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The bridge to possible

SRv6 Fundamentals

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BRKMPL-2203

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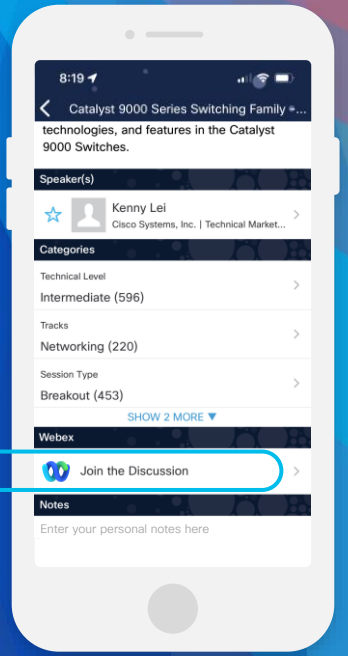

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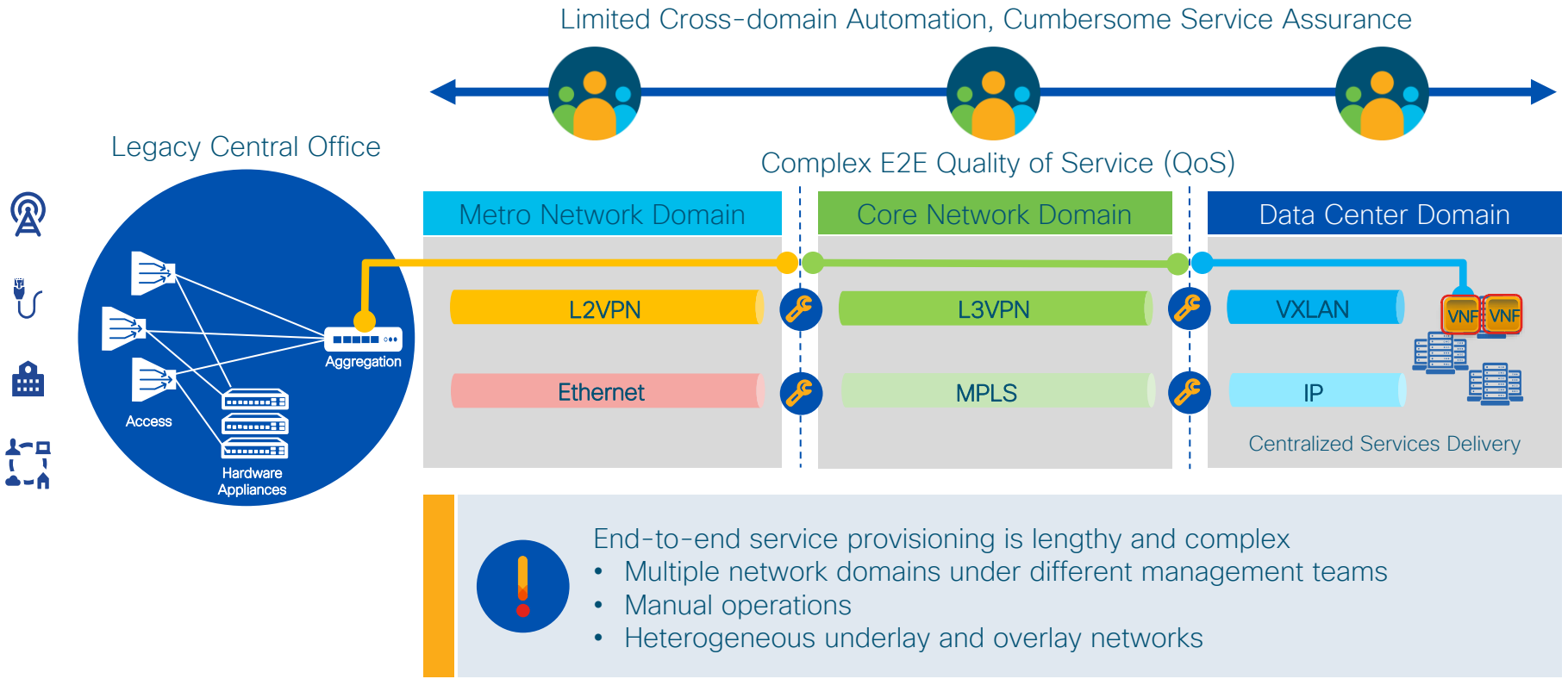
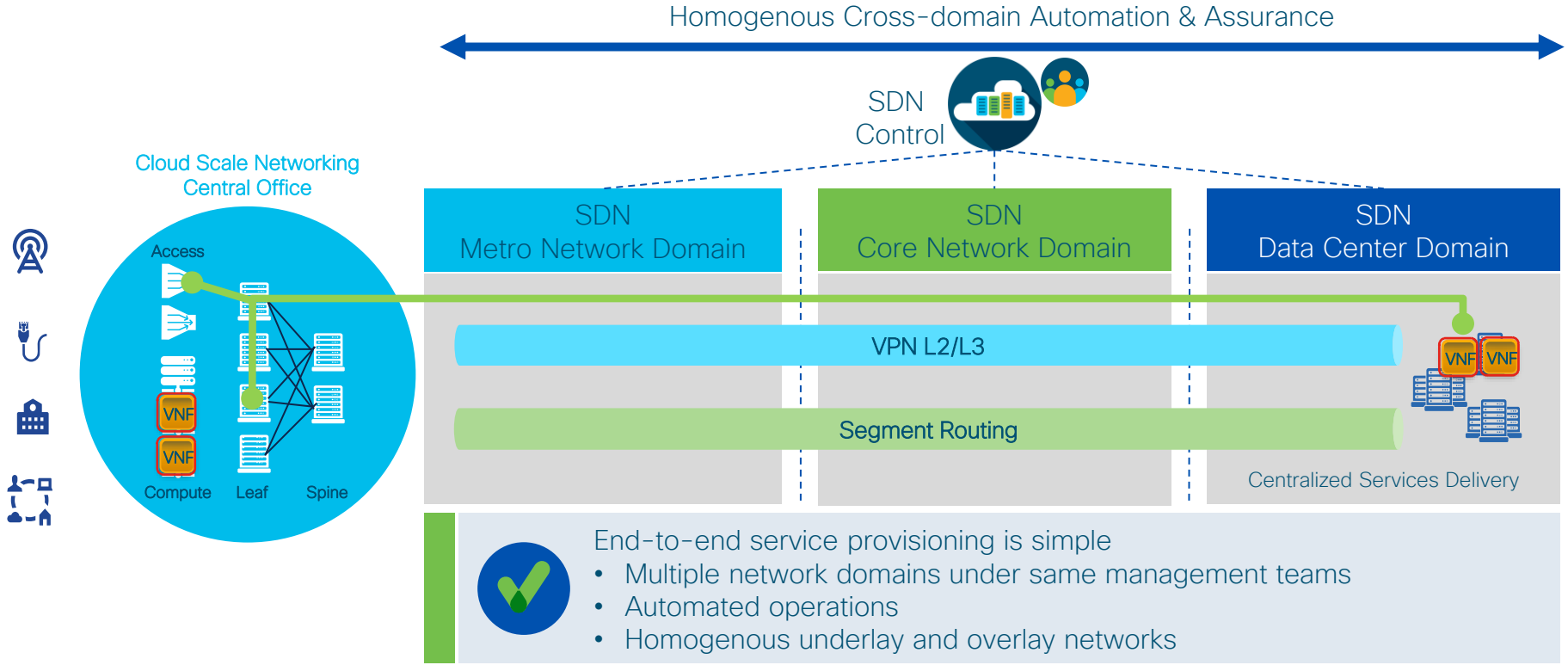
Agenda

- Introduction
- SRv6 Dataplane
- SRv6 Control Plane
- Addressing for SRv6
- SRv6 Migration
- Conclusion

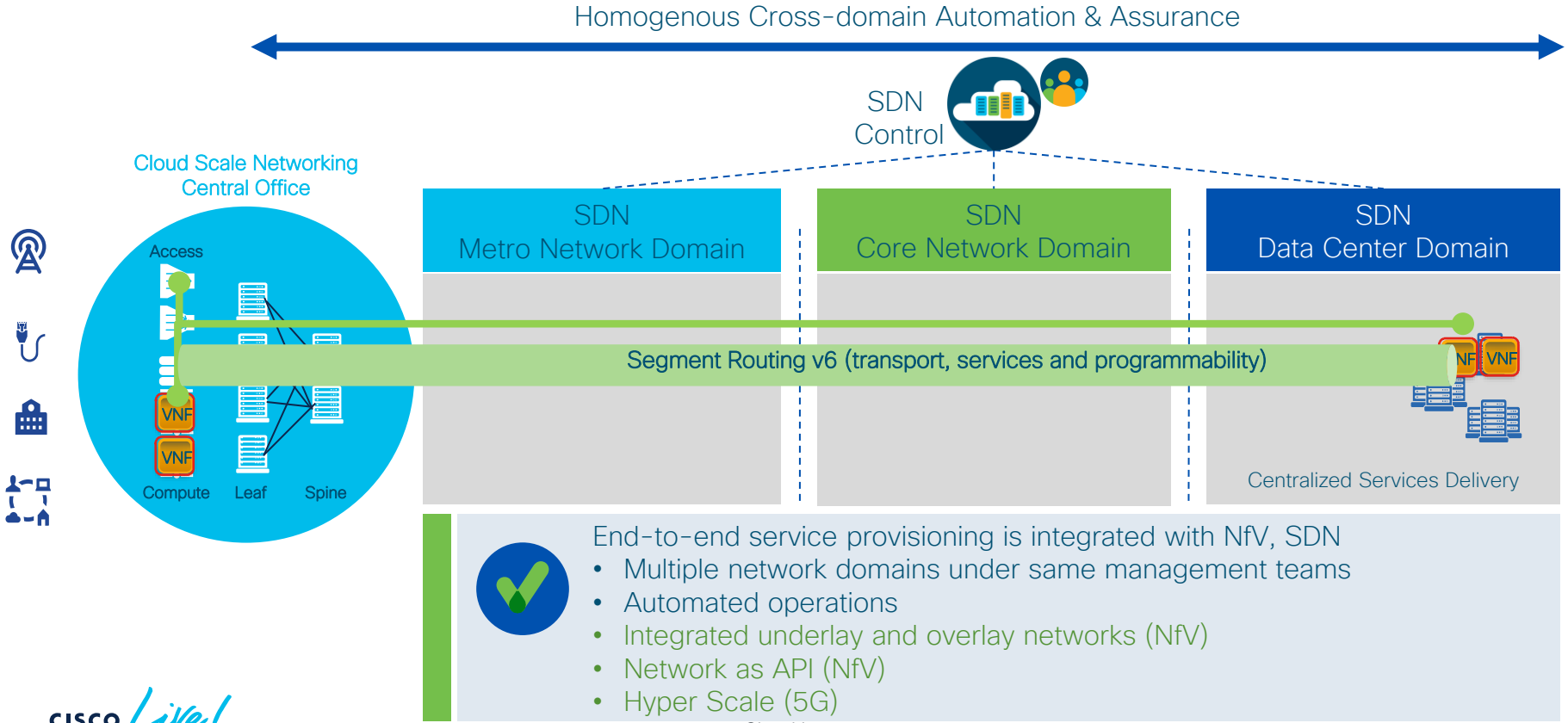
Understanding Today's Service Creation



SR-MPLS: SDN ready
“Network as a Fabric” for Service Creation



SRv6: SDN, NfV, 5G ready
“Network as an API” for Service Creation



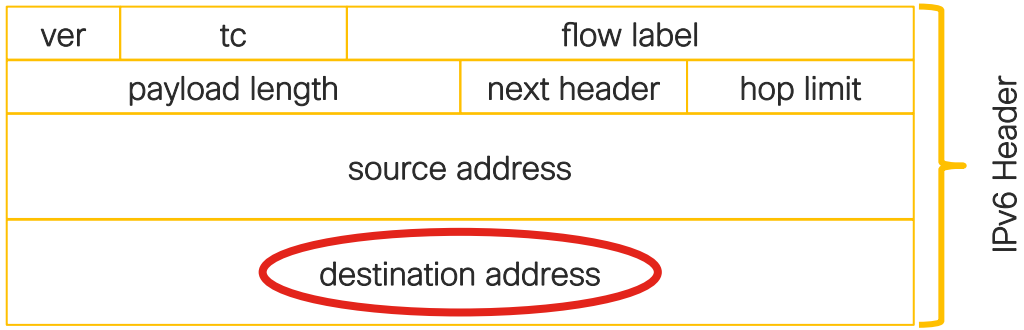
End-to-end service provisioning is integrated with NfV, SDN

- Multiple network domains under same management teams
- Automated operations
- Integrated underlay and overlay networks (NfV)
- Network as API (NfV)
- Hyper Scale (5G)

SRv6
IPv6 Segment Routing Header (SRH)

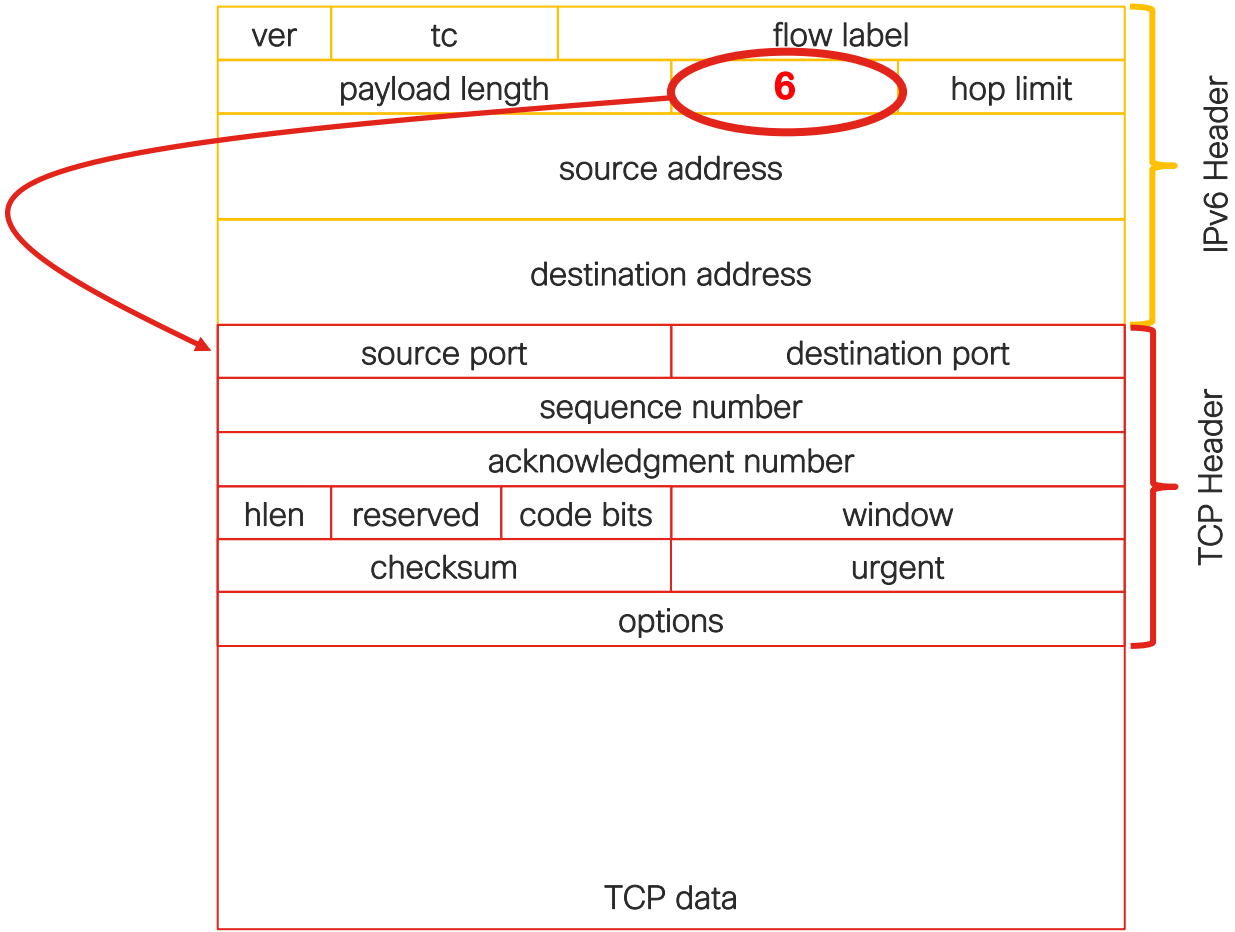
SRv6

- IPv6 Header
- Destination IP address



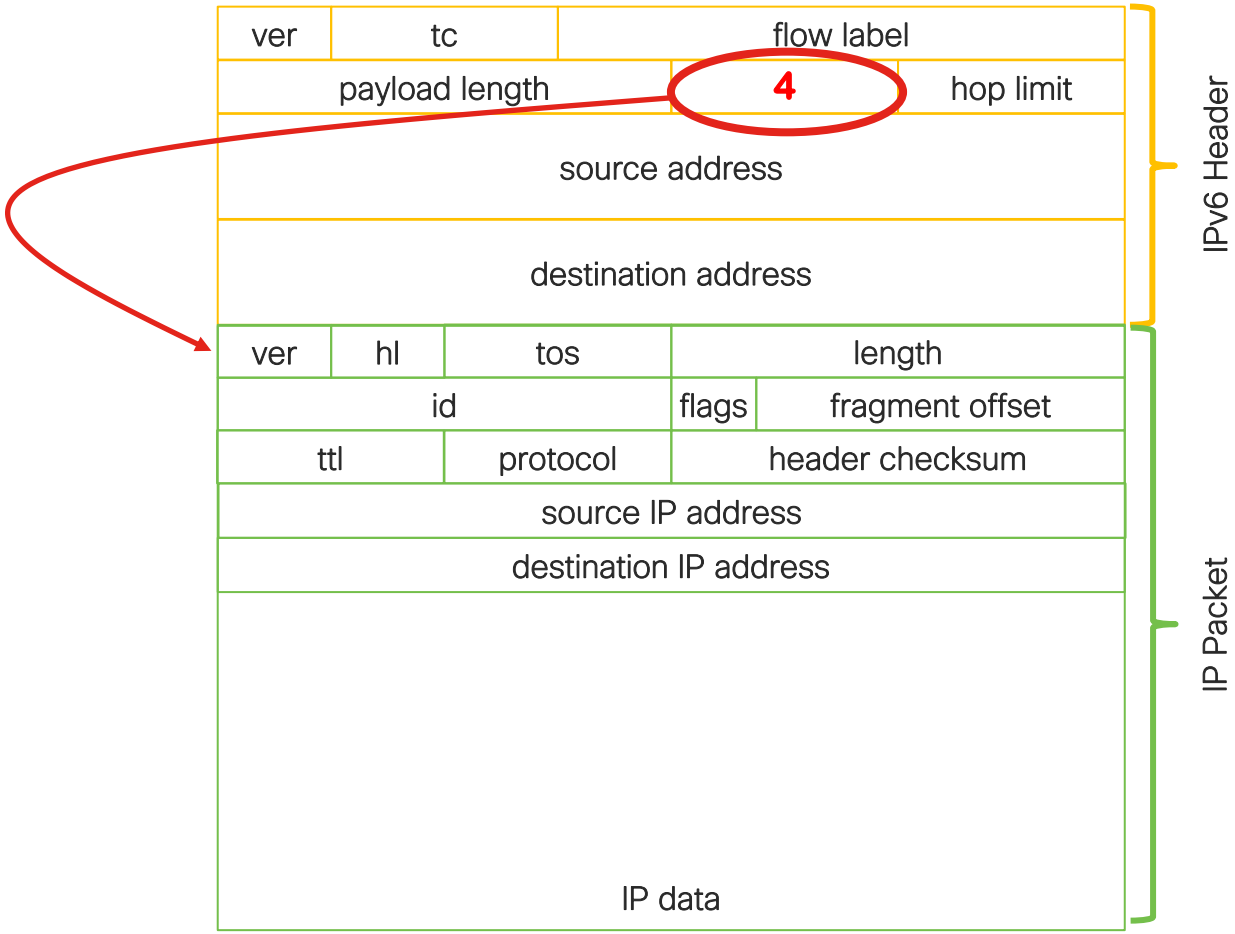
SRv6

- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....



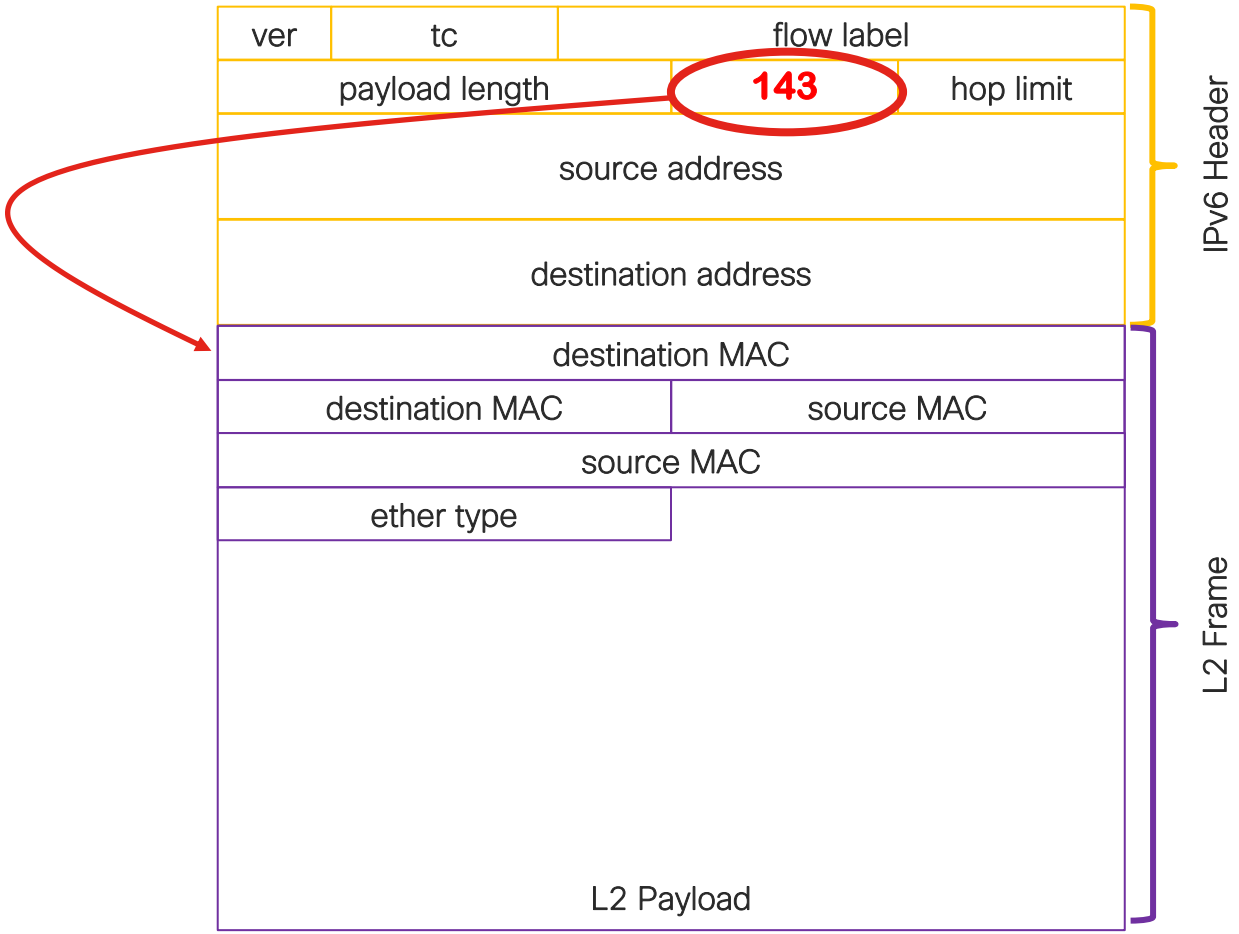
SRv6

- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....
  - IPv4, IPv6



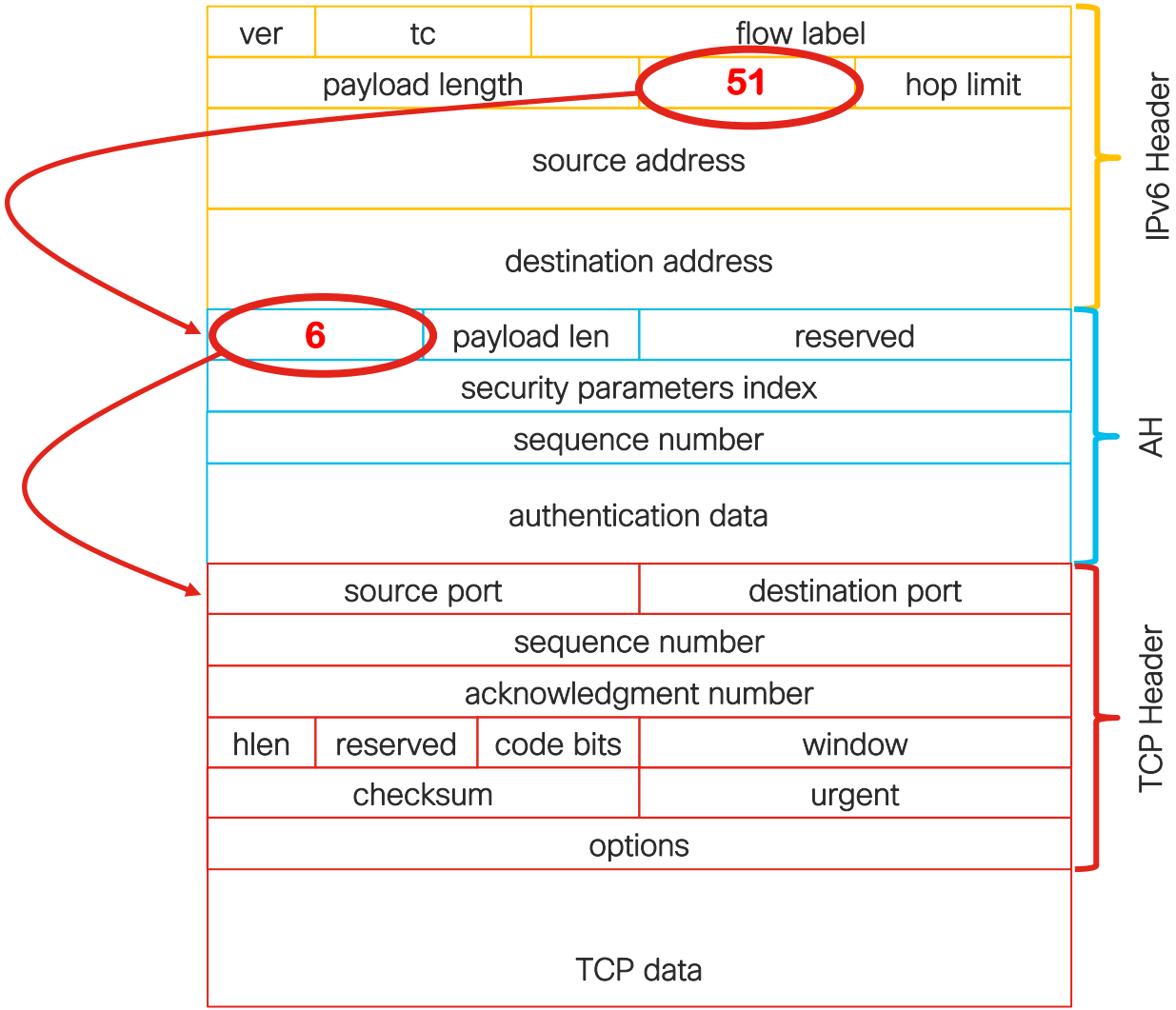
SRv6

- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....
  - IPv4, IPv6, L2



SRv6

- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....
  - IPv4, IPv6, L2
  - Hop by Hop, Dest. Options, Fragmentation, Authentication Header ...



SRv6

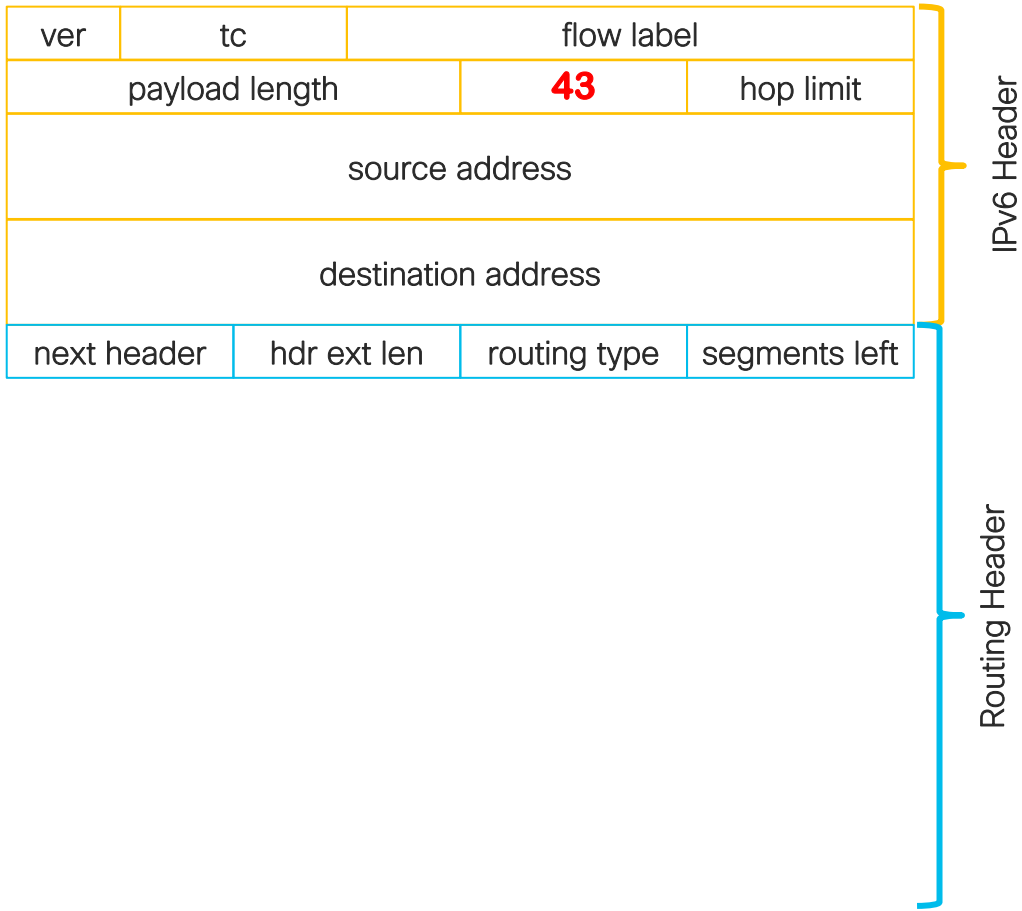
- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....
  - IPv4, IPv6, L2
  - Hop by Hop, Dest. Options, Fragmentation, Authentication Header ...
  - Routing Header

0 Source Route (deprecated)

1 Nimrod (deprecated)

2 Type 2 (RFC 6275)

3 RPL (RFC 6554)



SRv6

- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....
  - IPv4, IPv6, L2
  - Hop by Hop, Dest. Options, Fragmentation, Authentication Header ...
  - Routing Header

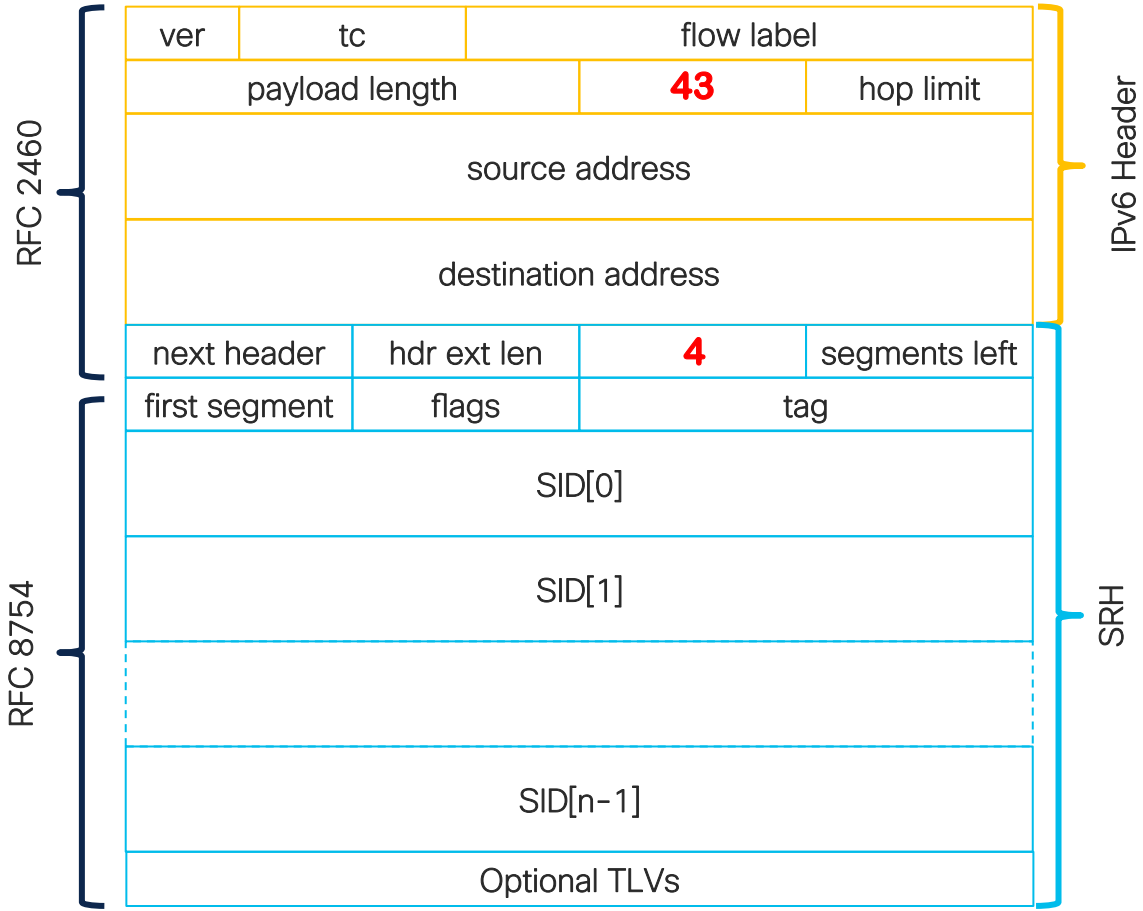
0 Source Route (deprecated)

1 Nimrod (deprecated)

2 Type 2 (RFC 6275)

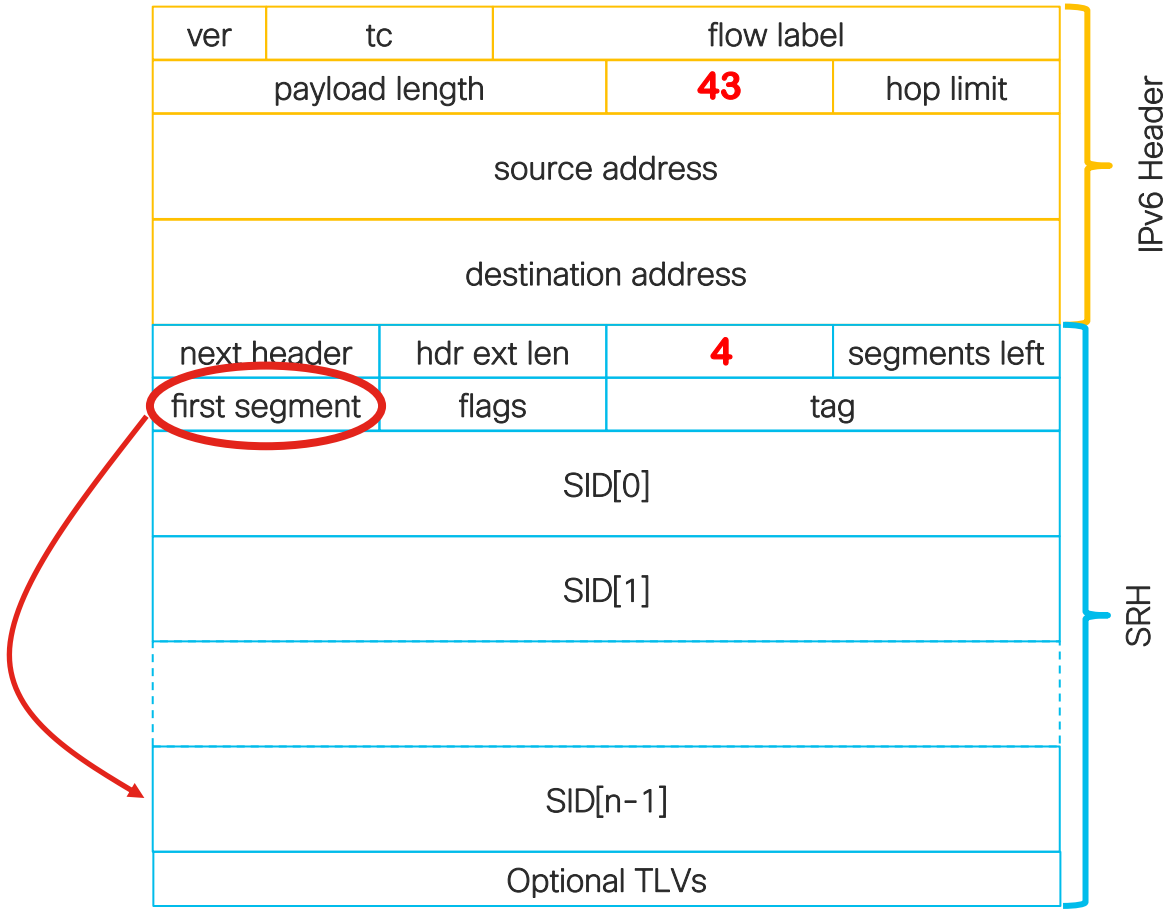
3 RPL (RFC 6554)

4 SRH (RFC 8754)



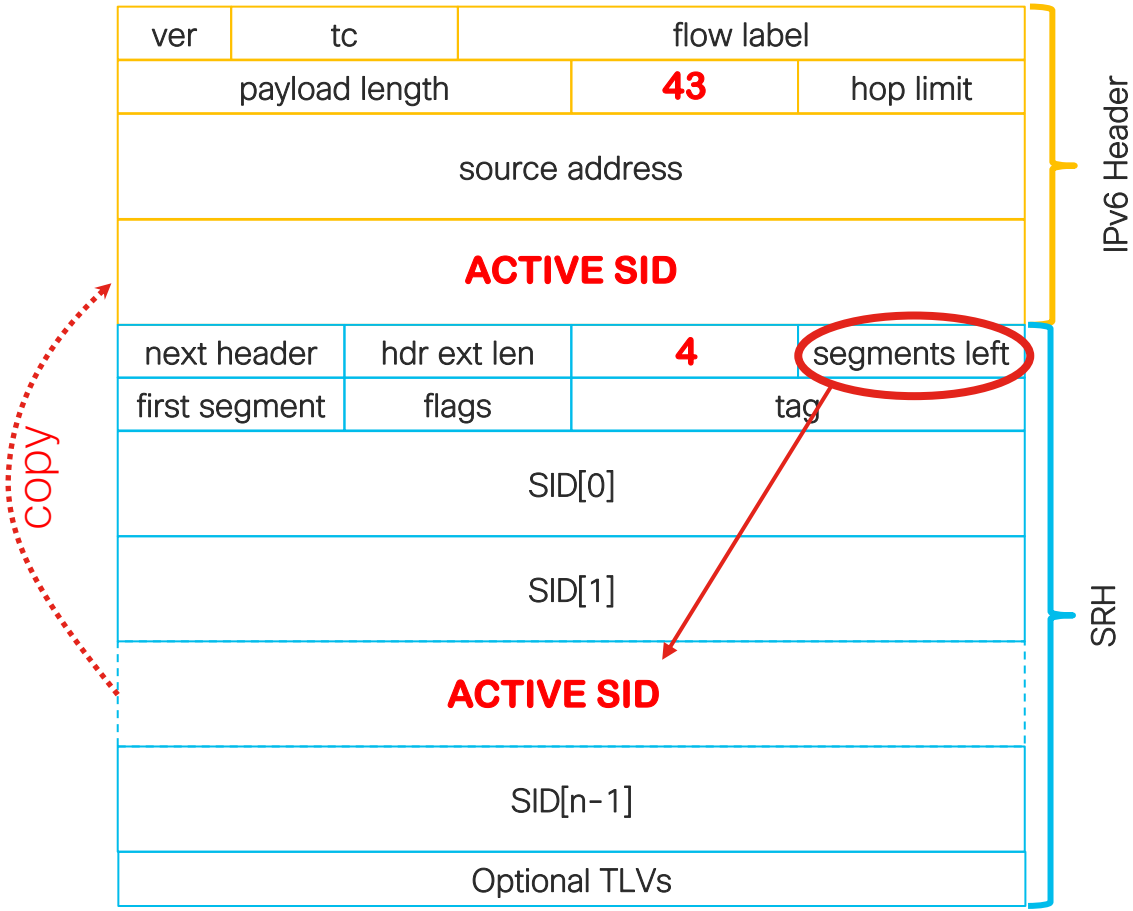
SRH

- Segment Routing Header
- First Segment
  - Pointer to very first SID



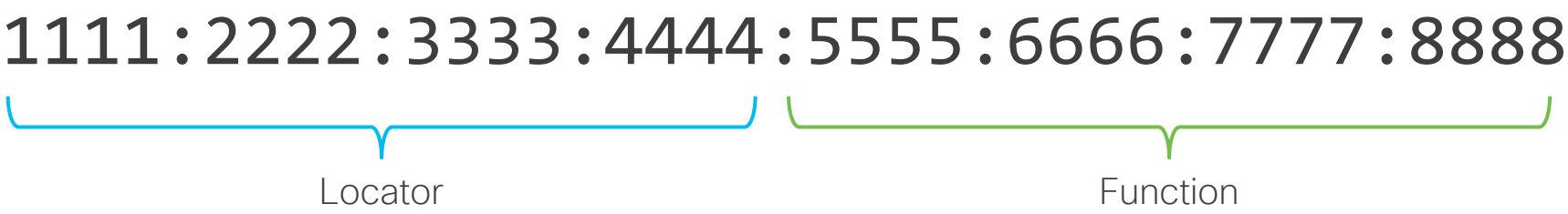
SRH

- Segment Routing Header
- First Segment
  - Pointer to very first SID
- Segments left
  - Pointer to Active SID
  - Active SID always in destination addr

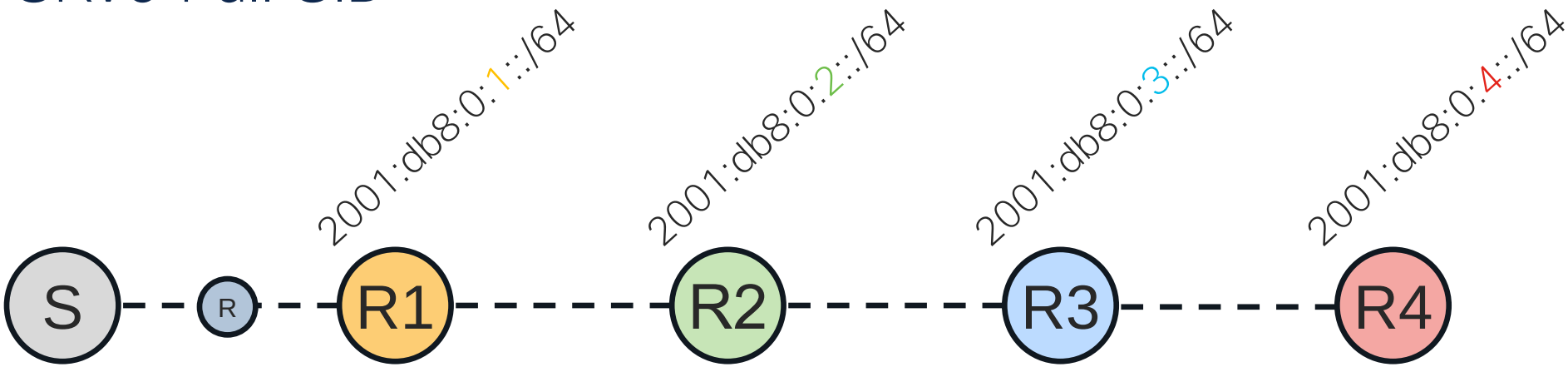


SID Structure -Locator

128 Bits Like IPv6 address but different semantics

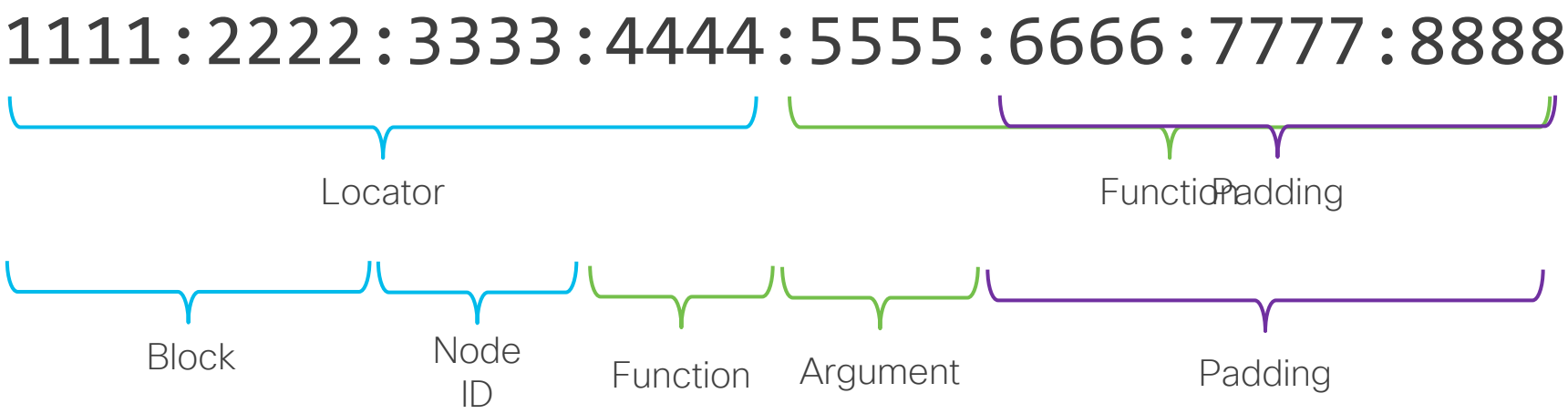


SRv6 Full SID



SID Structure

128 Bits Like IPv6 address but different semantics



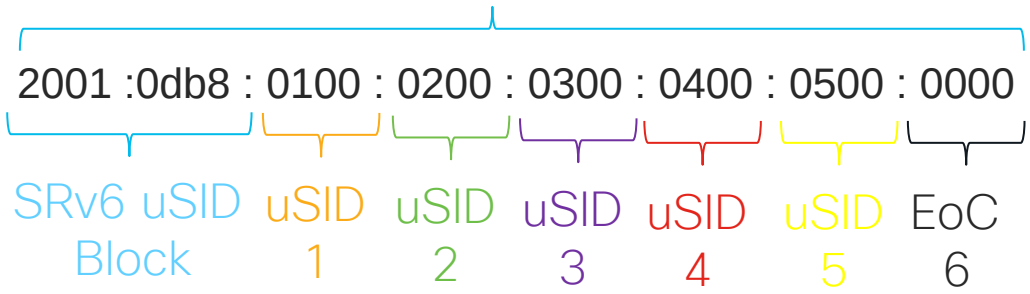
SRv6 uSID

SRv6 uSID format

: 0100 : =SRV6 uSID

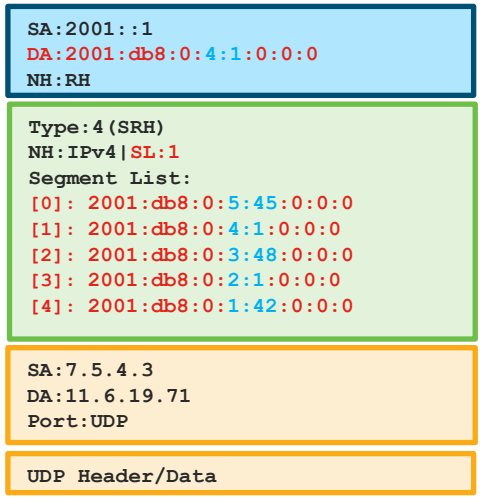
16 bits here, but can be anything

SRV6 uSID Container

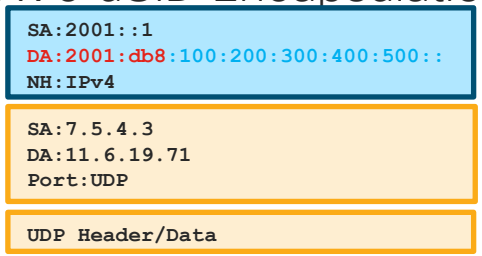


32 bits here,
but can be anything

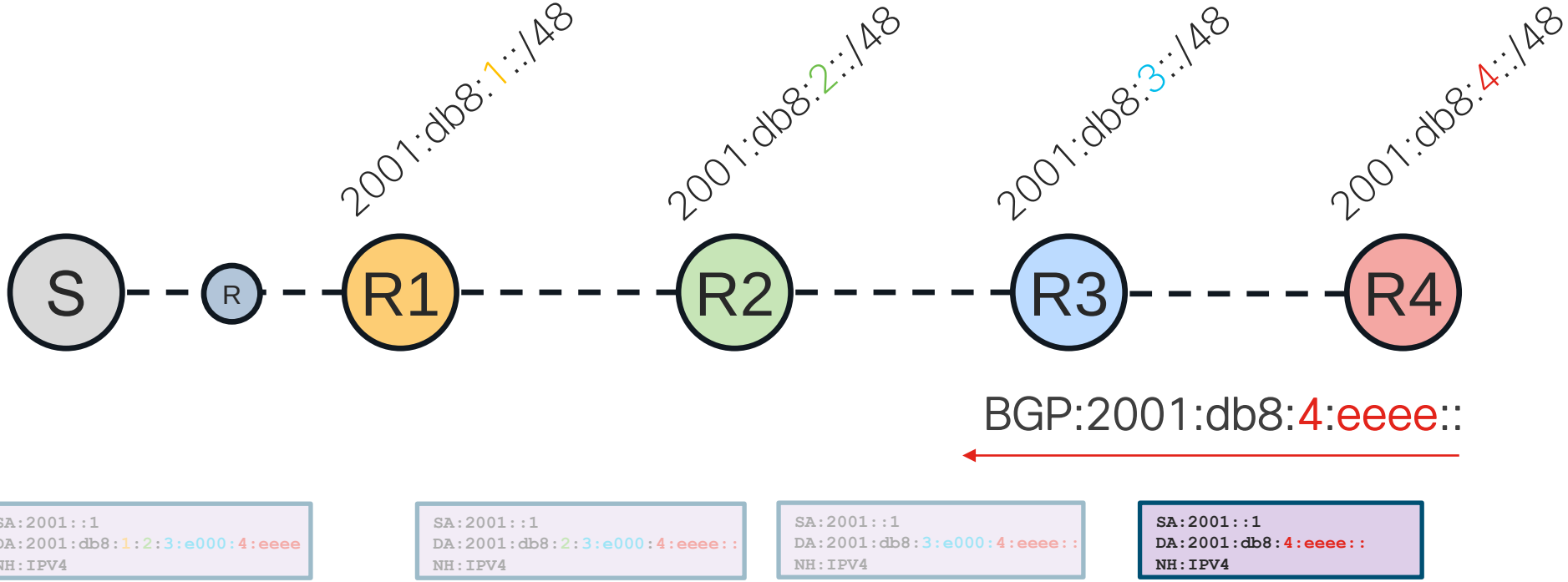
SRV6 Encapsulation



SRV6 uSID Encapsulation



SRv6 uSID F3216



SRv6 uSID More Than 6 SIDs?

100->200->300->400->500->600->700->800->900->a00->b00

Carrier 1 2001 : 0db8 : 0100 : 0200 : 0300 : 0400 : 0500 : 0600

Carrier 2 2001 : 0db8 : 0700 : 0800 : 0900 : 0a00 : 0b00 : 0000

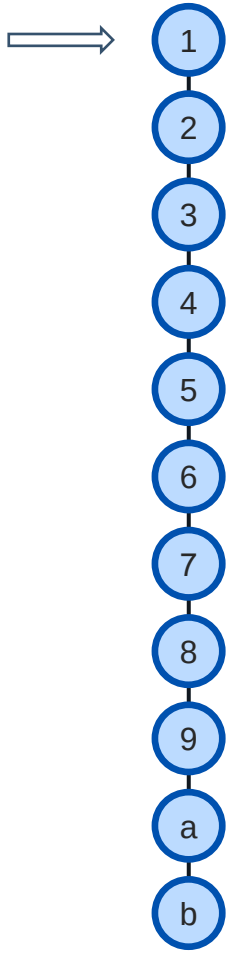
```
SA:2001::1
DA:2001:db8:[illegible]
NH:[illegible]
```

```
Type:4(SRH)
NH:IPv4|SL:[illegible]
Segment List:
[0]: 2001:db8:700:800:900:a00:b00::
```

```
SA:7.5.4.3
DA:11.6.19.71
Port:UDP
```

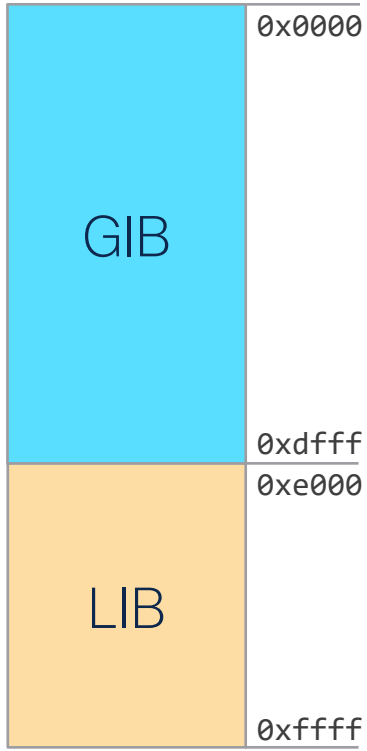
```
UDP Header/Data
```

Shift & Forward
END of Carrier
-> is there SRH?
Decrement SL
Copy New SID (Carrier)
PSP



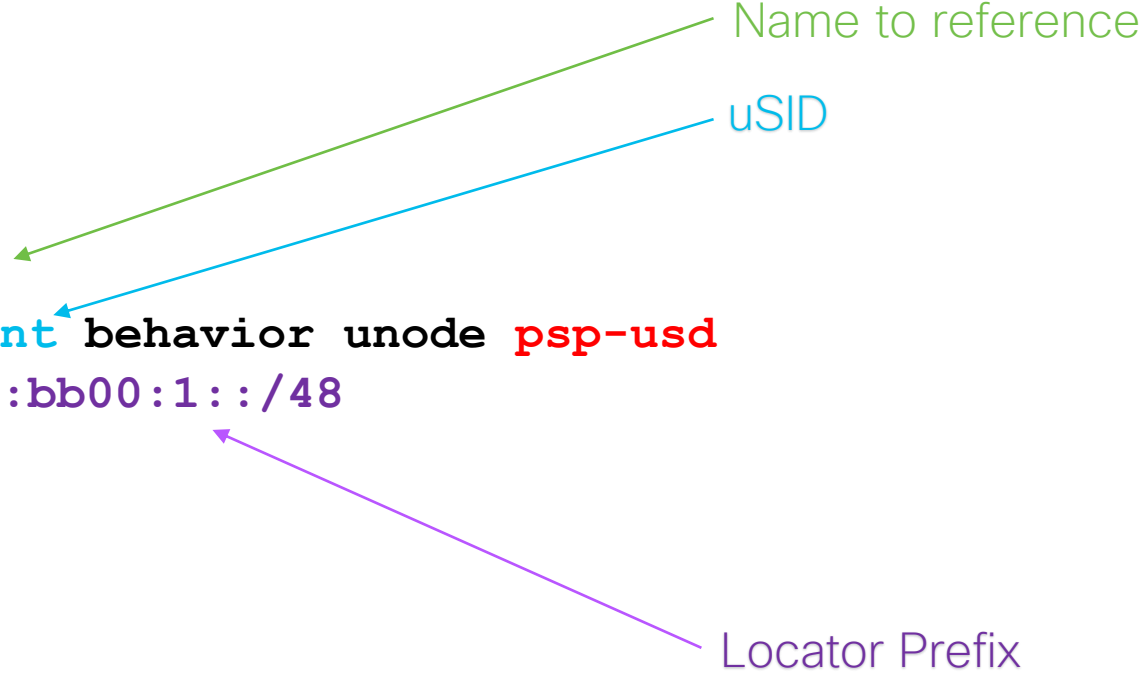
Sets, Global ID Block (GIB), Local ID Block (LIB)

- Within a Block, SIDs are allocated: `FCBB:BB00:SSII::/48`
- SID can be:
  - Global: shortest path to a node – globally unique
  - Local: a local function – not globally unique
- 256 Sets in a Block, identified by "SS"
- Global Sets (GIB): first "S" values 0 to D
  - 224 global Sets → 224 * 256 = 56k global IDs
- Local Sets (LIB): first "S" values E to F
  - 32 local Sets → 32 * 256 = 8k local IDs



SRv6 uSID Configuration

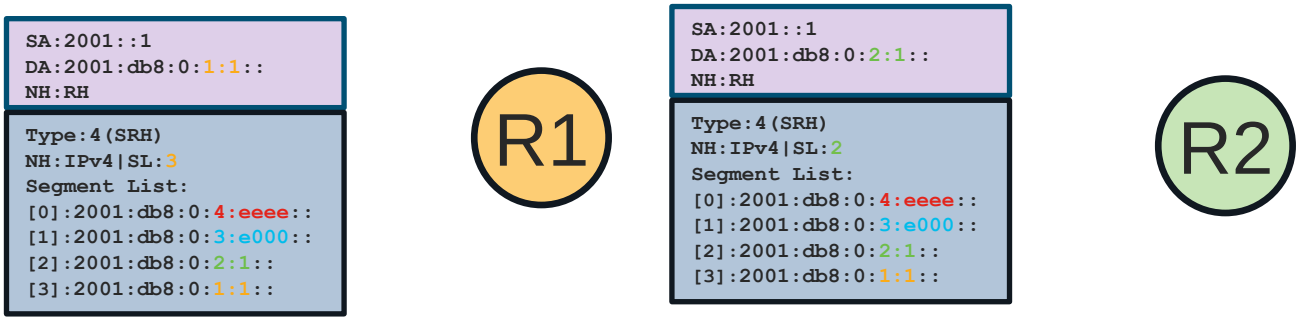
```
segment-routing
 srv6
  locators
   locator MAIN
    micro-segment behavior unode psp-usd
    prefix fcbb:bb00:1::/48
```



SRv6
Network Programming

END– Default endpoint (Node SID)

- *Decrement SL*
- *Copy Active SID*
- *Forward*

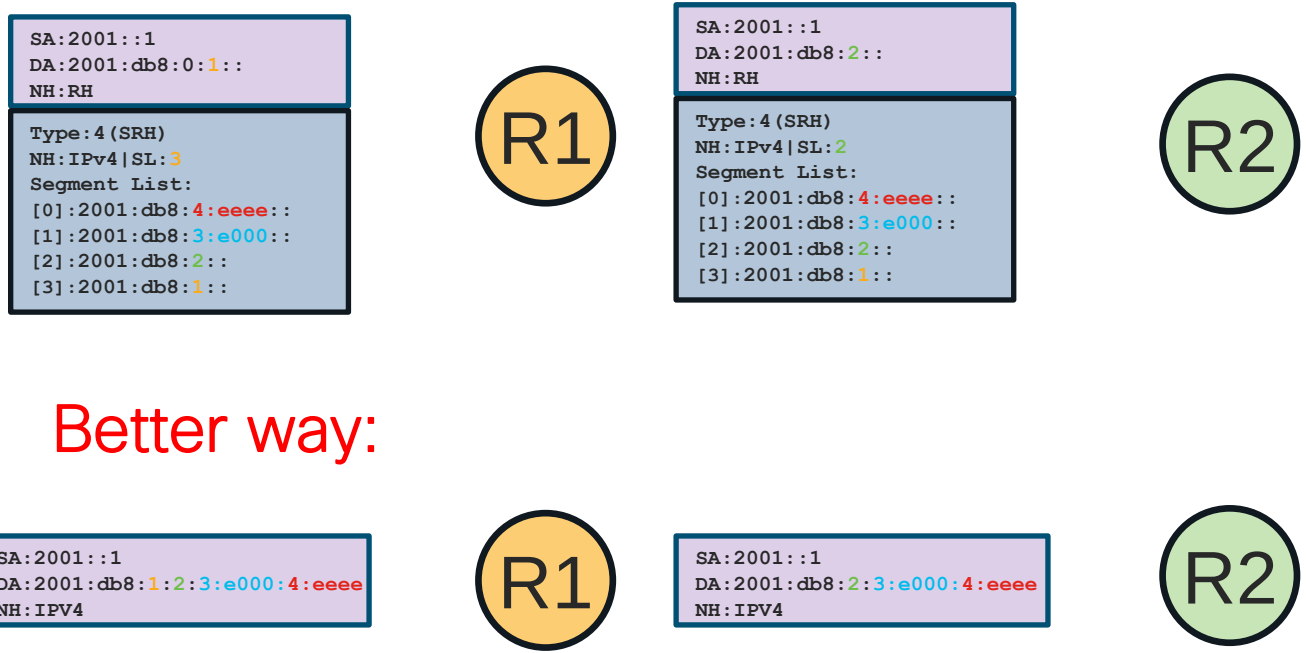


- Different Flavors:
  - End
  - End with PSP
  - End with USP
  - End with PSP & USP
  - End with USD
  - End with PSP & USD
  - End with USP & USD
  - End with PSP, USP & USD

- End with NEXT-ONLY-CSID
- End with NEXT-CSID
- End with NEXT-CSID & PSP
- End with NEXT-CSID & USP
- End with NEXT-CSID, PSP & USP
- End with NEXT-CSID & USD
- End with NEXT-CSID, PSP & USD
- End with NEXT-CSID, USP & USD
- End with NEXT-CSID, PSP, USP & USD

uN=END with Next – Default endpoint (Node SID)

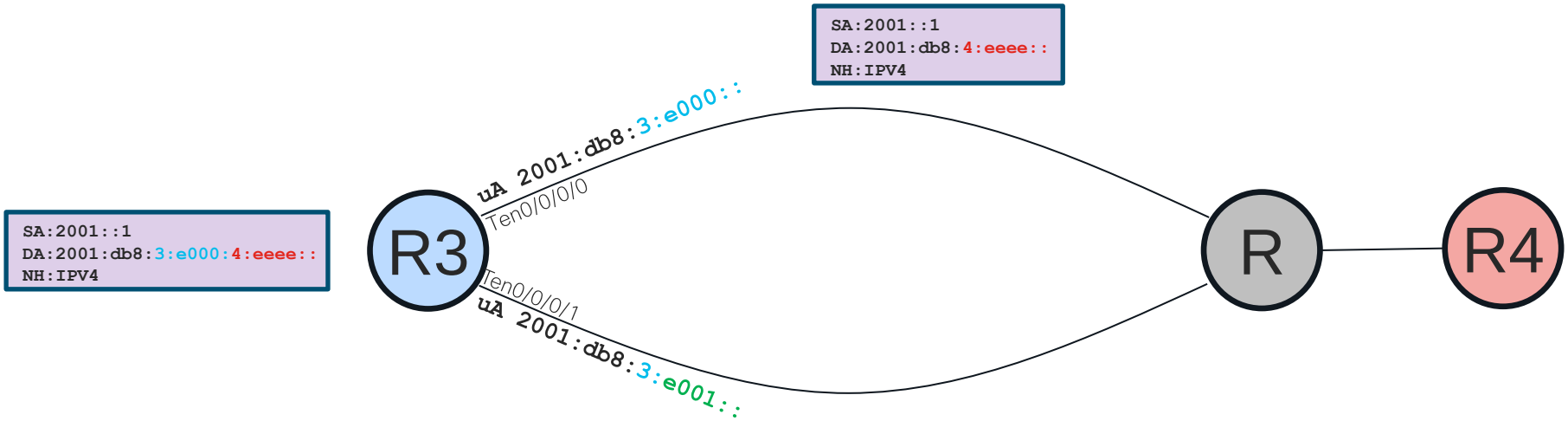
- *Decrement SL*
- *Copy Active SID*
- *Forward*



Better way:

- *Shift & Forward*

uA=END.X with Next – (Adjacency SID)



- *Shift & Forward to **SPECIFIC INTERFACE***

uDT4=END.DT4, uDT6=END.DT6
Endpoint with Decapsulation and Table Lookup

- *Decapsulate and Table Lookup (VRF)*
- *Same as Per VRF Label Allocation (aggregate label)*
- *Must be last function in SID list*

SRv6 functions: Steering and Services

Codename		Behavior	
End	uN	Endpoint	[Node SID]
End.X	uA	Endpoint with Layer-3 cross-connect	[Adj SID]
End.B6.Insert	uB6.Insert	Endpoint bound to an SRv6 policy	[BSID]
End.B6.Encap	uB6.Encaps	Endpoint bound to an SRv6 encapsulation policy	[BSID]
End.DX6	uDX6	Endpoint with decapsulation and IPv6 cross-connect	[L3VPN Per-CE]
End.DX4	uDX4	Endpoint with decapsulation and IPv4 cross-connect	[L3VPN Per-CE]
End.DT6	uDT6	Endpoint with decapsulation and specific IPv6 table lookup	[L3VPN Per-VRF]
End.DT4	uDT4	Endpoint with decapsulation and specific IPv4 table lookup	[L3VPN Per-VRF]
End.DX2	uDX2	Endpoint with decapsulation and L2 cross-connect	[E-LINE]
End.DT2U/M	uDT2U/M	Endpoint with decapsulation and L2 unicast lookup / flooding	[E-LAN]
End.DTM	uDTM	Endpoint with decapsulation and MPLS table lookup	[Interworking]
H.Insert / H.Encaps		Headend with Insertion / Encapsulation of / into an SRv6 policy	[TiLFA]
H. Encaps.L2		H.Encaps Applied to Received L2 Frames	[L2 Port Mode]
H.Encaps.M		H.Encaps Applied to MPLS Label Stack	[Interworking]

ISIS Extensions

Functions might be signaled differently

Signalling	IGP	BGP-LS	BGP-IP/VPN
End, uN	Yes	Yes	
End.X, uA	Yes	Yes	
End.T	Yes	Yes	
End.DX4,uDX4		Yes	Yes
End.DX6,uDX6	Yes	Yes	Yes
End.DX2,uDX2		Yes	Yes
END.DT4,uDT4		Yes	Yes
End.DT6,uDT6	Yes	Yes	Yes
End.B		Yes	

Signalling	IGP	BGP-LS	BGP-IP/VPN
T.insert		Yes	
T.Encap		Yes	

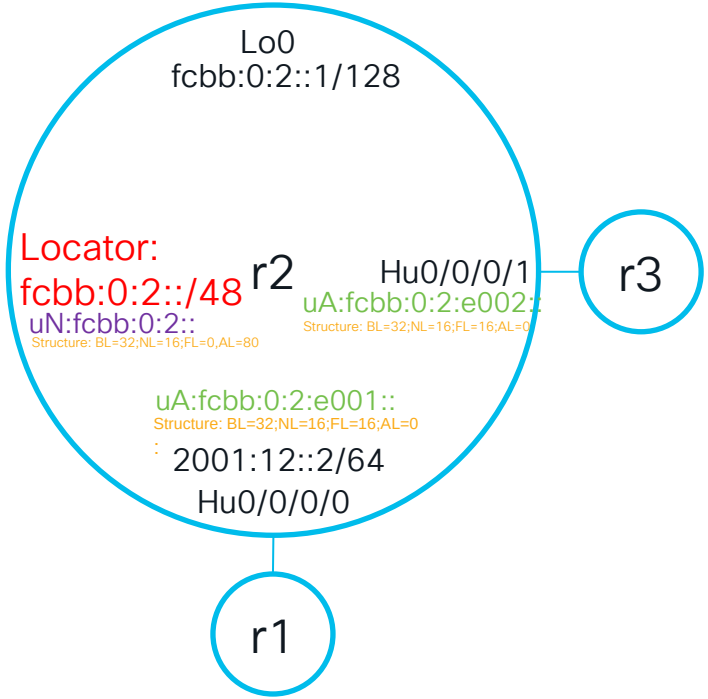
Locator – routing table

ISIS for SRv6

LSP (Link State Packet):

TLVs:

Hostname:	r2	
Interfaces:	Hu0/0/0/0	uA:fcbb:0:2:e001:: Structure: BL=32;NL=16;FL=16;AL=0
	Hu0/0/0/1	uA:fcbb:0:2:e002:: Structure: BL=32;NL=16;FL=16;AL=0
	Lo0	
Neighbors:	r1	
	r3	
IP addresses:	fcbb:0:2::1/128	
	2001:12::2/64	
Locator:	fcbb:0:2::/48	
	uN:fcbb:0:2:: Structure: BL=32;NL=16;FL=0,AL=80	
Capabilities:	Algorithms	
	SIDs can insert	
	SIDs can decap	
	.....	



SRv6 ISIS Configuration

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

Name of the Locator

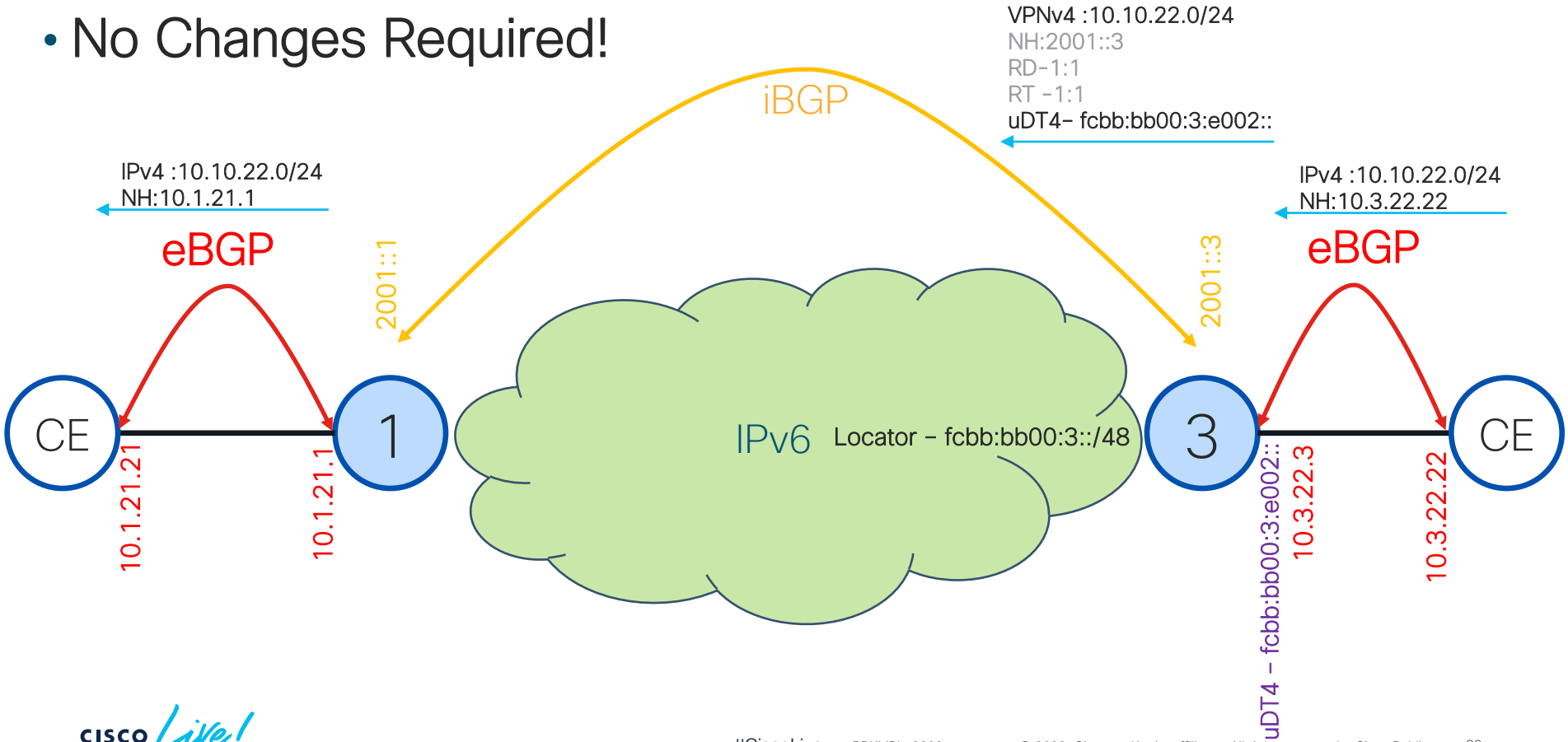
This will result in:

- Locator is advertised
- uN function is advertised
- uA for each ISIS interface is allocated and advertised

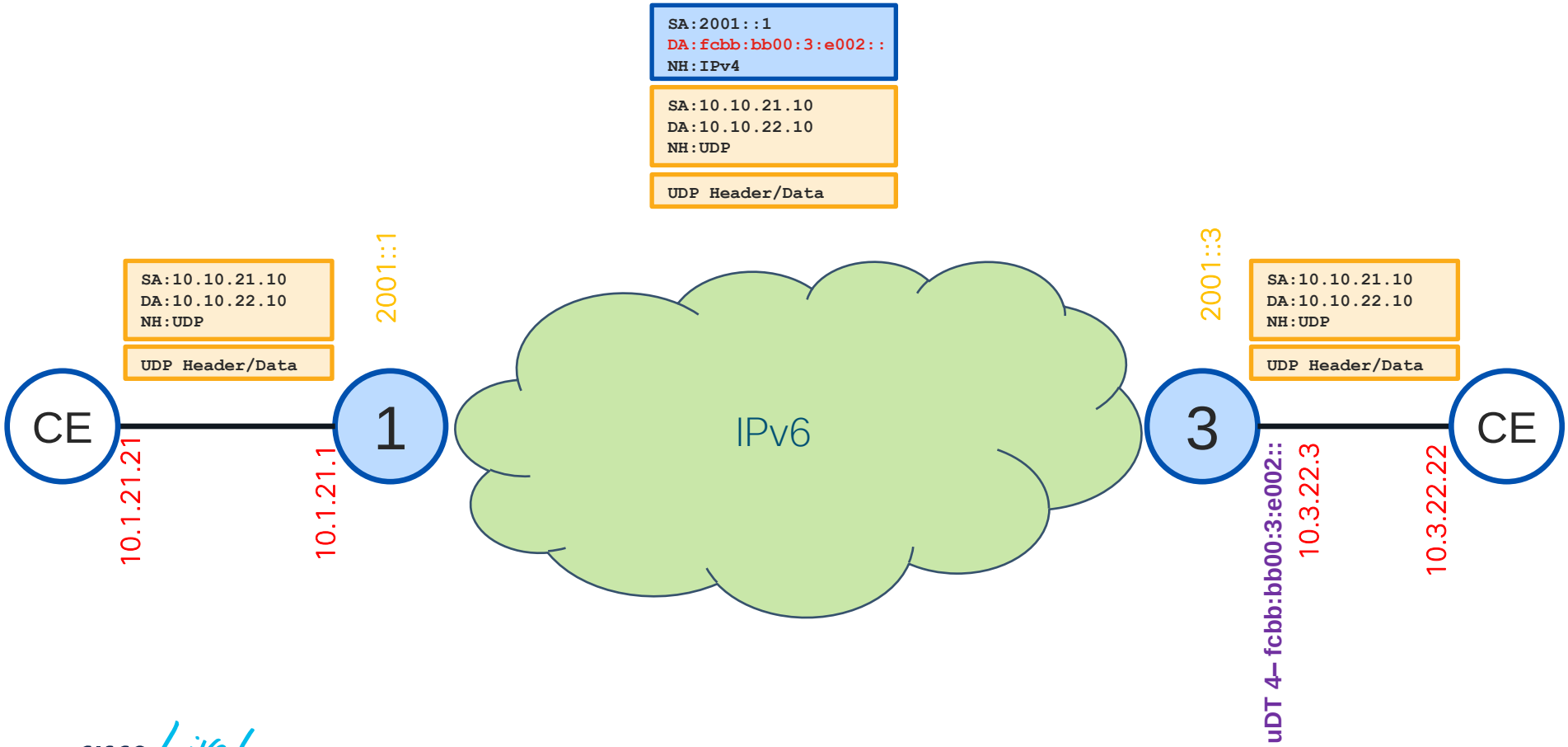
BGP for Overlay

BGP

- No Changes Required!



L3 VPN Dataplane



SRv6 L3 VPN Configuration

```
router bgp 1
 address-family vpnv4 unicast
 vrf BestEffort
  rd 1:1
  address-family ipv4 unicast
   segment-routing srv6
    locator MAIN
    alloc mode per-vrf
```

Name of the Locator

Single DT function is allocated per VRF and AF

This will result in:

- uDT4 function is allocated
- All prefixes are advertised with uDT4 function

SRv6 Addressing

Separation between SIDs and addresses

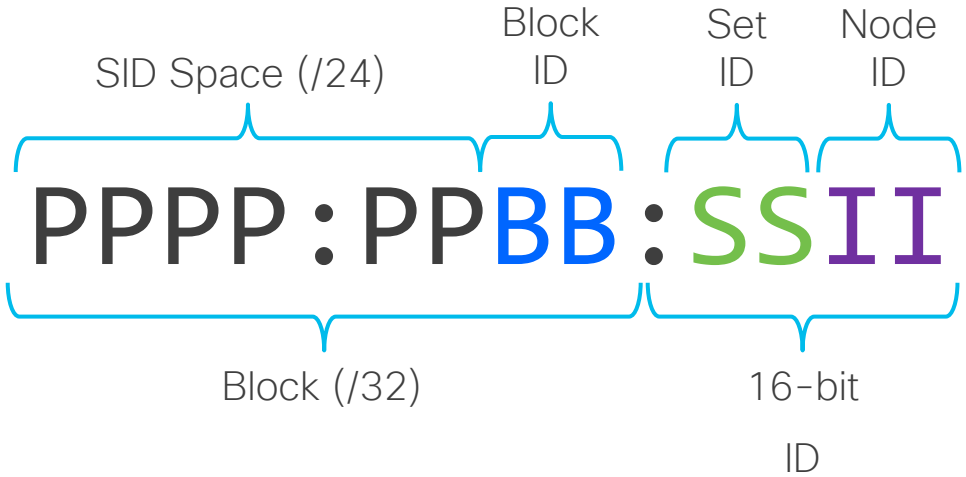
- Infrastructure addressing and SRv6 SID allocation belong to two different planes and are different
  - Infrastructure IP addresses (e.g., link interfaces, loopbacks) are allocated on the management plane
  - SRv6 SIDs are allocated on the service plane
- SRv6 SIDs are assigned to a node independently 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.

Terminology – uSID F3216

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

- uSID F3216 structure:



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

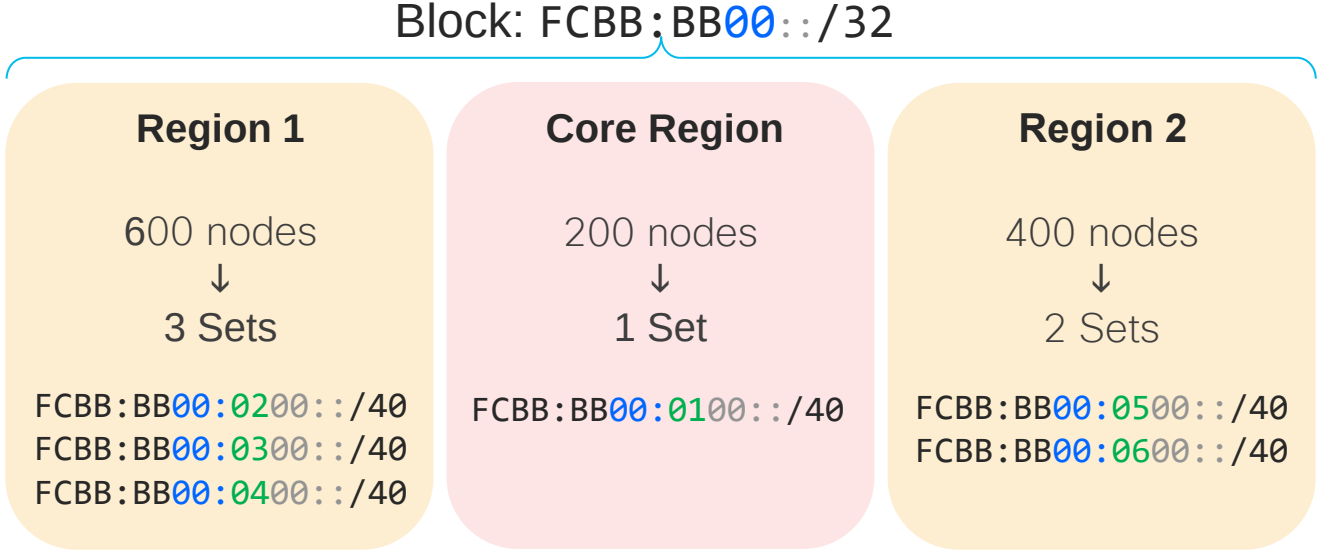
uSID Block per slice (Flex Algo) if possible

- 256 Blocks are available in the SRv6 Space:

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

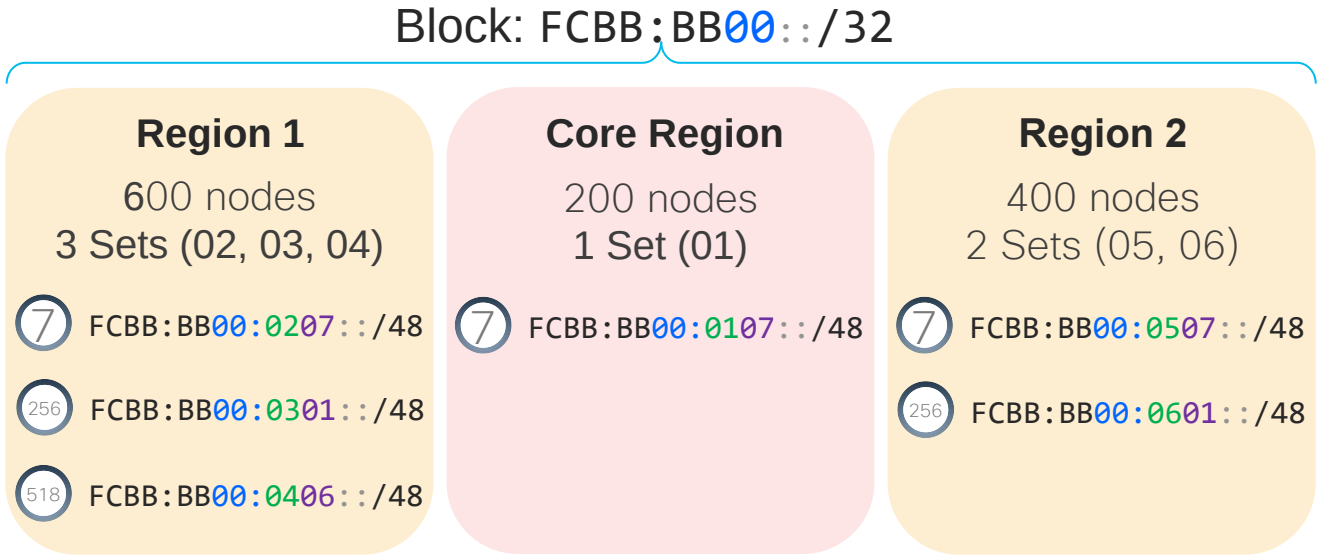
  - Multiple Blocks can be concurrently used on a node
  - 63 Blocks available on DNX1 platforms (`TT` = 00 to 3E)
- We assume 2 slices (Blocks), e.g.:
  - `FCBB:BB00::/32` Low-cost slice (algo 0) ← focus, other Blocks are similar
  - `FCBB:BB01::/32` Low-delay slice (algo 128)

Set Allocation Example



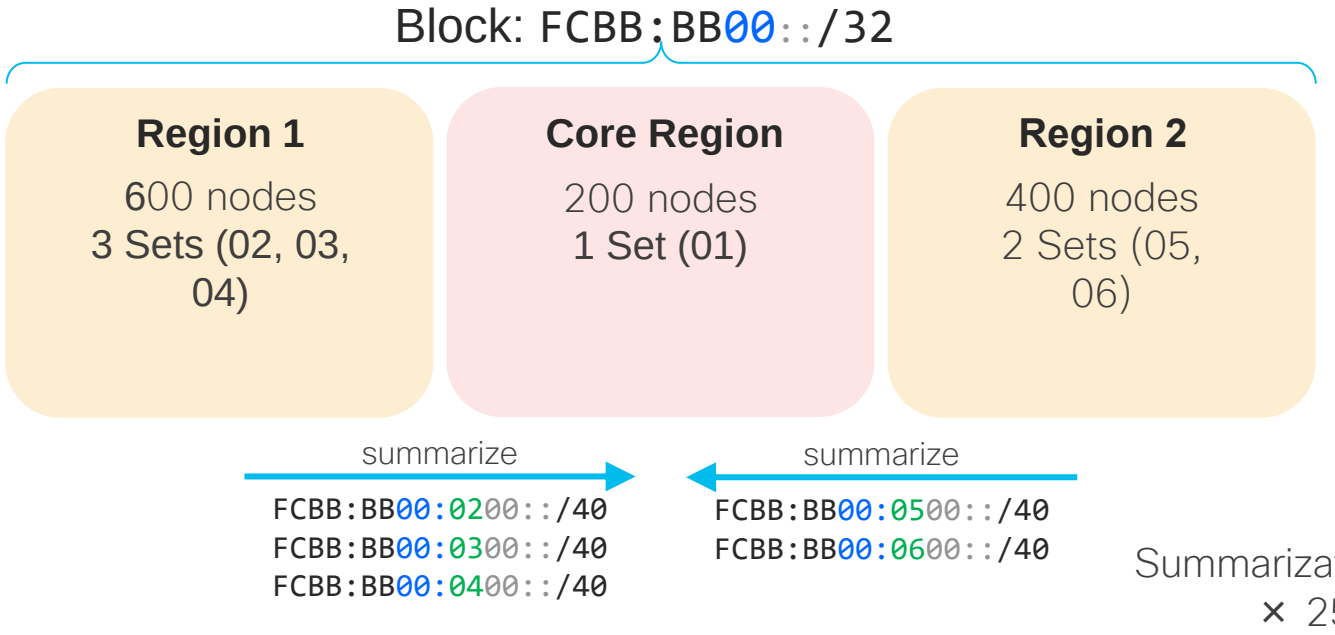
- If a region outgrows its allocated Sets, then allocate more Sets to this region

uSID Allocation Example



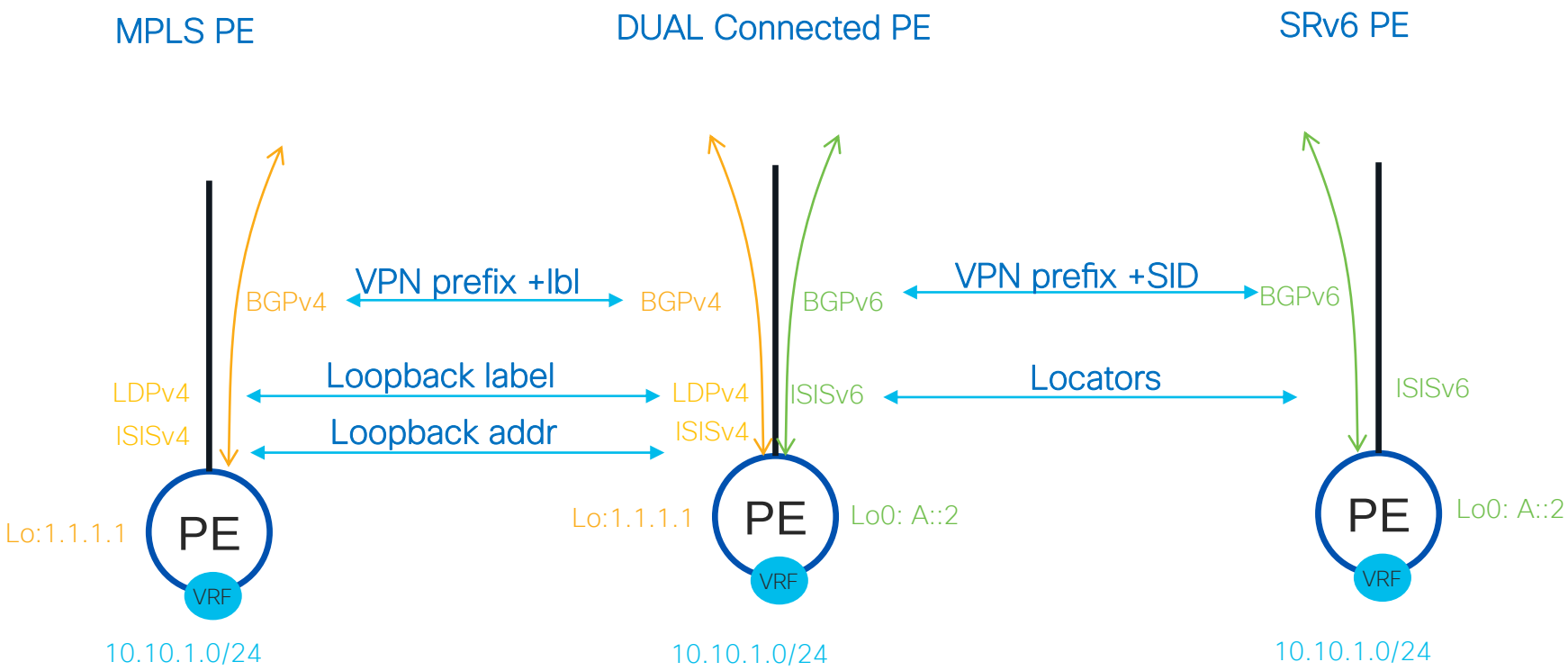
- Remaining unallocated uSIDs in Sets are for future growth

Summarization

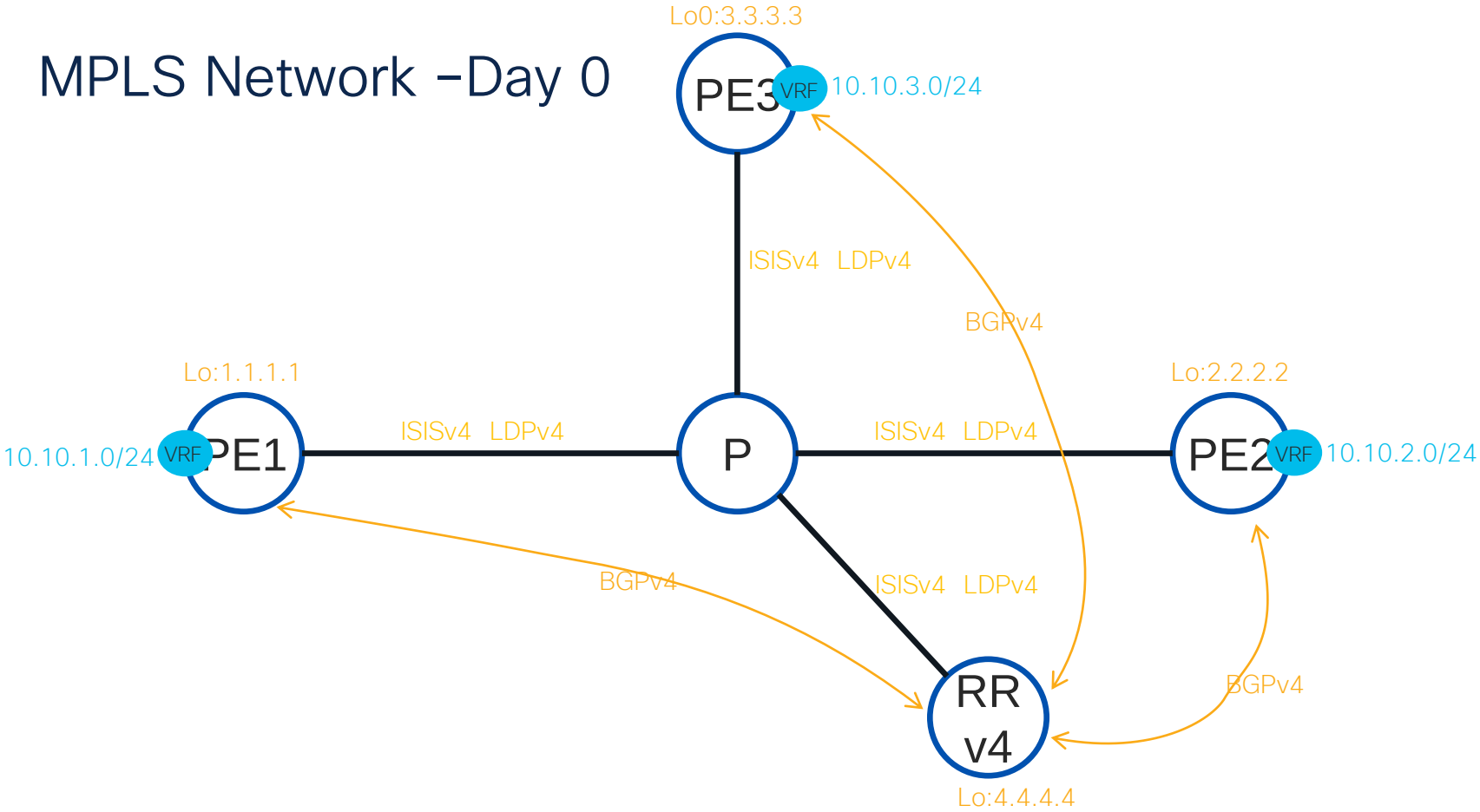


SRv6 Migration

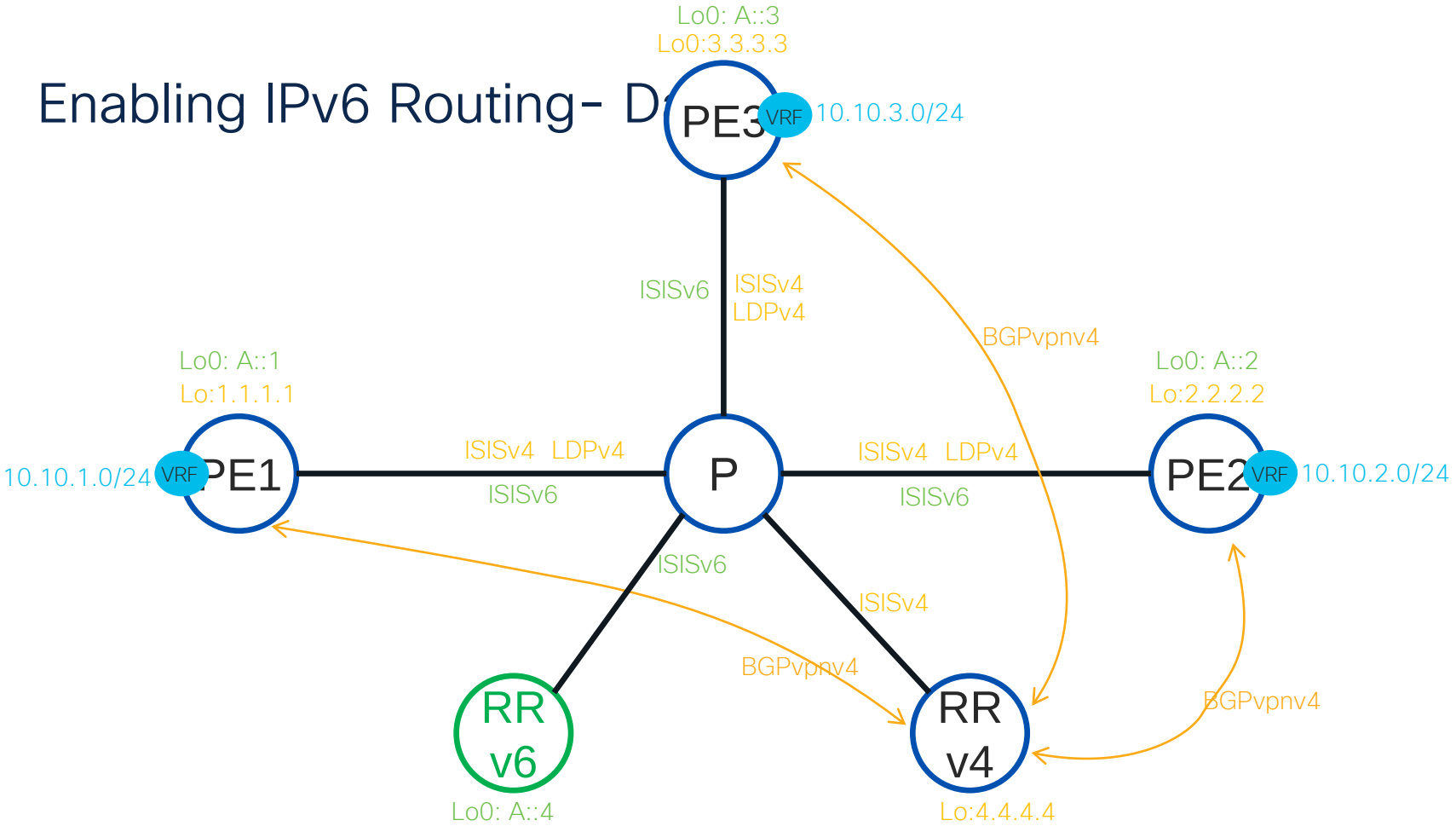
Dual Connected PE



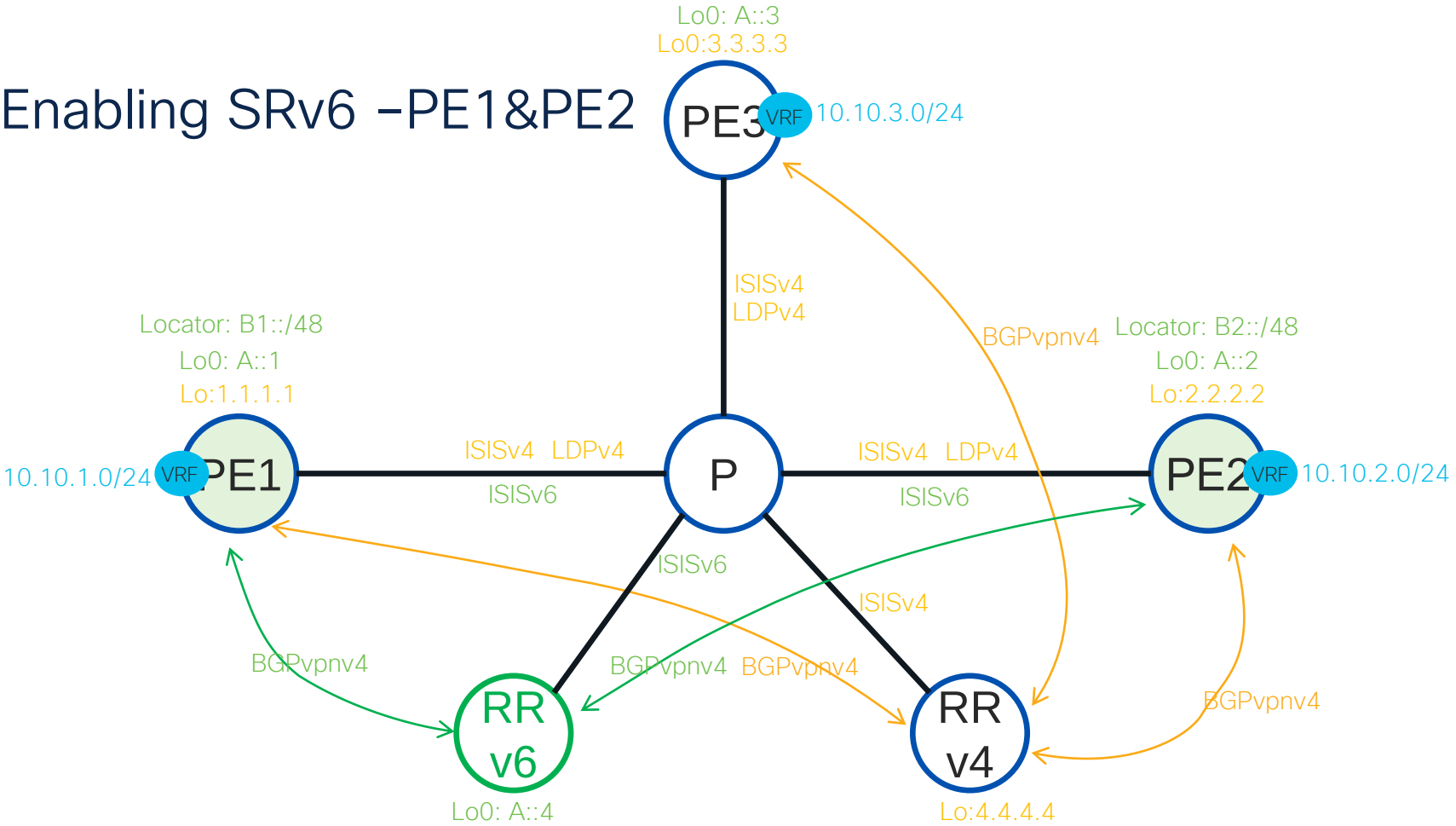
MPLS Network –Day 0



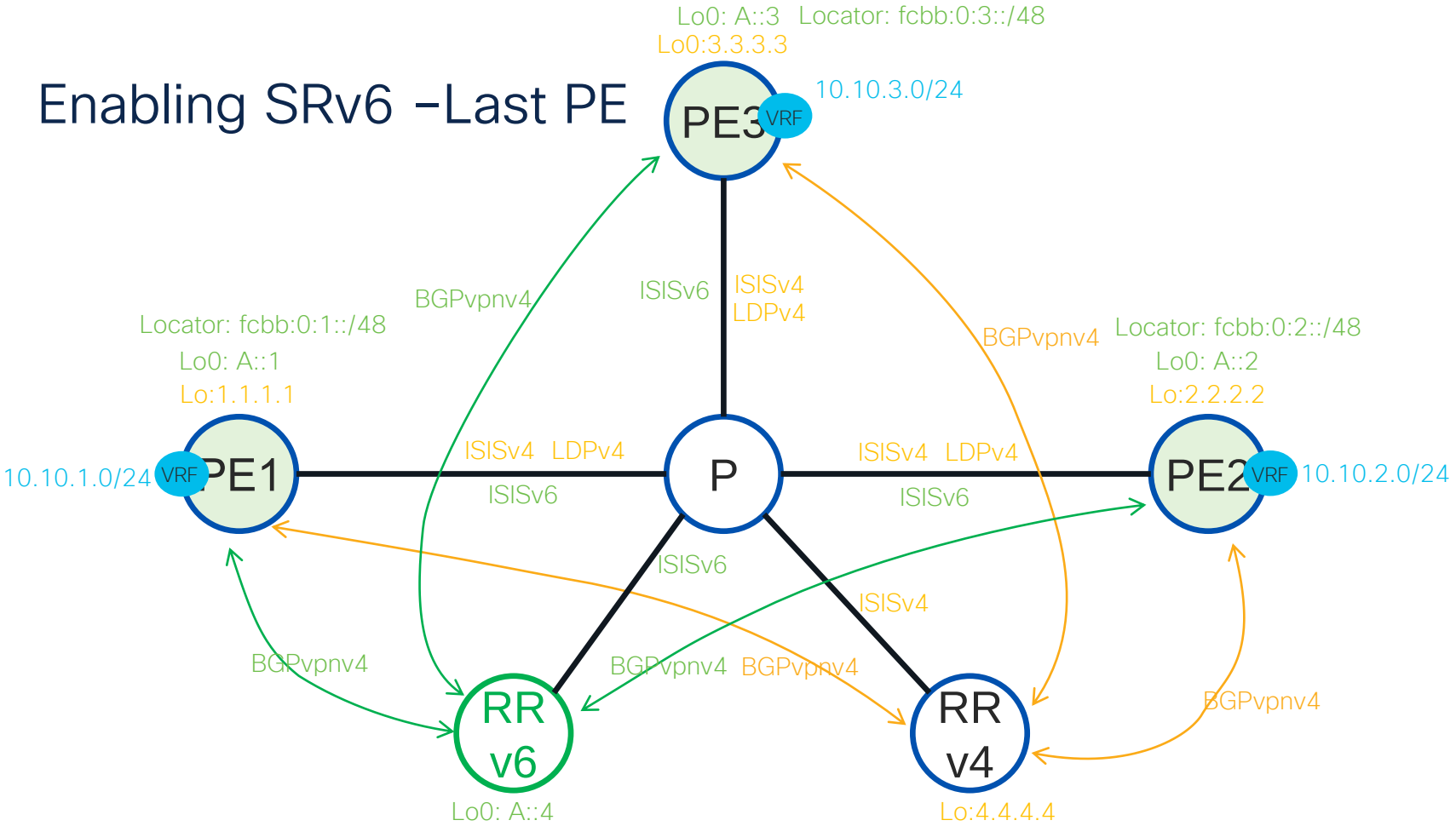
Enabling IPv6 Routing- D



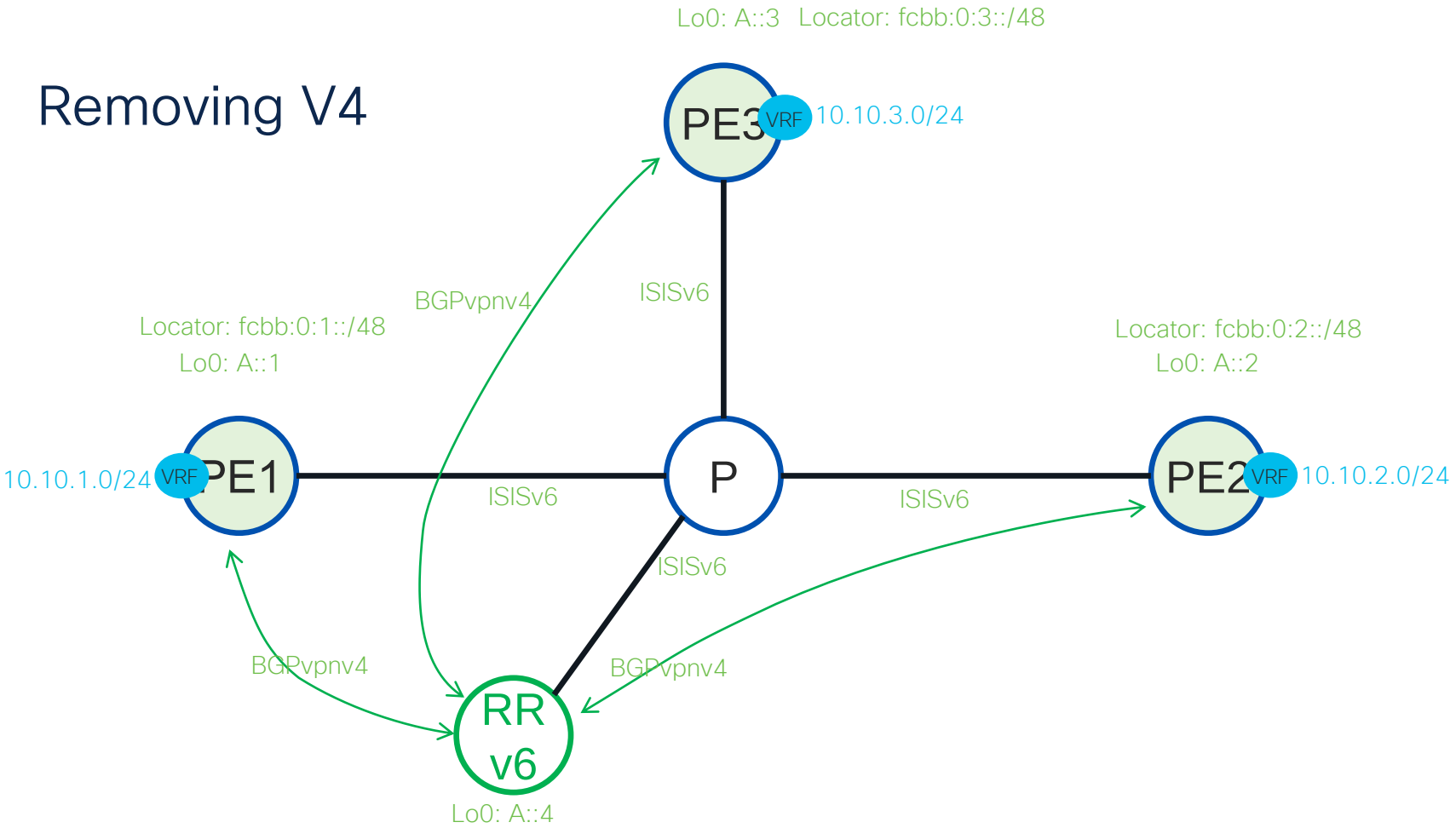
Enabling SRv6 –PE1&PE2



Enabling SRv6 –Last PE



Removing V4



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
```

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

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

SRv6 uSID Conclusion

Simplicity Always Prevails

~~LDP~~

~~RSVP-TE~~

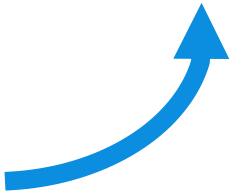
~~BGP 3108~~

~~MPLS~~

~~UDP/VxLAN~~

~~NSH~~

Furthermore, with more scale



and functionality

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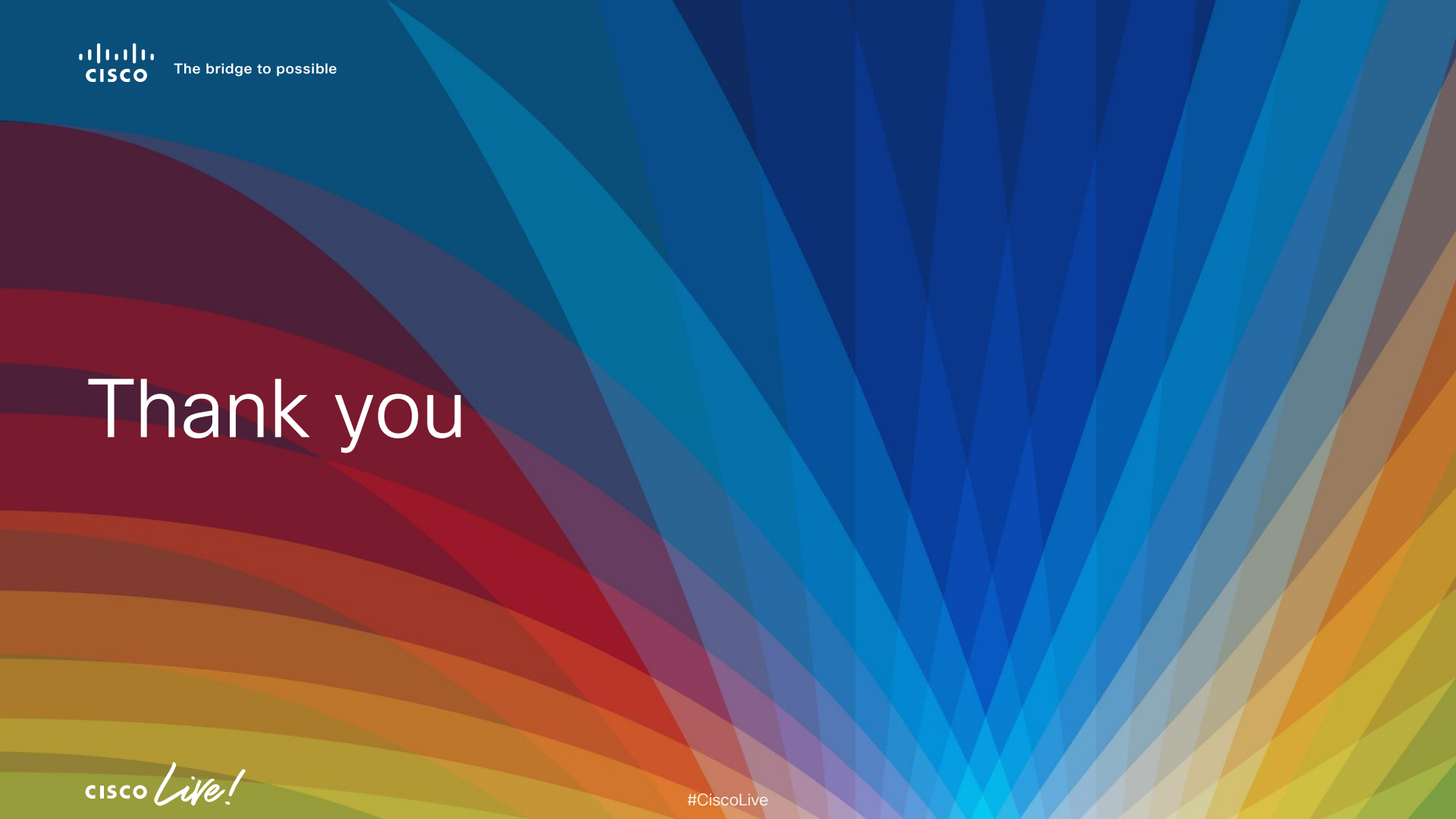
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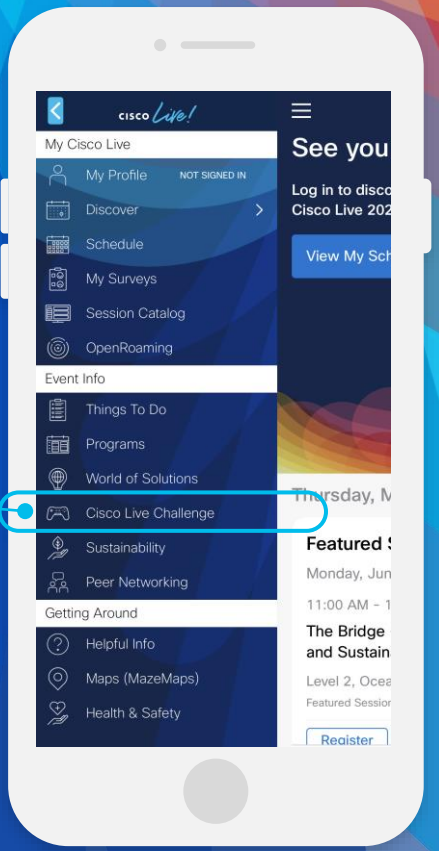


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