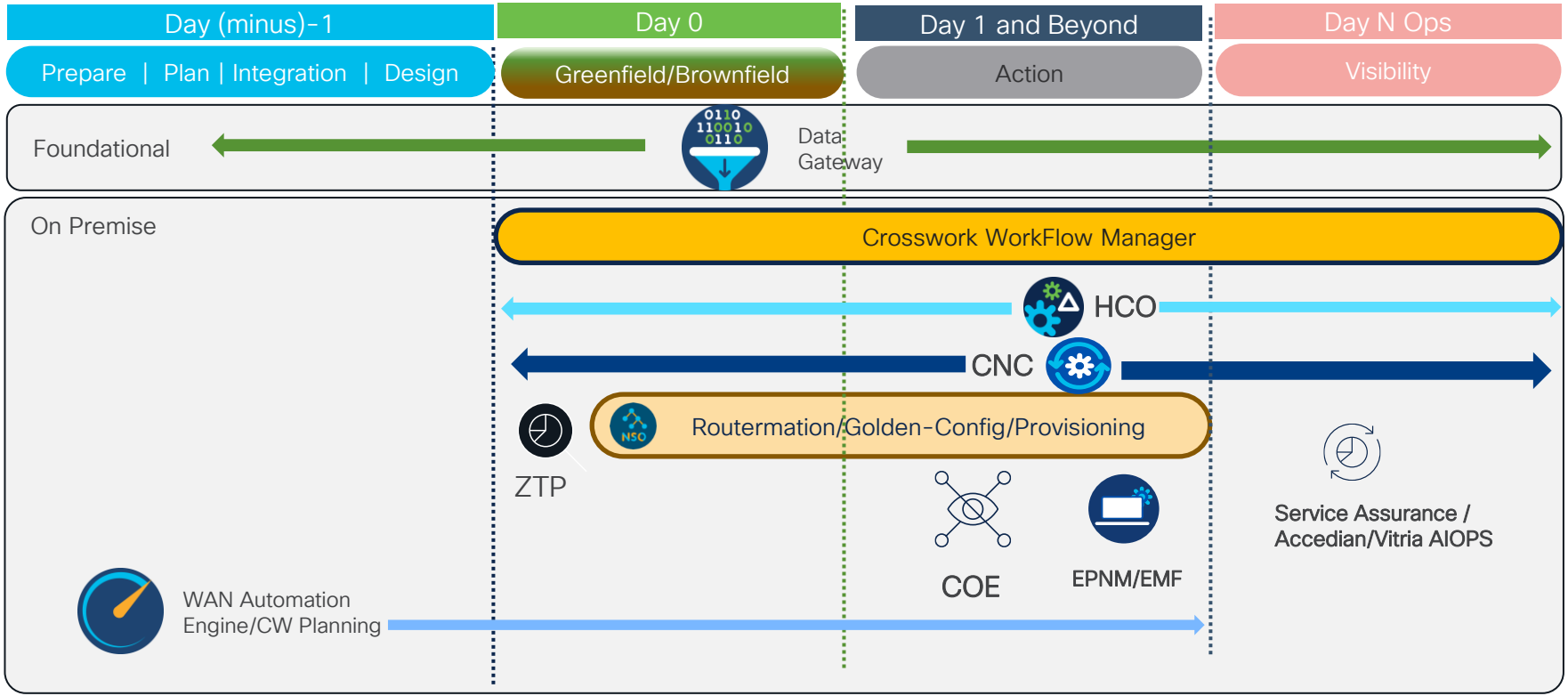
Cisco Crosswork Automation Portfolio

Day (minus) -1 to Day N Ops



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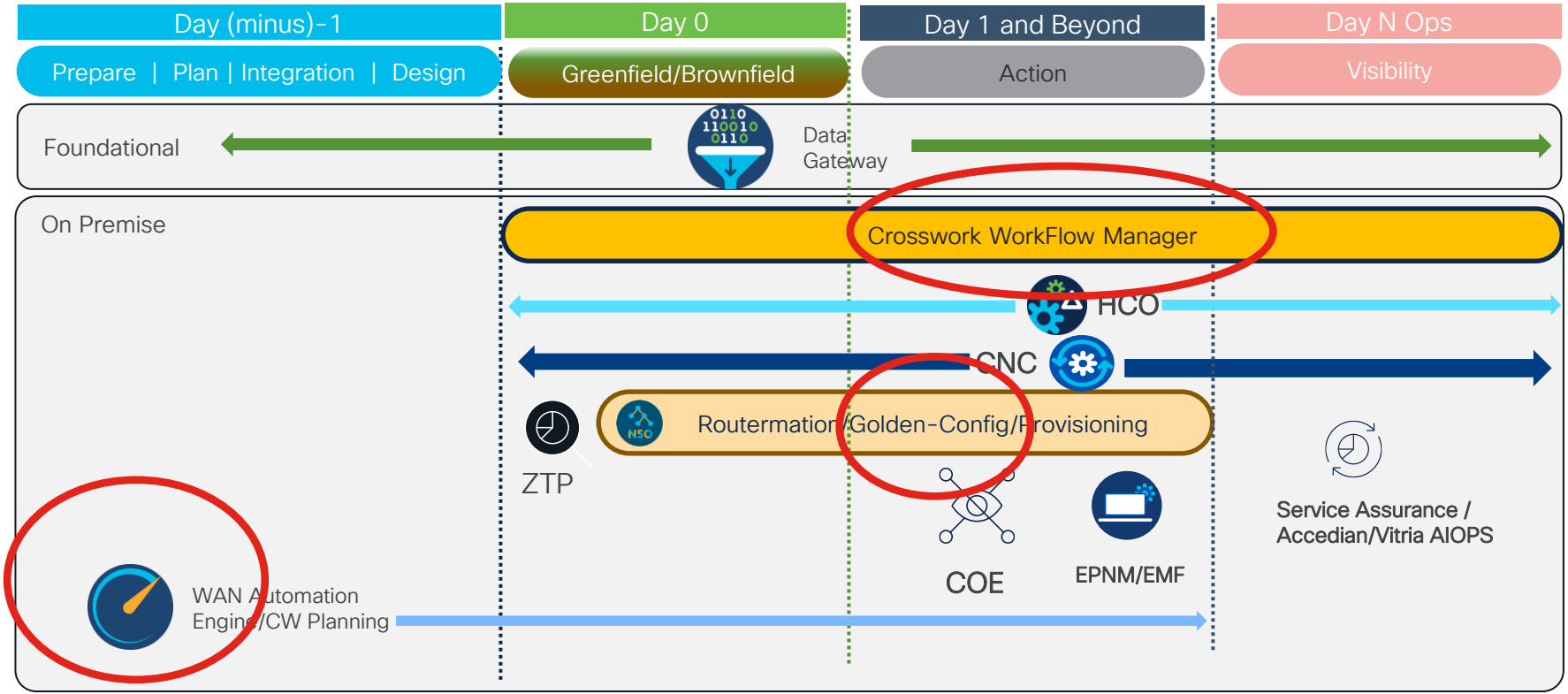
Cisco Crosswork Automation Portfolio

Day (minus) -1 to Day N Ops



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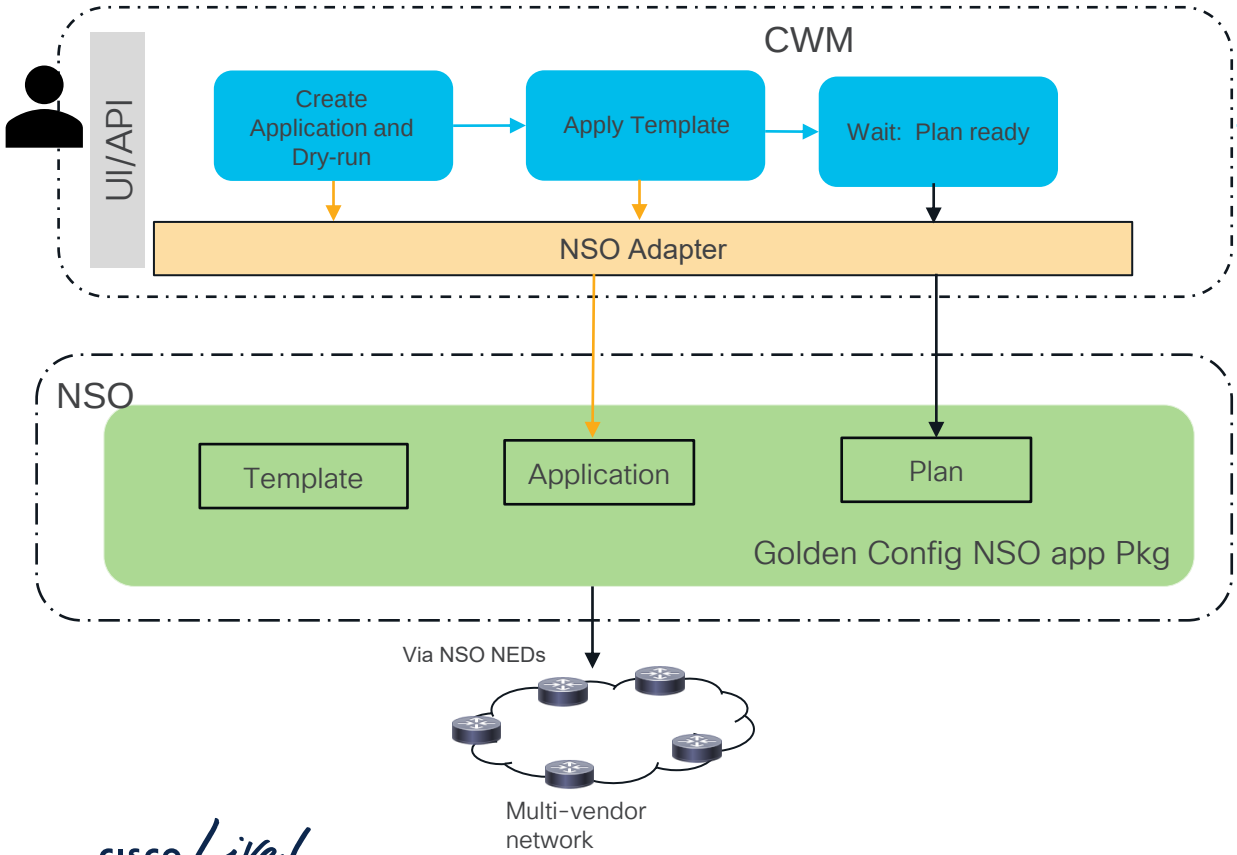
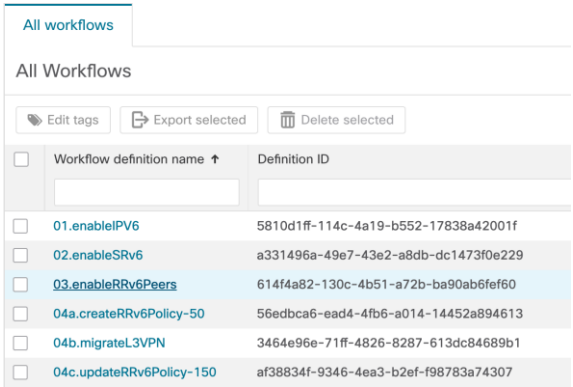
CWM with GC – Migration Flow



Webex Notifications



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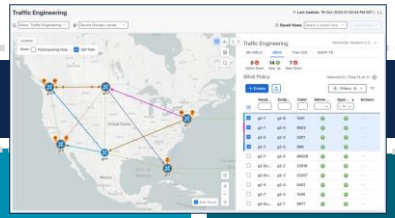
Migration to SRv6 from MPLS underlay



Cisco Crosswork Network Automation

Design SRv6 network topology	Introduce a new SRv6 RR	• Enable IPv6 Routing • SRv6 on first set of PEs • SRv6 on the rest of the PEs	Remove MPLS from the network	Post migration network checks
Design and Plan	Prepare	Operate and Optimize		

CP

NSO/CWM

Crosswork Network Controller

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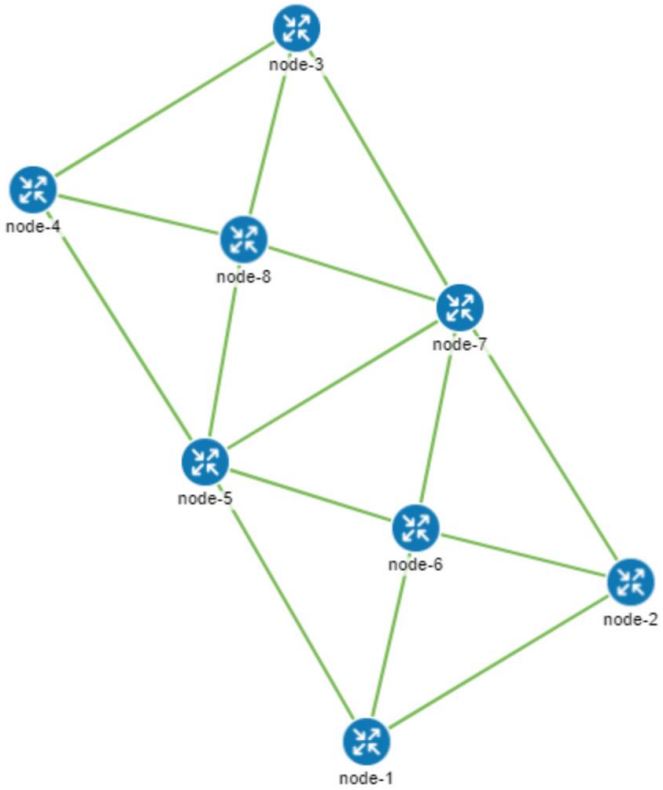
Topology



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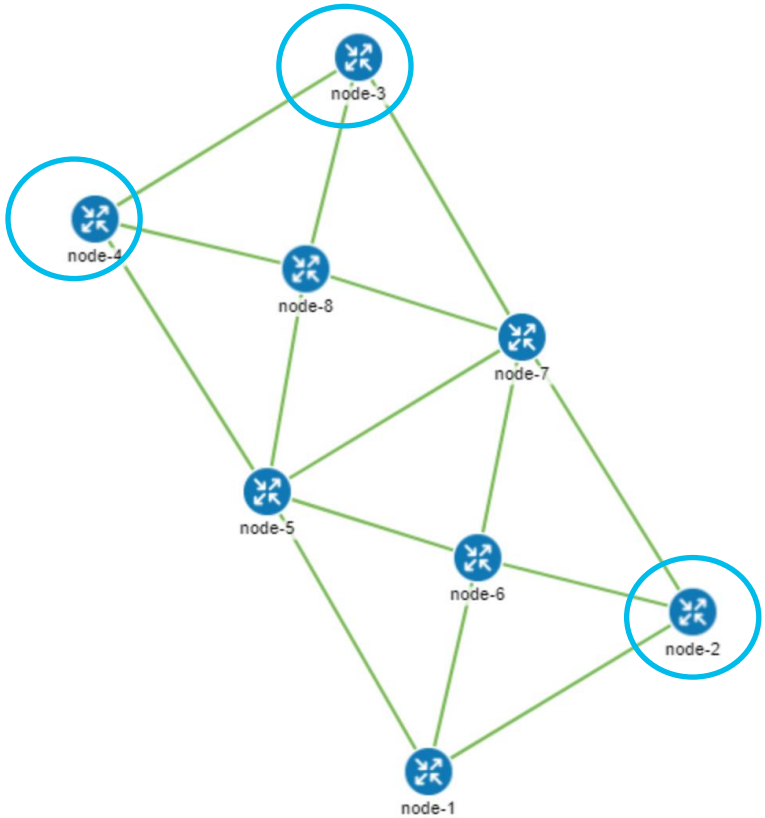
Topology



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Migration to SRv6

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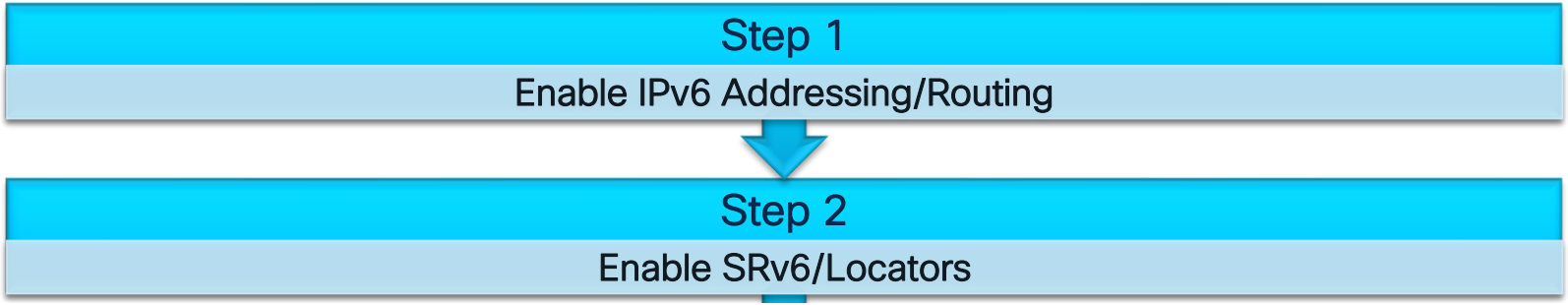
Migration to SRv6



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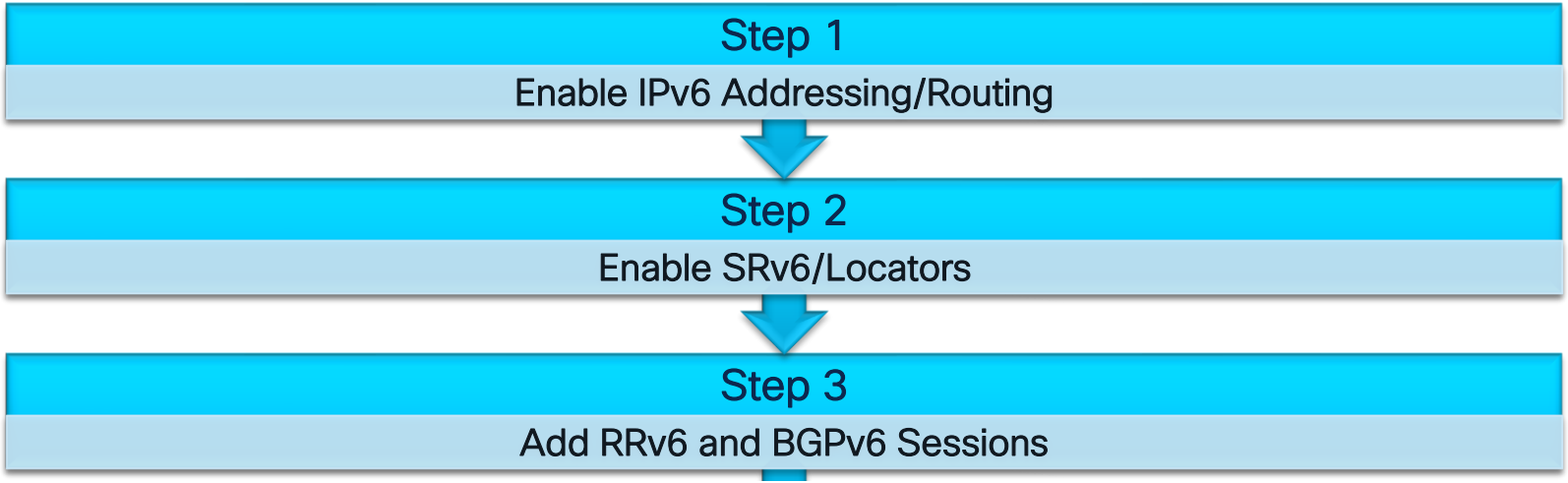
Migration to SRv6



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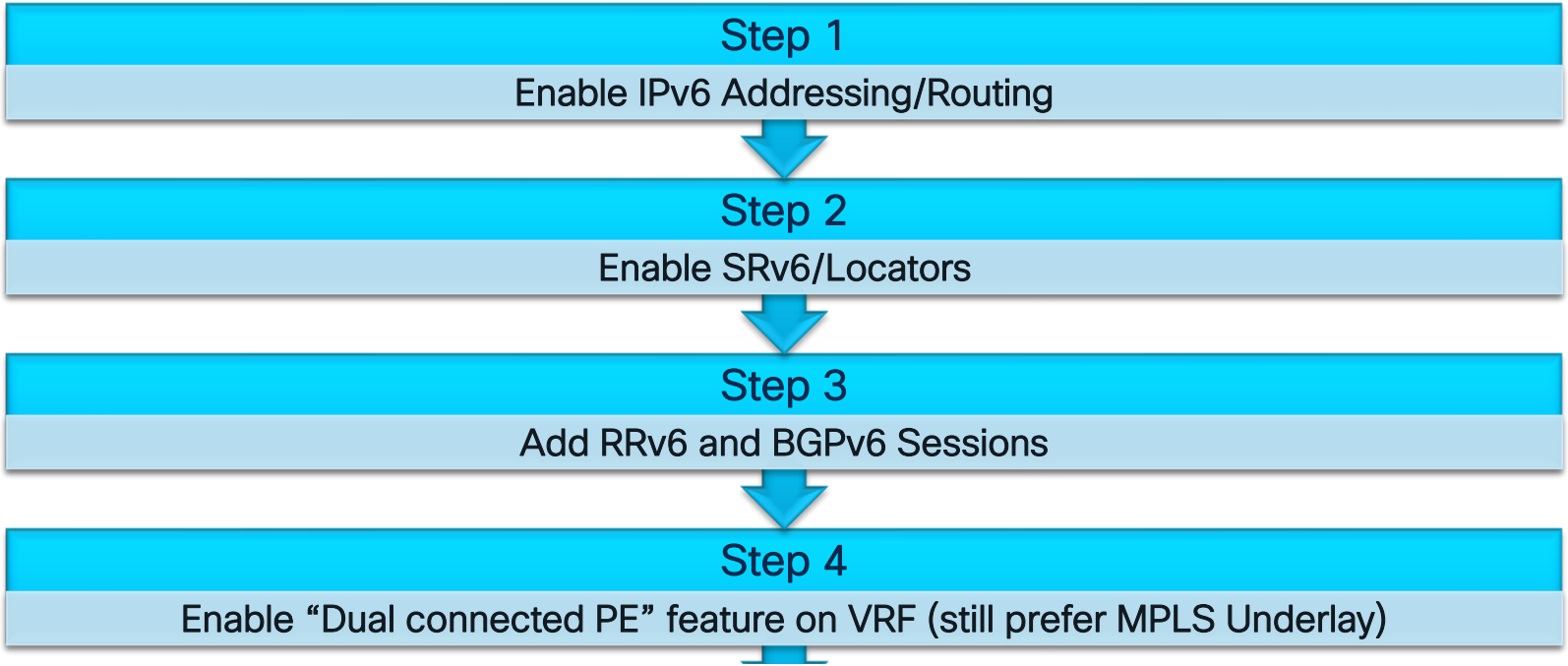
Migration to SRv6



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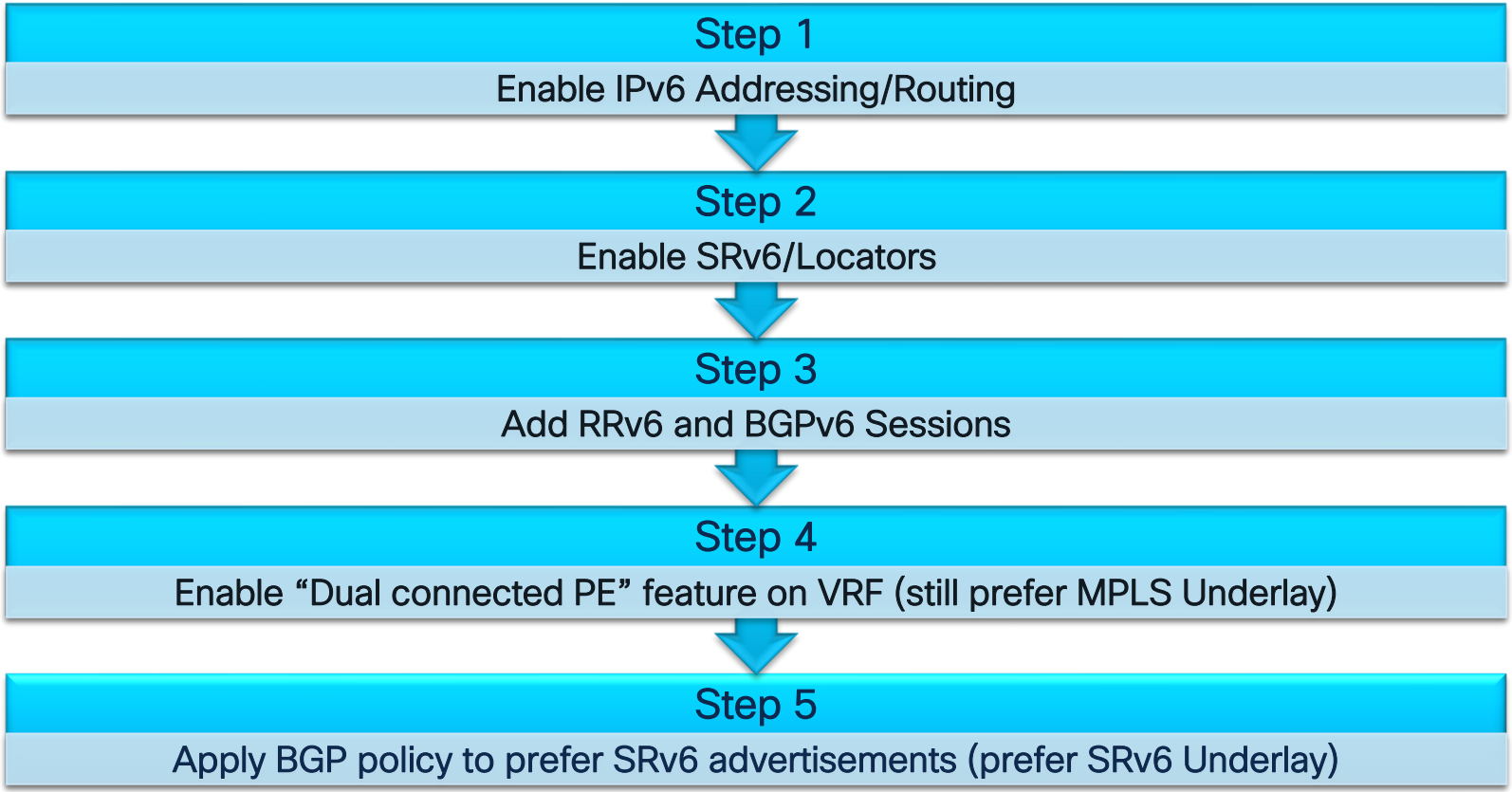
Migration to SRv6



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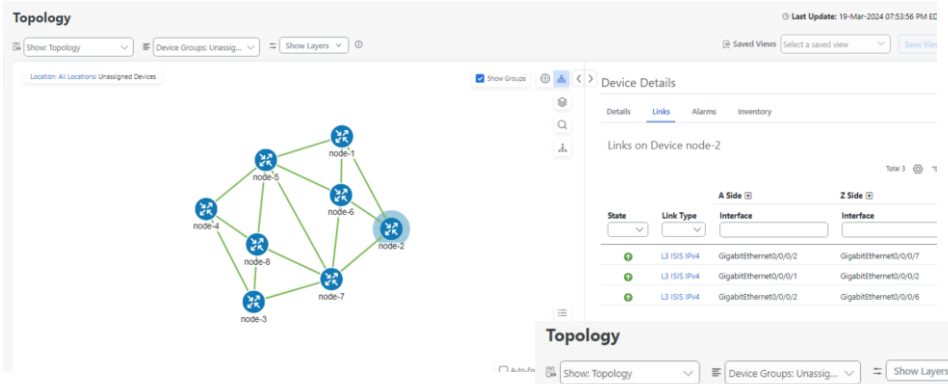
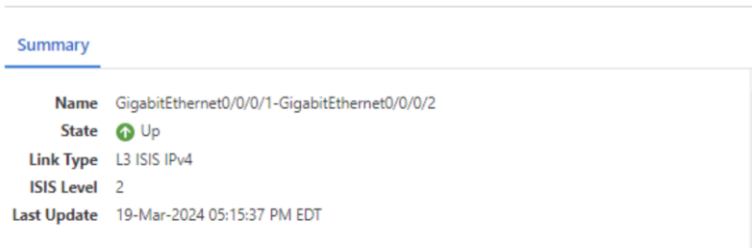
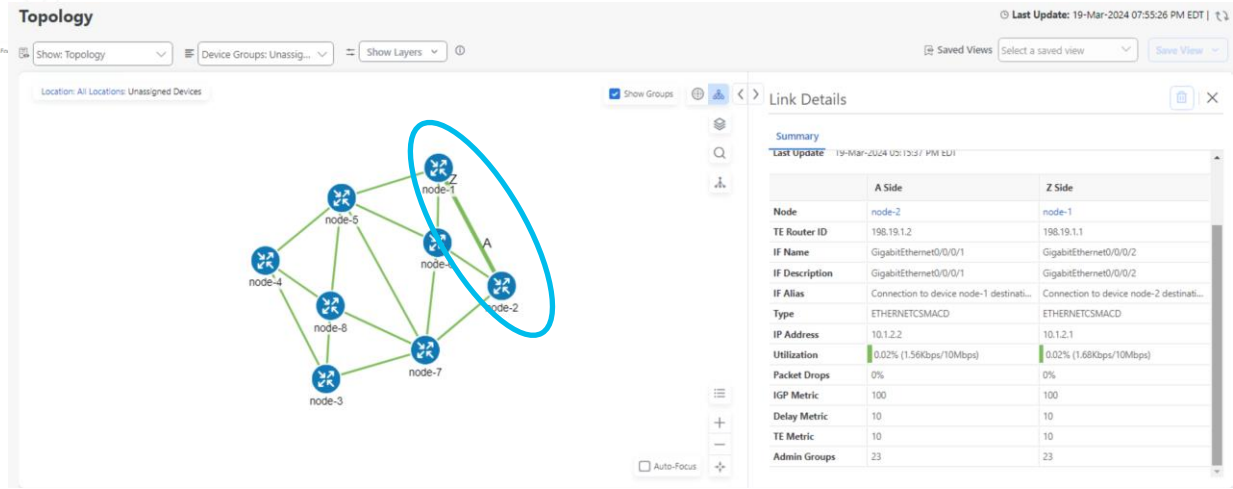
Topology : ISISv4







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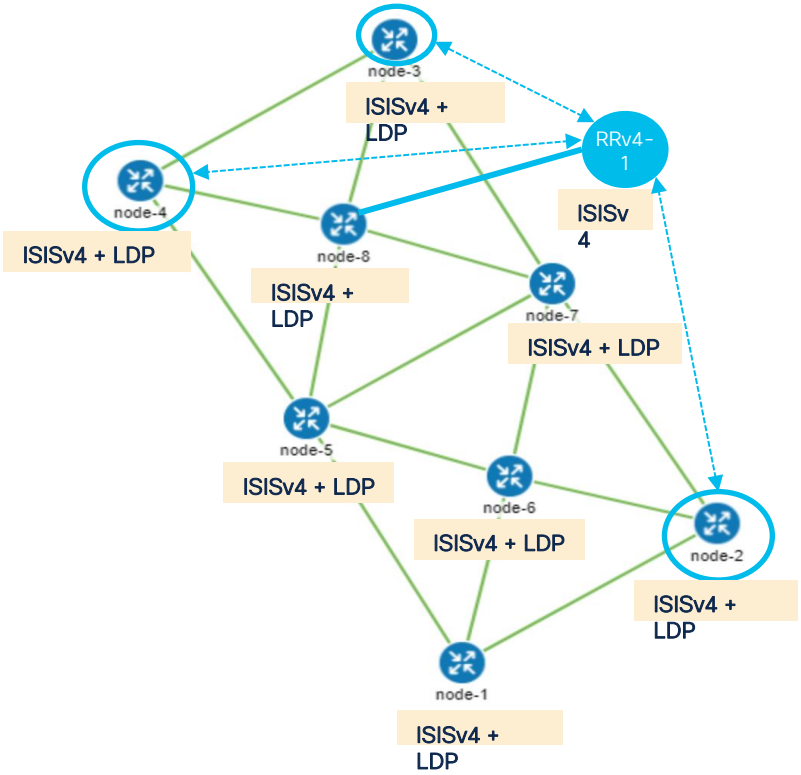
L3VPN – MPLS LDP to SRv6 Migration

VRF:VPN-101
MPLS VRF

PE:
Node-02
Node-03
Node-04



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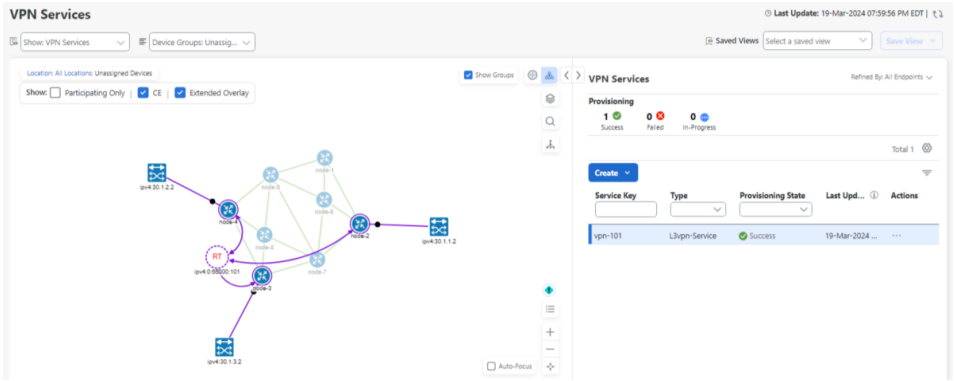
CNC : L3VPN Service Provisioning




```
cpe-12#ping vrf slice-1 30.1.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.1.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 6/6/9 ms
```

```
RP/0/RP0/CPU0:node-2#show bgp vrf vpn-101 ipv4 unicast
Tue Mar 19 23:59:29.100 UTC
BGP VRF vpn-101, state: Active
BGP Route Distinguisher: 65000:101
VRF ID: 0x60000001
BGP router identifier 198.19.1.2, local AS number 65000
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
  Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 65000:101 (default for vrf vpn-101)
Route Distinguisher Version: 13
*> 30.1.1.0/24      0.0.0.0                  0         32768 ?
*>i30.1.2.0/24      198.19.1.4               0    100      0 ?
* i                 198.19.1.4               0    100      0 ?
*>i30.1.3.0/24      198.19.1.3               0    100      0 ?
* i                 198.19.1.3               0    100      0 ?
```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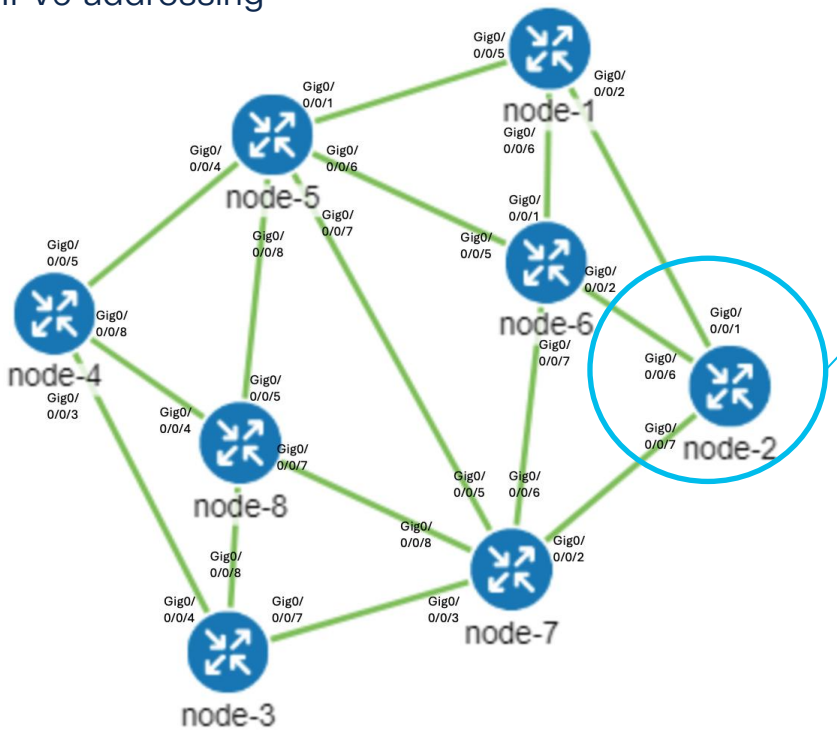
Topology- Configure IPv6 Routing

Step1a: Enable IPv6 addressing




```
interface Loopback 0
 ipv6 address  2010::2/128
 no shutdown
exit
interface GigabitEthernet 0/0/0/1
 ipv6 enable
 no shutdown
exit

interface GigabitEthernet 0/0/0/6
 ipv6 enable
 no shutdown
exit

interface GigabitEthernet 0/0/0/7
 ipv6 enable
 no shutdown
exit
```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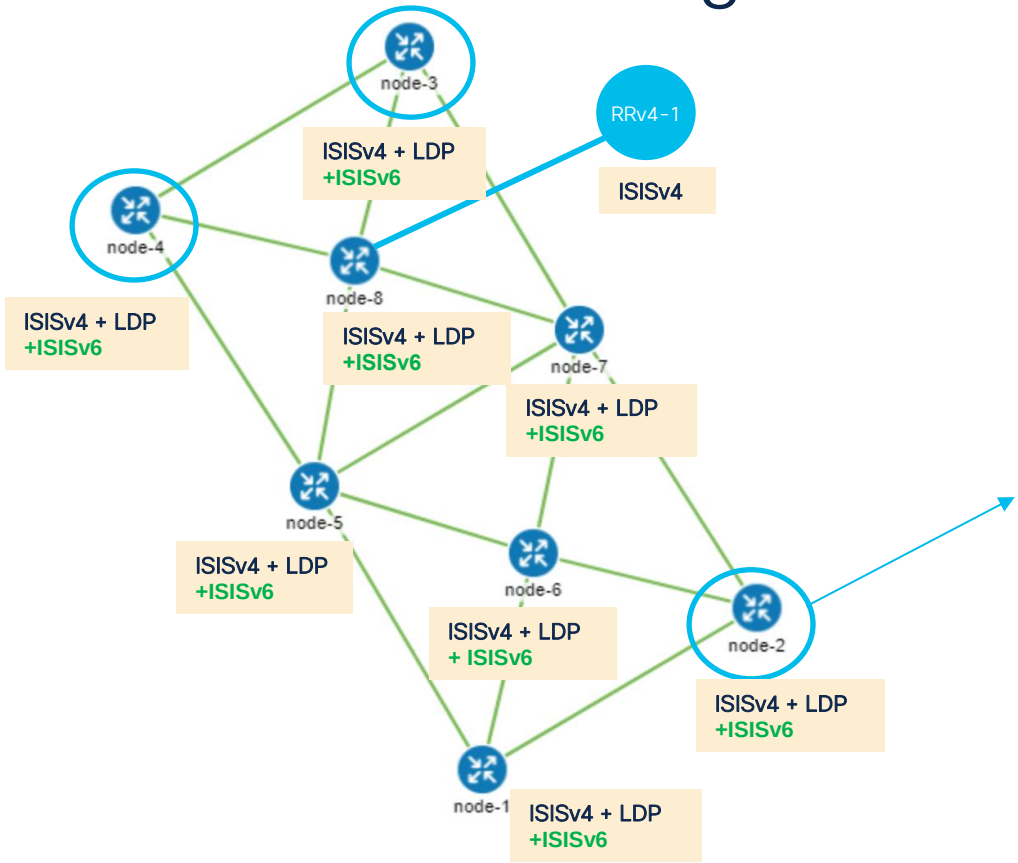
L3VPN – MPLS LDP to SRv6 Migration

Step1b: Enable ISISv6




```
router-id Loopback0
!
Interface Loopback0
 passive
 address-family ipv6 unicast
 !
!
Interface
GigabitEthernet0/0/0/1
  point-to-point
  address-family ipv6 unicast
  !
!
 interface
GigabitEthernet0/0/0/6
  point-to-point
  address-family ipv6 unicast
  !
!
 interface
GigabitEthernet0/0/0/7
  point-to-point
  address-family ipv6 unicast
  !
```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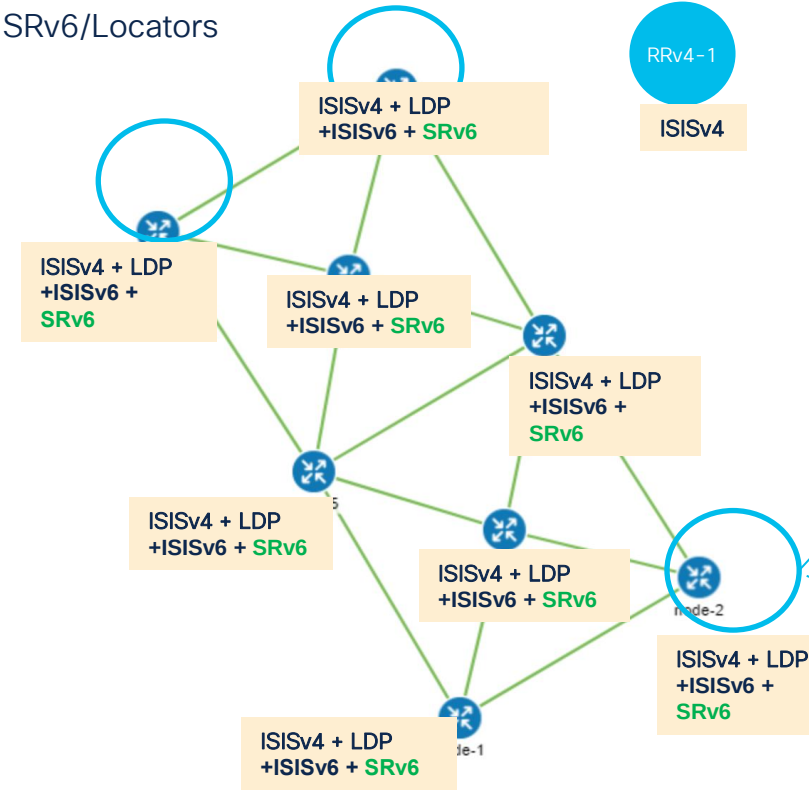
L3VPN – MPLS LDP to SRv6 Migration

Step2: Enable SRv6/Locators




```
segment-routing
 srv6
  locators
   locator TOP
    micro-segment behavior unode psp-usd
    prefix fcbb:2:2::/48
    algorithm 129
   !
   locator MAIN
    micro-segment behavior unode psp-usd
    prefix fcbb:0:2::/48
   !
   locator BOTTOM
    micro-segment behavior unode psp-usd
    prefix fcbb:3:2::/48
    algorithm 130
   !
   locator LATENCY
    micro-segment behavior unode psp-usd
    prefix fcbb:1:2::/48
    algorithm 128
   !
  !
 !
!
```

```
router isis 1
 address-family ipv6 unicast
  segment-routing srv6
   locator TOP
   !
   locator MAIN
   !
   locator BOTTOM
   !
   locator LATENCY
   !
  !
 !
!
end
```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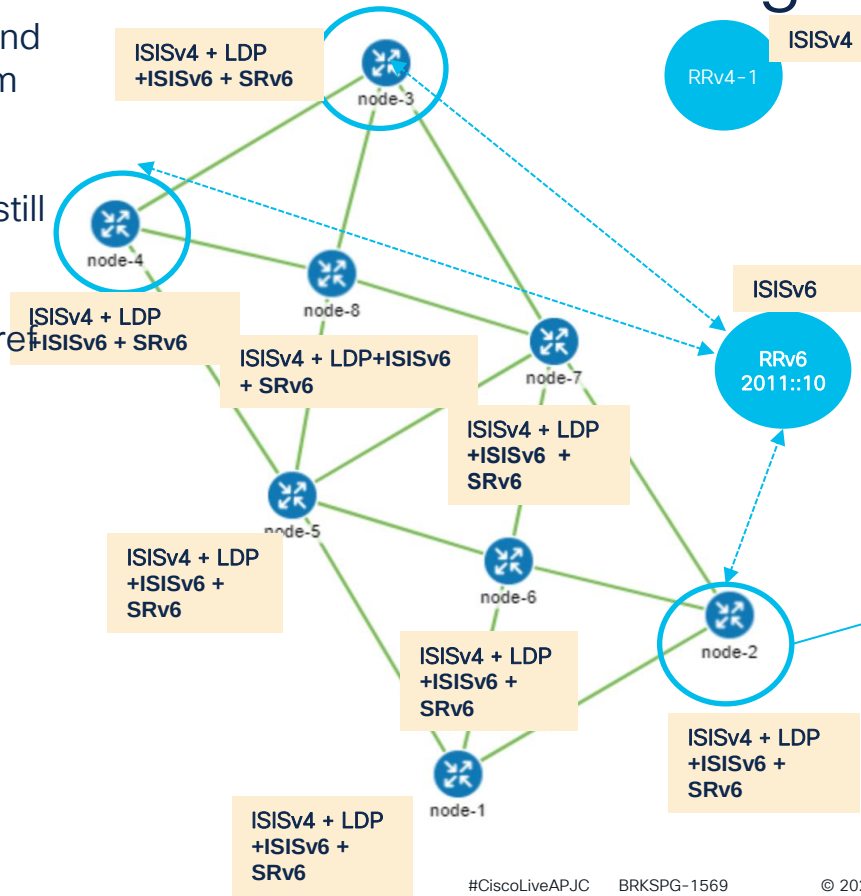
L3VPN – MPLS LDP to SRv6 Migration

Step3: Add RRv6 and BGPv6 session from PE

Use BGP policy to still prefer MPLS advertisements
e.g. Lower Local Pref towards RRv6




```
route-policy RRv6
  set local-preference 50
end-policy
!
router bgp 65000
  neighbor 2011::10
   remote-as 65000
   update-source Loopback0
   address-family vpnv4 unicast
    route-policy RRv6 out
    encapsulation-type srv6
   exit
  exit
 exit
```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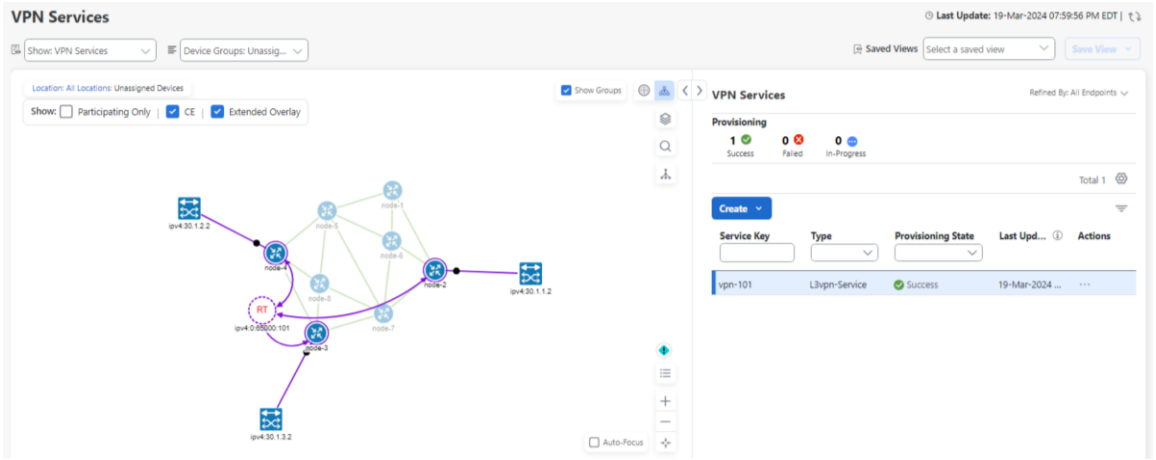
L3VPN – MPLS LDP to SRv6 Migration

Step4: Enable Dual connected PE feature for selected VRF to migrate




```
router bgp 65000
 vrf vpn-101
  address-family ipv4 unicast
   mpls alloc enable
   segment-routing srv6
    locator MAIN
   !
  !
 !
!
```

```
cpe-12#ping vrf slice-1 30.1.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.1.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 6/6/9 ms
```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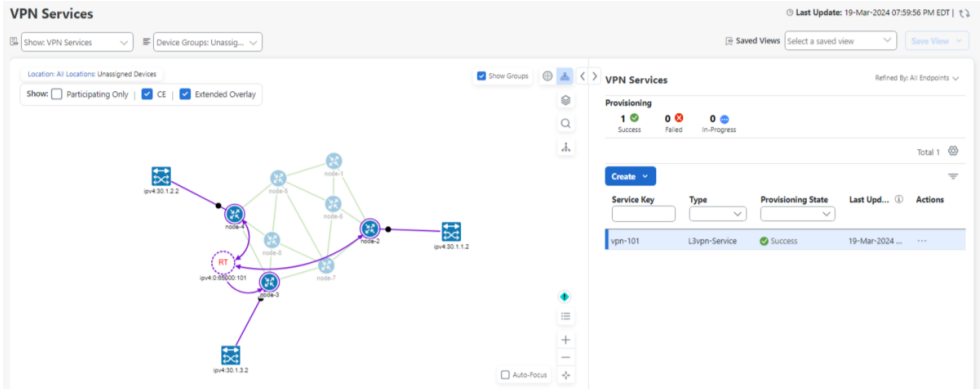
Verification : Prefixes are learned from both RRv4 and RRv6 BGP Path with IPv4 next hop is best path



cpe-12#ping vrf slice-1 30.1.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.1.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 6/6/9 ms

RP/0/RP0/CPU0:node-2#show bgp vrf vpn-101 ipv4 unicast
Tue Mar 19 23:59:29.100 UTC
BGP VRF vpn-101, state: Active
BGP Route Distinguisher: 65000:101
VRF ID: 0x60000001
BGP router identifier 198.19.1.2, local AS number 65000
Status codes: s suppressed, d damped, h history, * valid, > best
i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 65000:101 (default for vrf vpn-101)					
Route Distinguisher Version: 13					
*> 30.1.1.0/24	0.0.0.0	0		32768	?
***>i30.1.2.0/24**	**198.19.1.4**	**0**	**100**	**0**	**?**
* i	2010::4	0	50	0	?
***>i30.1.3.0/24**	**198.19.1.3**	**0**	**100**	**0**	**?**
* i	2010::3	0	50	0	?

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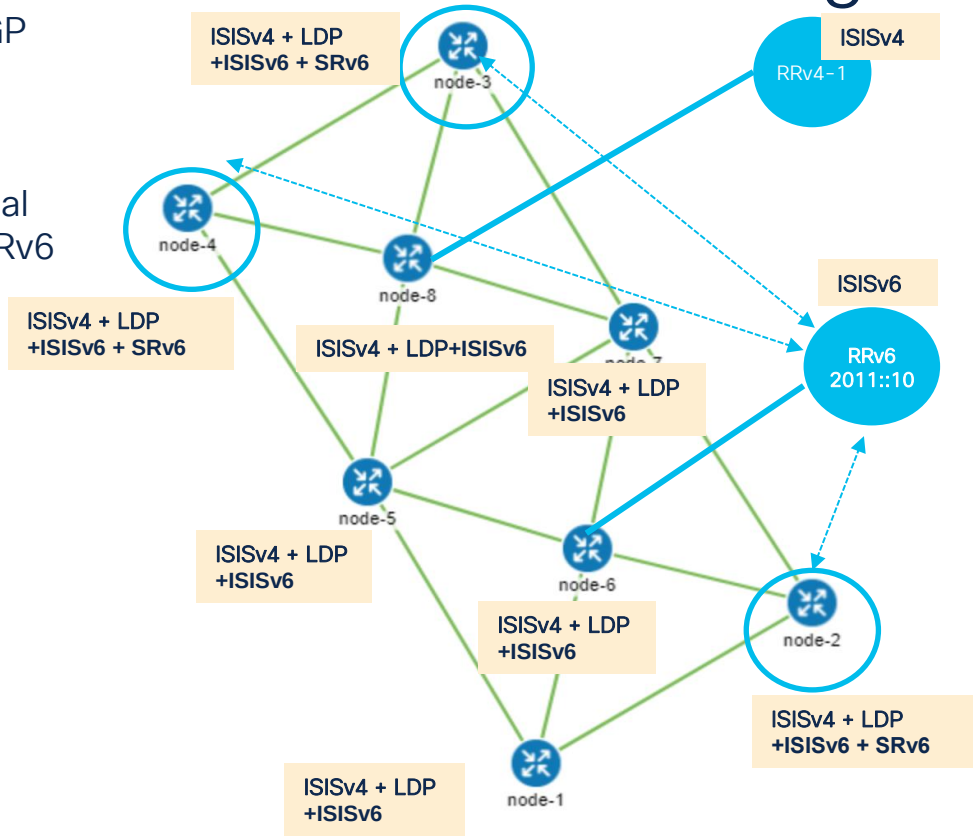
L3VPN – MPLS LDP to SRv6 Migration

Step 5: Use BGP policy to prefer SRv6 advertisements e.g. Higher Local Pref towards RRv6



Node 2, 3, 4

```
route-policy RRv6
set local-preference 150
end-policy
```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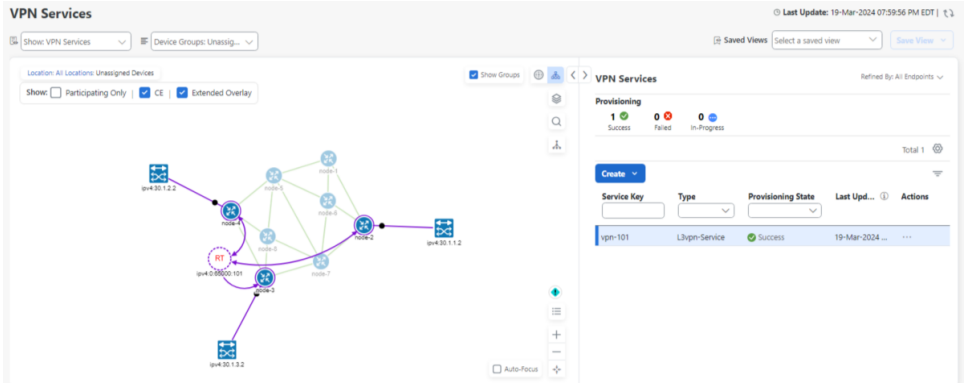
Verification : Prefixes are learned from both RR BGP Path with IPv6 next hop is best path




```
cpe-12#ping vrf slice-1 30.1.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.1.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 6/6/9 ms
```

```
RP/0/RP0/CPU0:node-2#show bgp vrf vpn-101 ipv4 unicast
Tue Mar 19 23:59:29.100 UTC
BGP VRF vpn-101, state: Active
BGP Route Distinguisher: 65000:101
VRF ID: 0x60000001
BGP router identifier 198.19.1.2, local AS number 65000
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
  Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 65000:101 (default for vrf vpn-101)
Route Distinguisher Version: 13
* i30.1.1.0/24     198.19.1.2               0    100      0 ?
*>i               2010::2                  0    150      0 ?
*> 30.1.2.0/24     0.0.0.0                  0         32768 ?
* i30.1.3.0/24     198.19.1.3               0    100      0 ?
*>i               2010::3                  0    150      0 ?
```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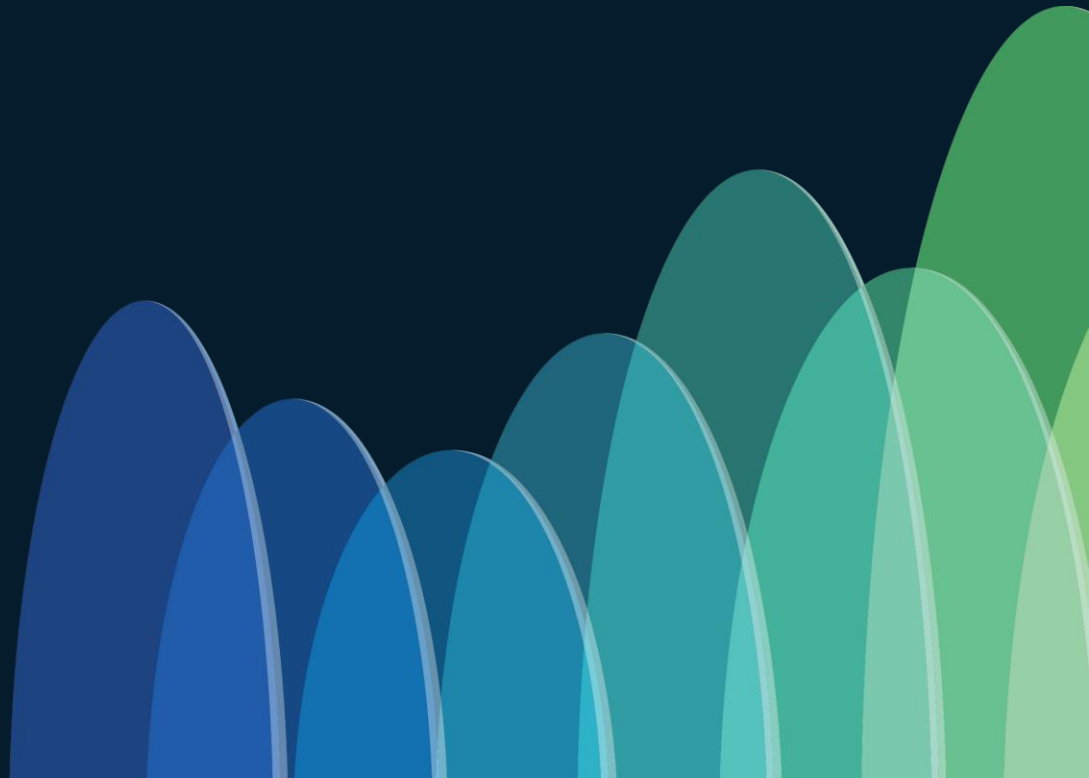
Conclusion



Conclusion

- SRv6 is fully ready for brownfield deployments
- SRv6 uSID is the only reasonable format
- SRv6 uSID supported across cisco platform
- SRv6 uSID supported across vendors

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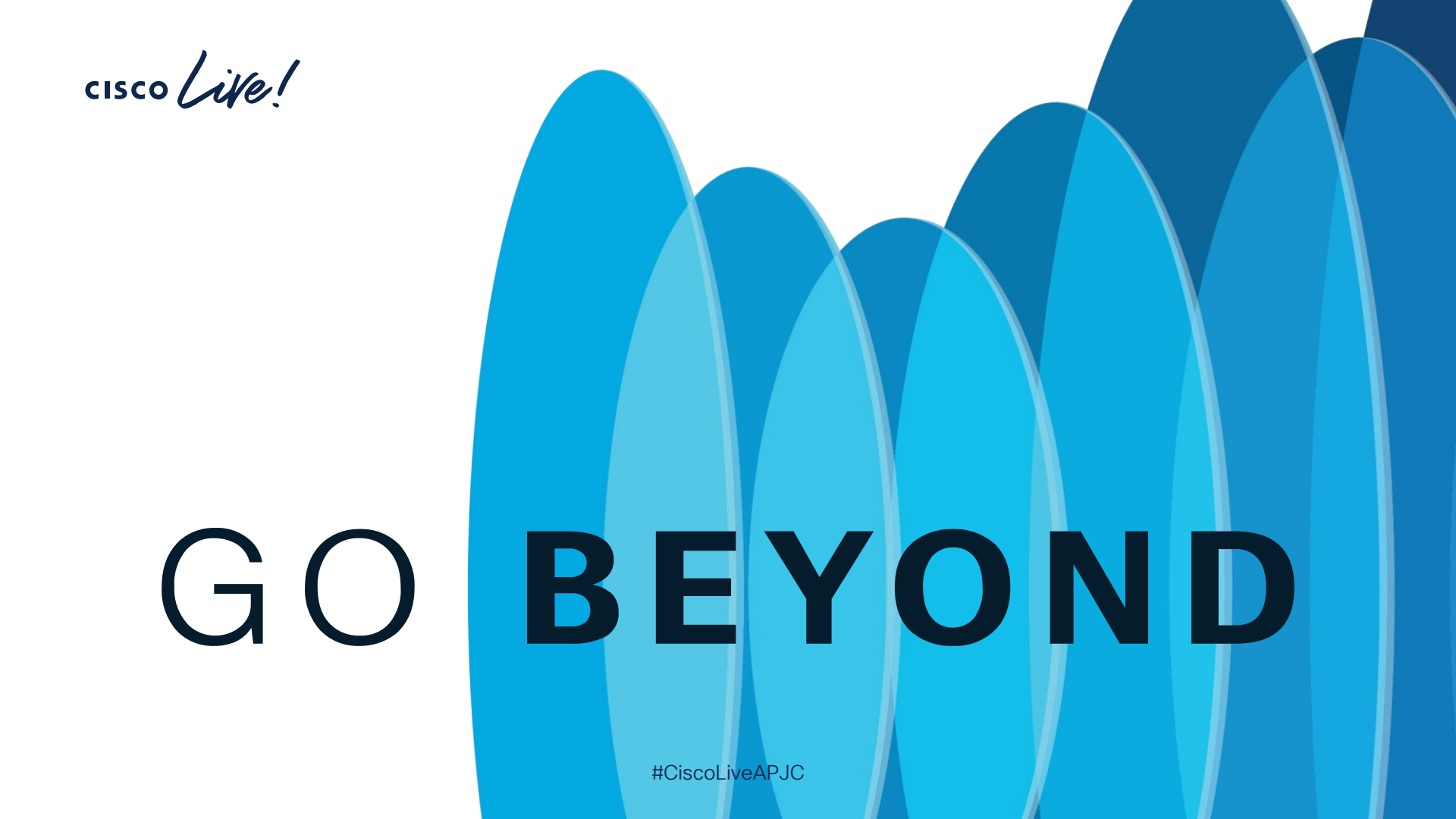
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