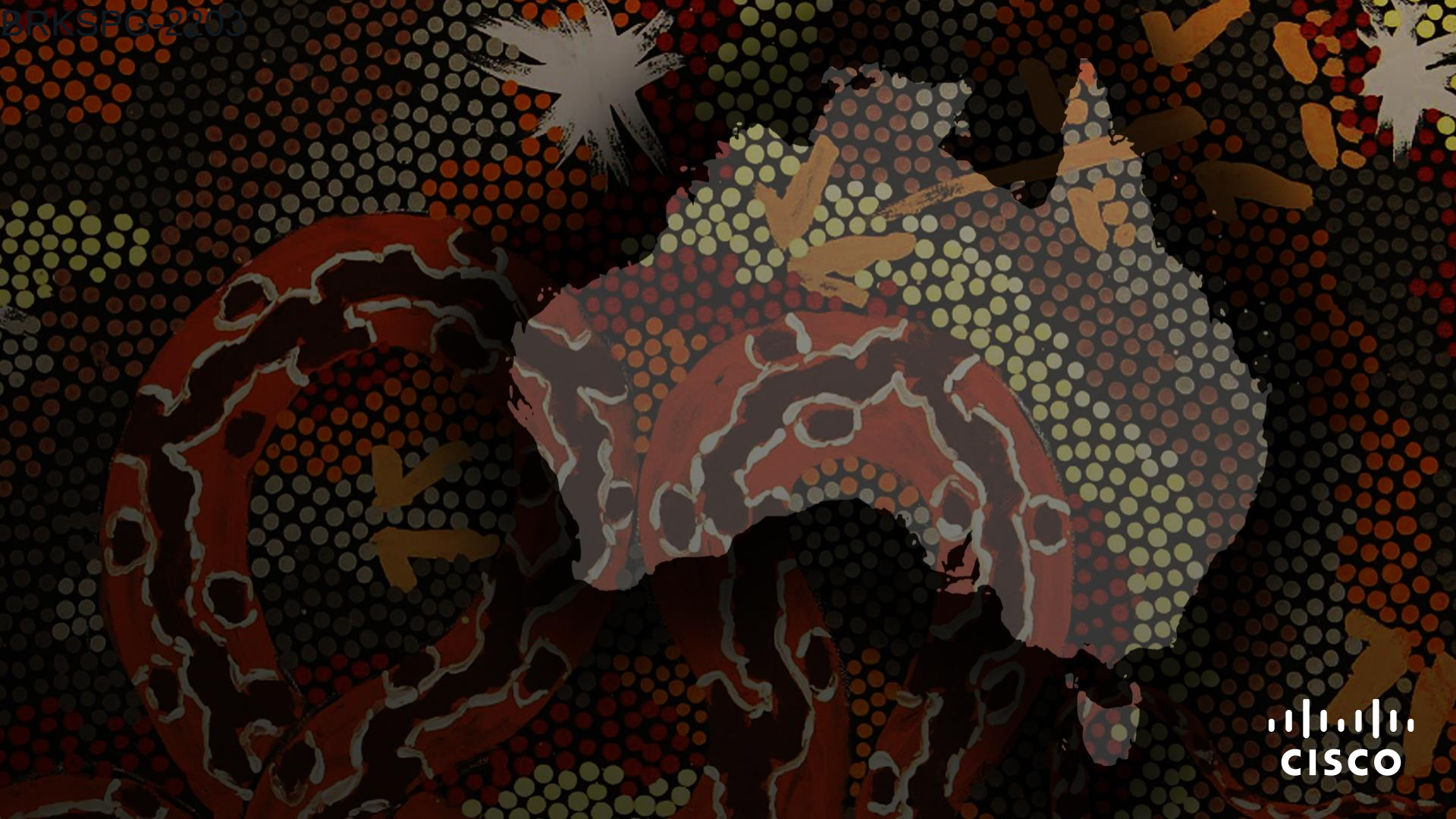
The bridge to possible

Introduction to SRv6 uSID

Jakub Horn
Principal Technical Marketing Engineer



Cisco Webex App

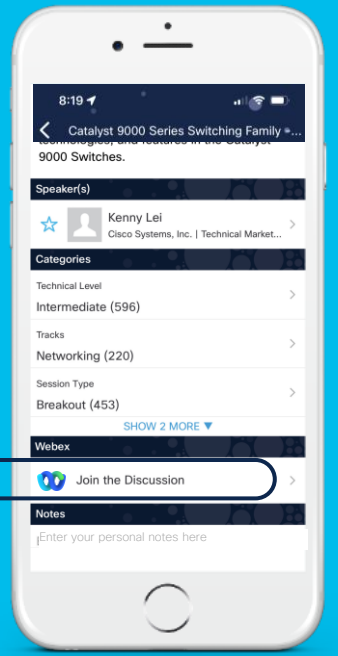
Questions?

Use Cisco Webex App to chat
with the speaker after the session

How

1. Find this session in the Cisco Live Mobile App
2. Click “Join the Discussion”
3. Install the Webex App or go directly to the Webex space
4. Enter messages/questions in the Webex space

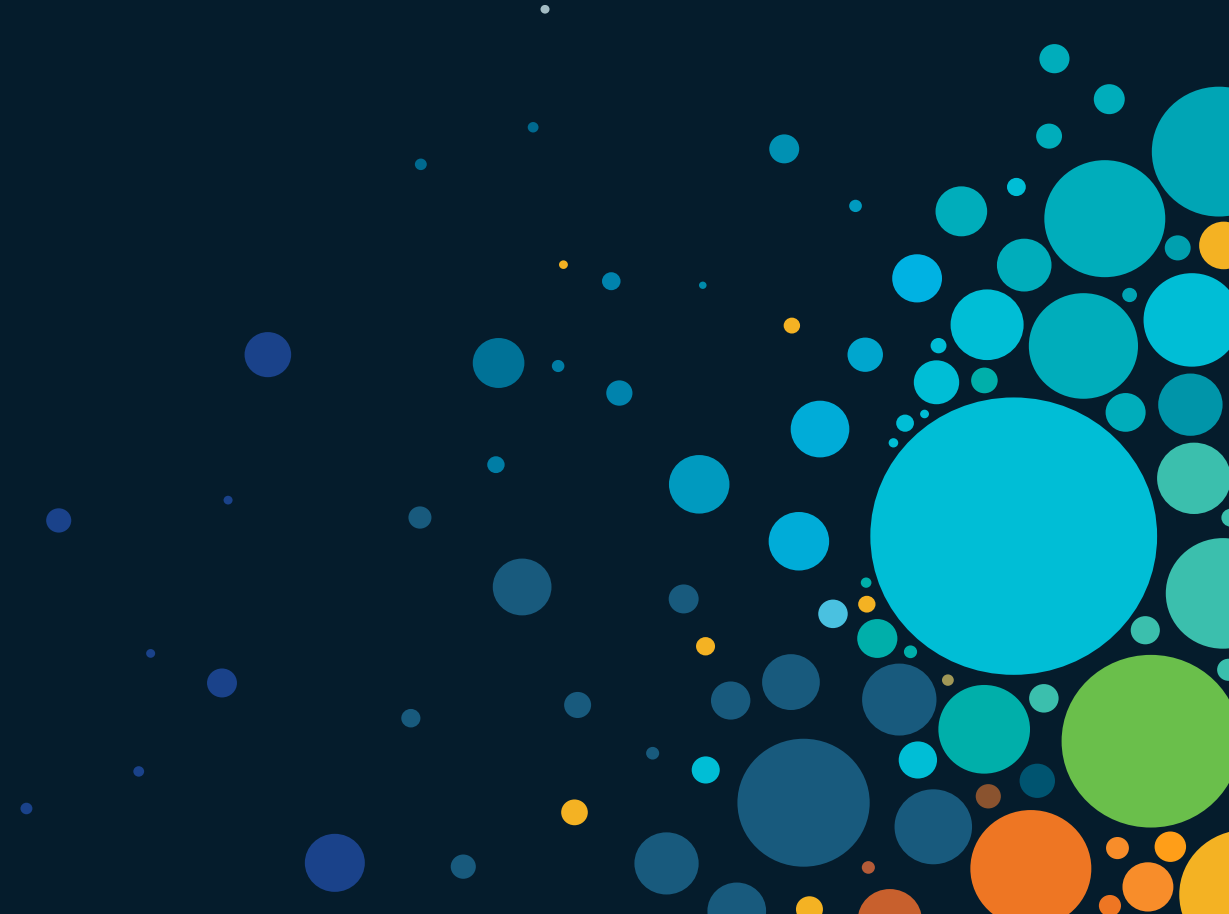
Webex spaces will be moderated until February 24, 2023.



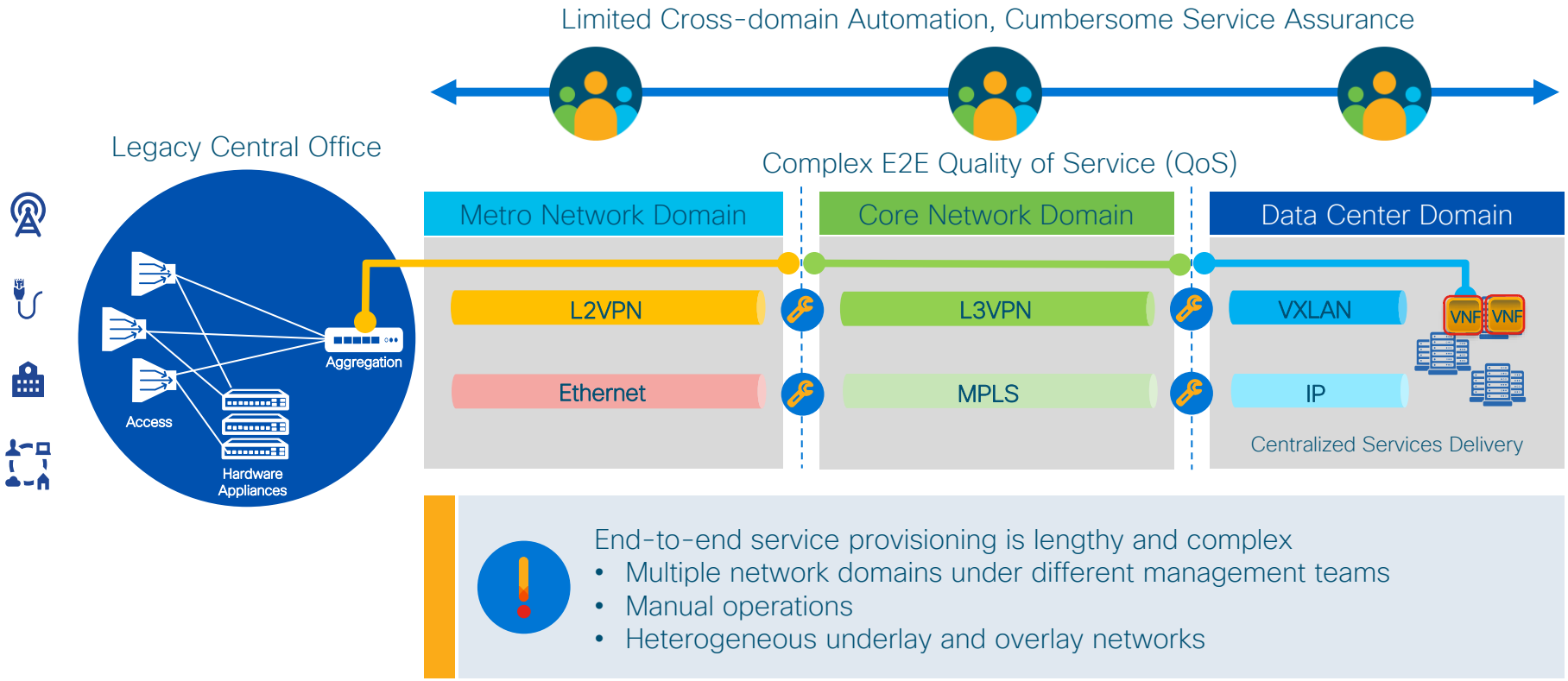
Agenda

- Introduction
- SRv6 uSID Dataplane
- SRv6 uSID Control Plane
- Flexible Algorithm
- MPLS to SRv6 Migration
- Conclusion
- Customer Reference

Introduction



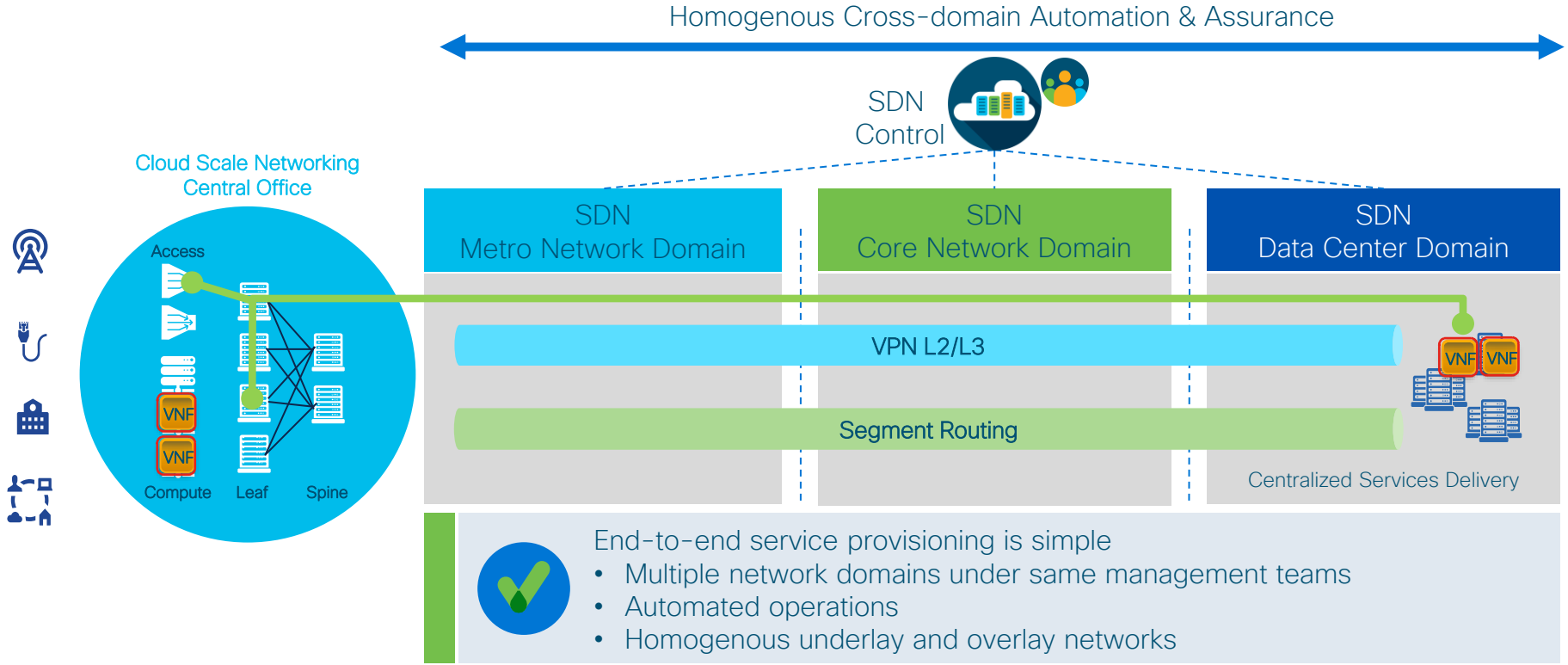
Understanding Today's Service Creation



End-to-end service provisioning is lengthy and complex

- Multiple network domains under different management teams
- Manual operations
- Heterogeneous underlay and overlay networks

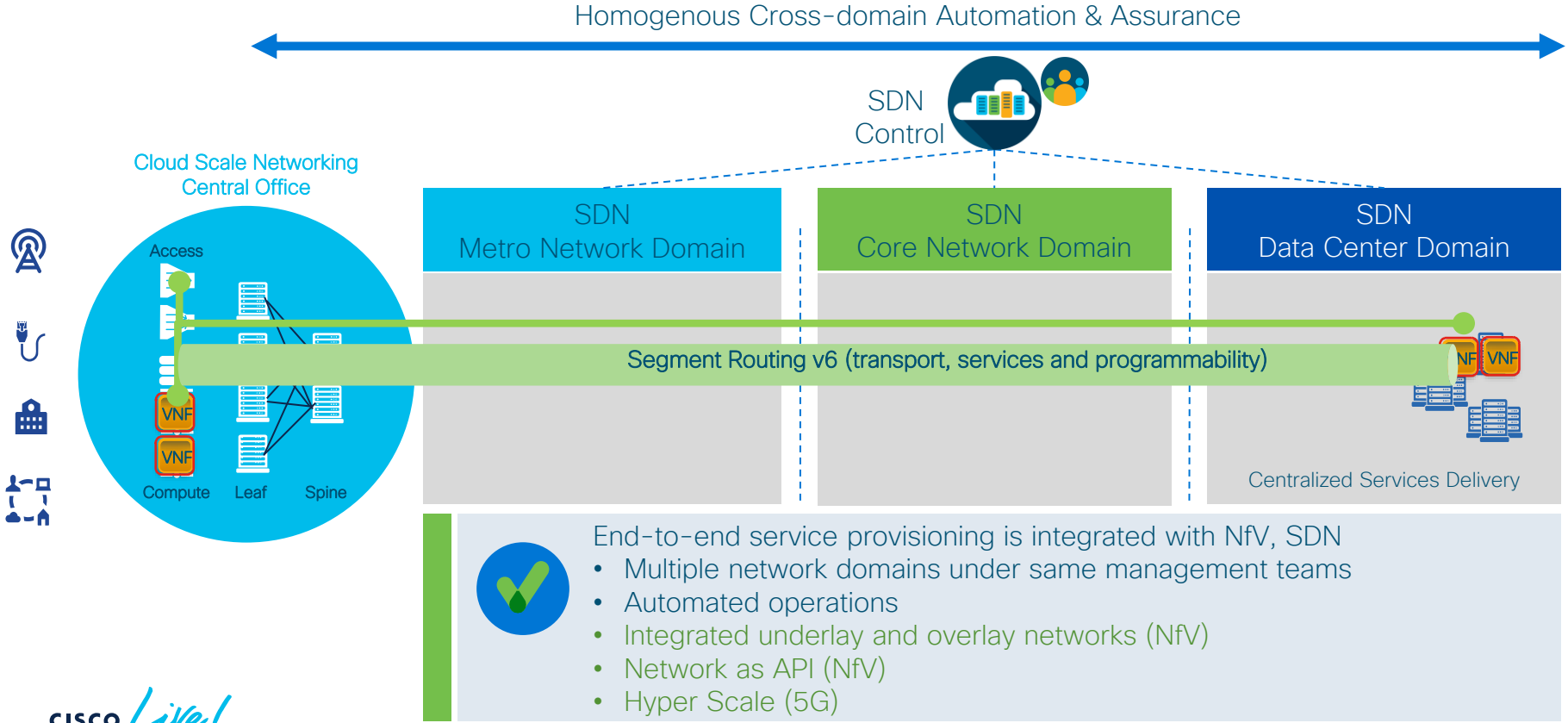
SR-MPLS: SDN ready
“Network as a Fabric” for Service Creation



End-to-end service provisioning is simple

- Multiple network domains under same management teams
- Automated operations
- Homogenous underlay and overlay networks

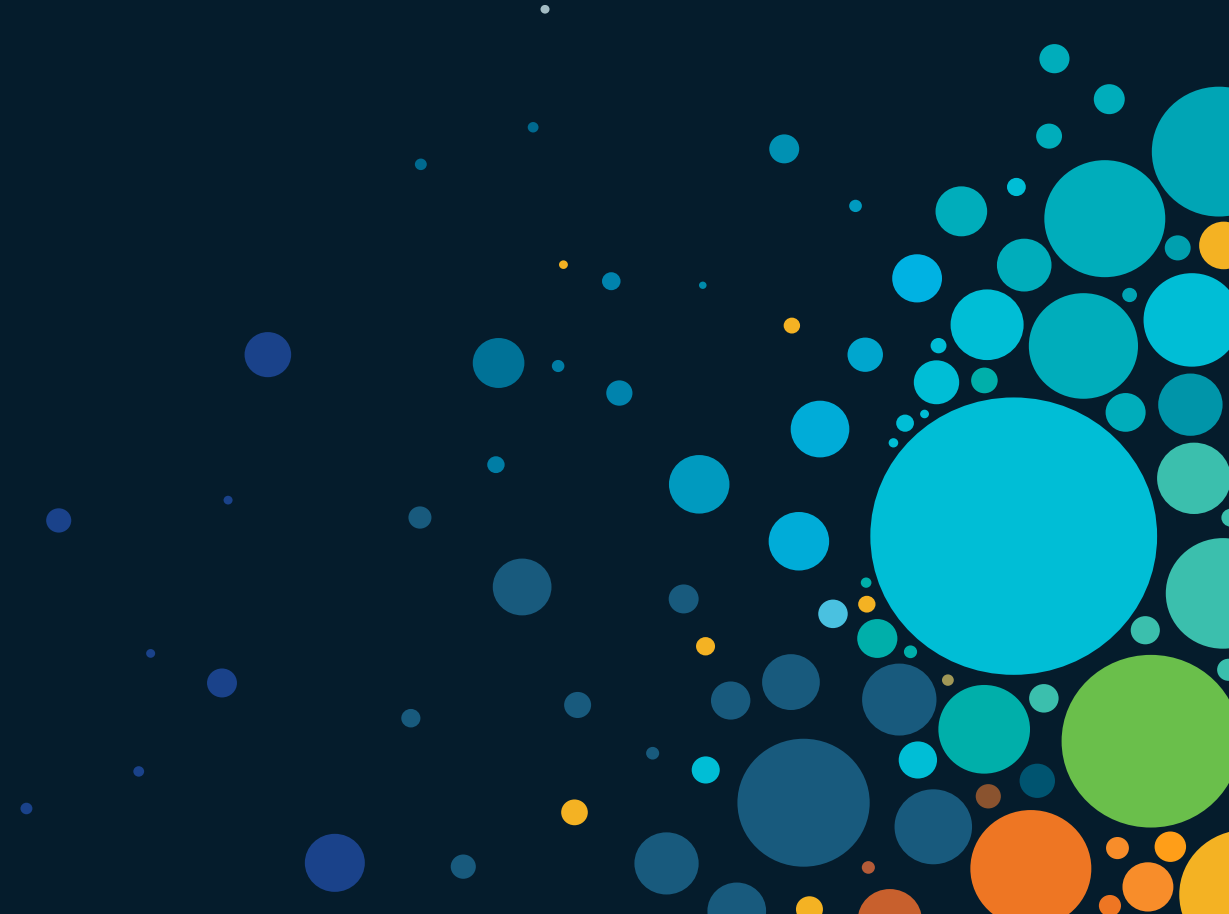
SRv6: SDN, NfV, 5G ready
“Network as an API” for Service Creation



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

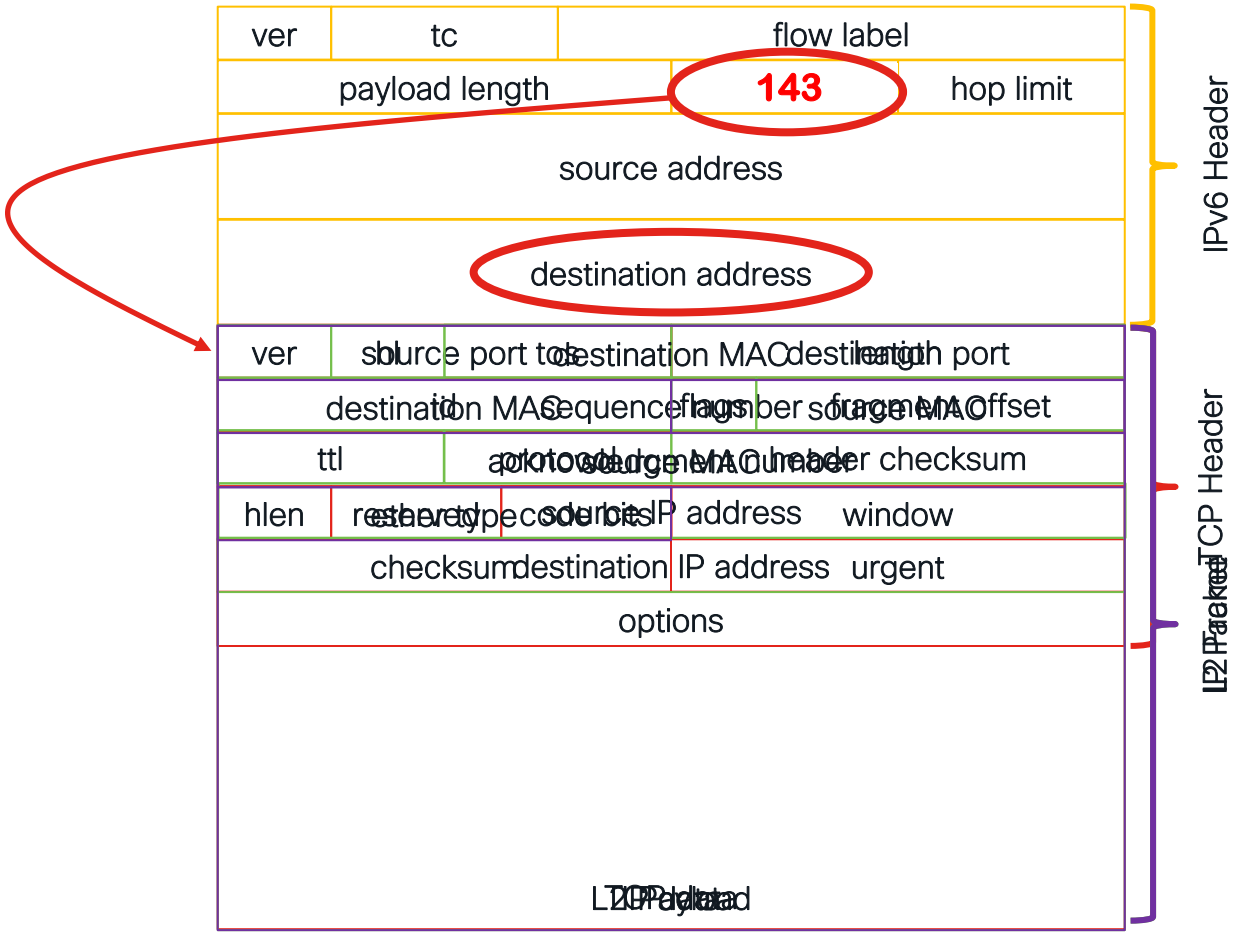
- Multiple network domains under same management teams
- Automated operations
- Integrated underlay and overlay networks (NfV)
- Network as API (NfV)
- Hyper Scale (5G)

Dataplane



SRv6

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



SRv6

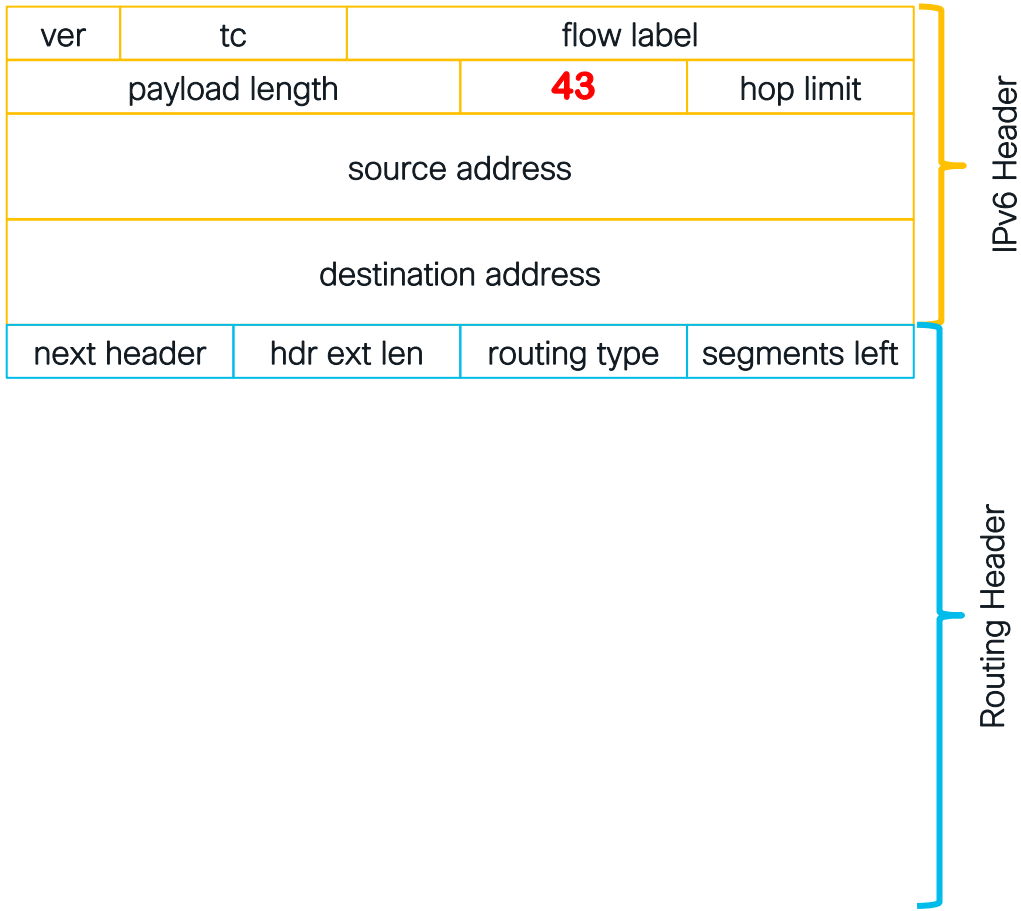
- IPv6 Header
- Destination IP address
- Next header field:
  - TCP, UDP, ICMP....
  - IPv4, IPv6, L2
  - Hop by Hop, Dest. Options, Fragmentation, Authentication Header ...
  - Routing Header

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

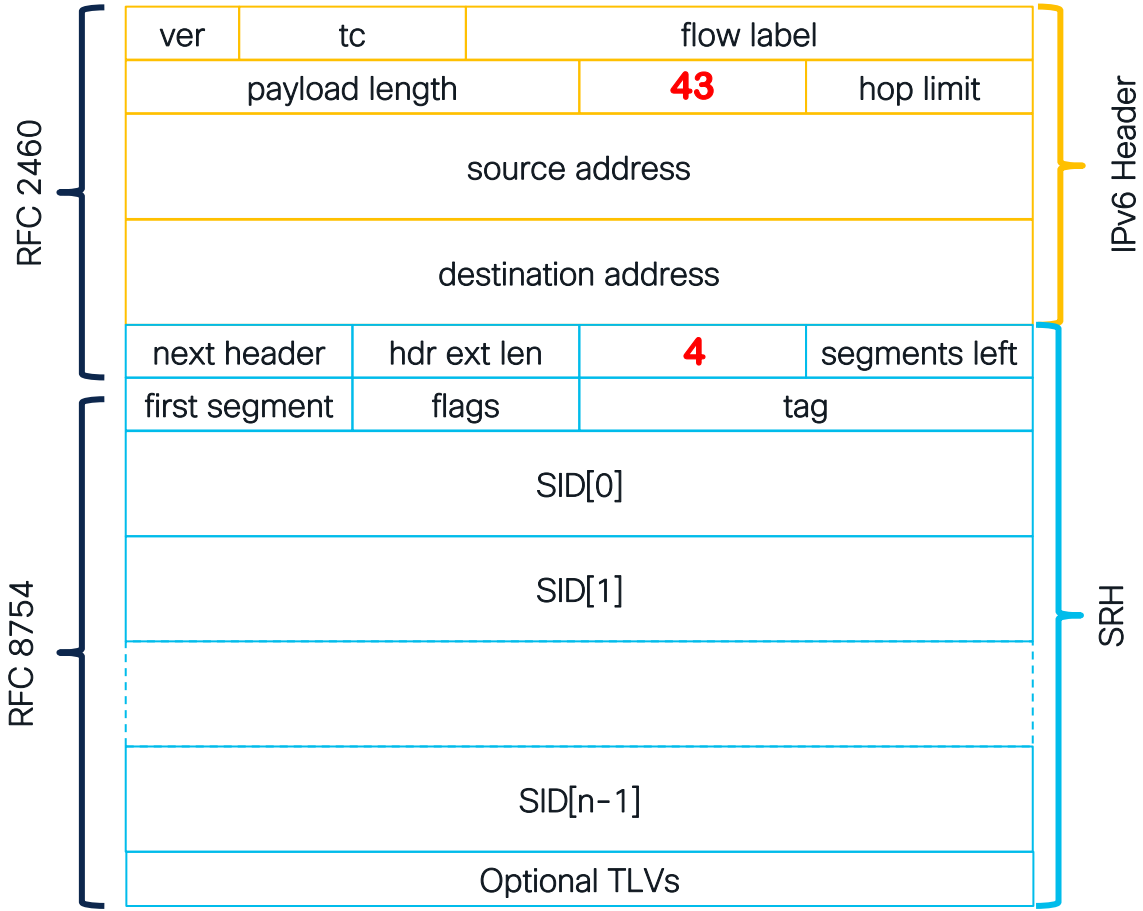
0 Source Route (deprecated)

1 Nimrod (deprecated)

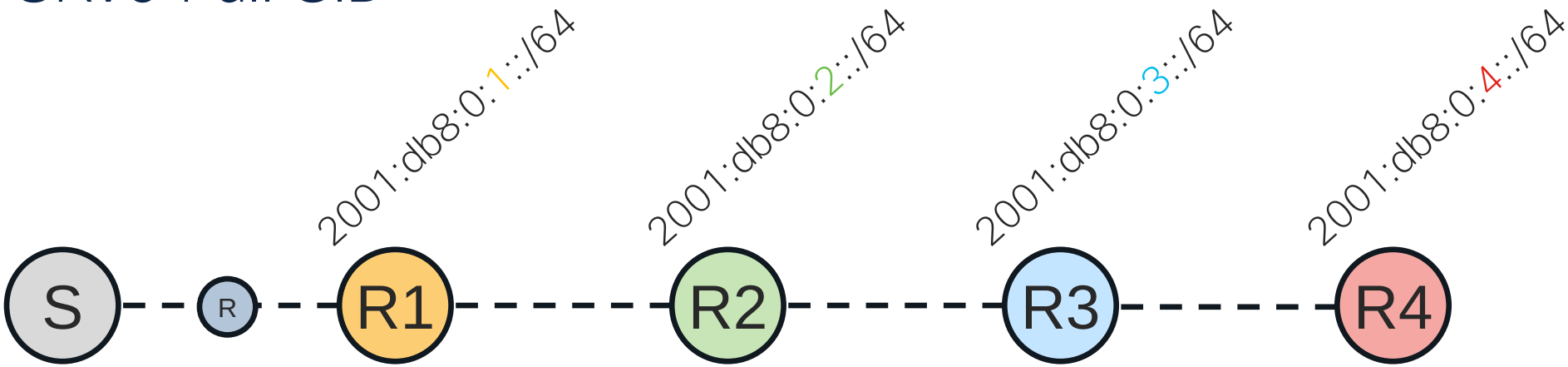
2 Type 2 (RFC 6275)

3 RPL (RFC 6554)

4 SRH (RFC 8754)



SRv6 Full SID




```
SA:2001::1
DA:2001:db8:0:1:1::
NH:RH
Type:4(SRH)
NH:IPv4|SL:3
Segment List:
[0]:2001:db8:0:4:eeee::
[1]:2001:db8:0:3:48::
[2]:2001:db8:0:2:1::
[3]:2001:db8:0:1:1::
```

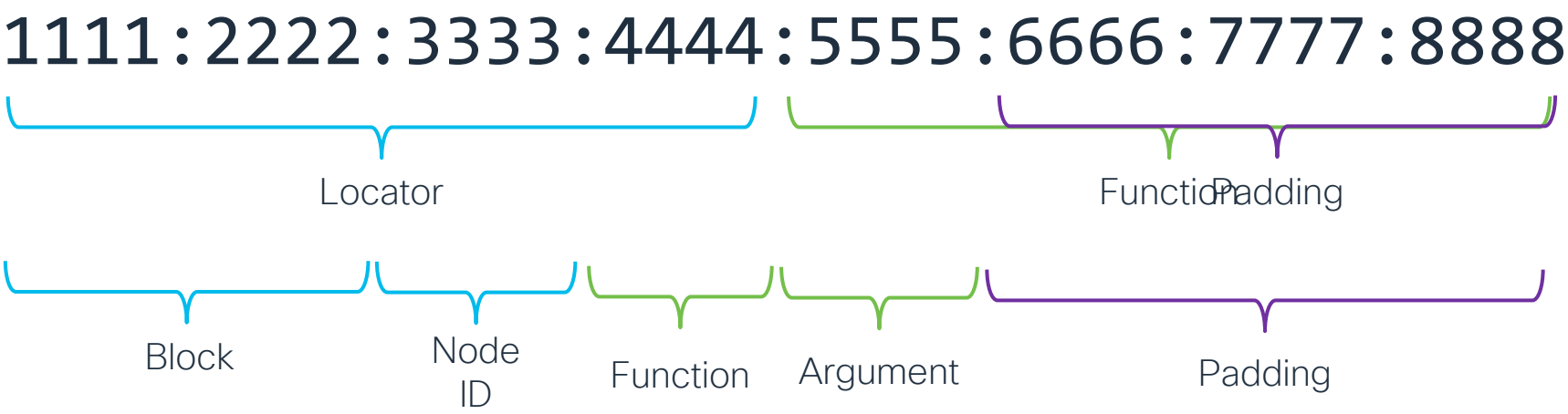
```
SA:2001::1
DA:2001:db8:0:2:1::
NH:RH
Type:4(SRH)
NH:IPv4|SL:2
Segment List:
[0]:2001:db8:0:4:eeee::
[1]:2001:db8:0:3:48::
[2]:2001:db8:0:2:1::
[3]:2001:db8:0:1:1::
```

```
SA:2001::1
DA:2001:db8:0:3:48::
NH:RH
Type:4(SRH)
NH:IPv4|SL:1
Segment List:
[0]:2001:db8:0:4:eeee::
[1]:2001:db8:0:3:48::
[2]:2001:db8:0:2:1::
[3]:2001:db8:0:1:1::
```

```
SA:2001::1
DA:2001:db8:0:4:eeee::
NH:RH
```

SID Structure

128 Bits Like IPv6 address but different semantics

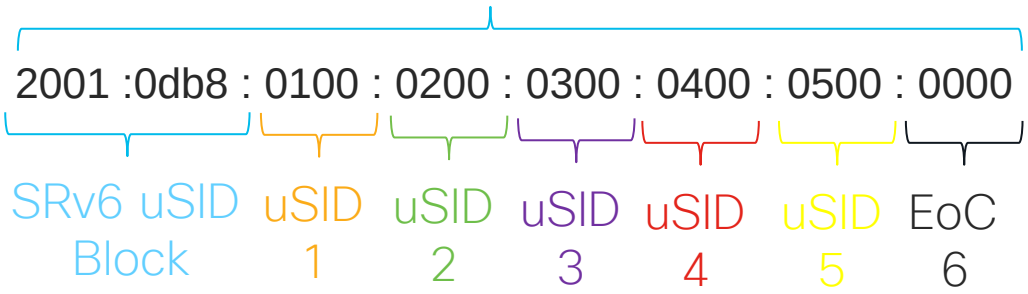


SRv6 uSID format

: 0100 : =SRV6 uSID

16 bits here, but can be anything

SRV6 uSID Carrier



32 bits here,
but can be anything

SRV6 Encapsulation

```
SA:2001::1
DA:2001:db8:0:4:1:0:0:0
NH:RH

Type:4(SRH)
NH:IPv4|SL:1
Segment List:
[0]: 2001:db8:0:5:45:0:0:0
[1]: 2001:db8:0:4:1:0:0:0
[2]: 2001:db8:0:3:48:0:0:0
[3]: 2001:db8:0:2:1:0:0:0
[4]: 2001:db8:0:1:42:0:0:0

SA:7.5.4.3
DA:11.6.19.71
Port:UDP

UDP Header/Data
```

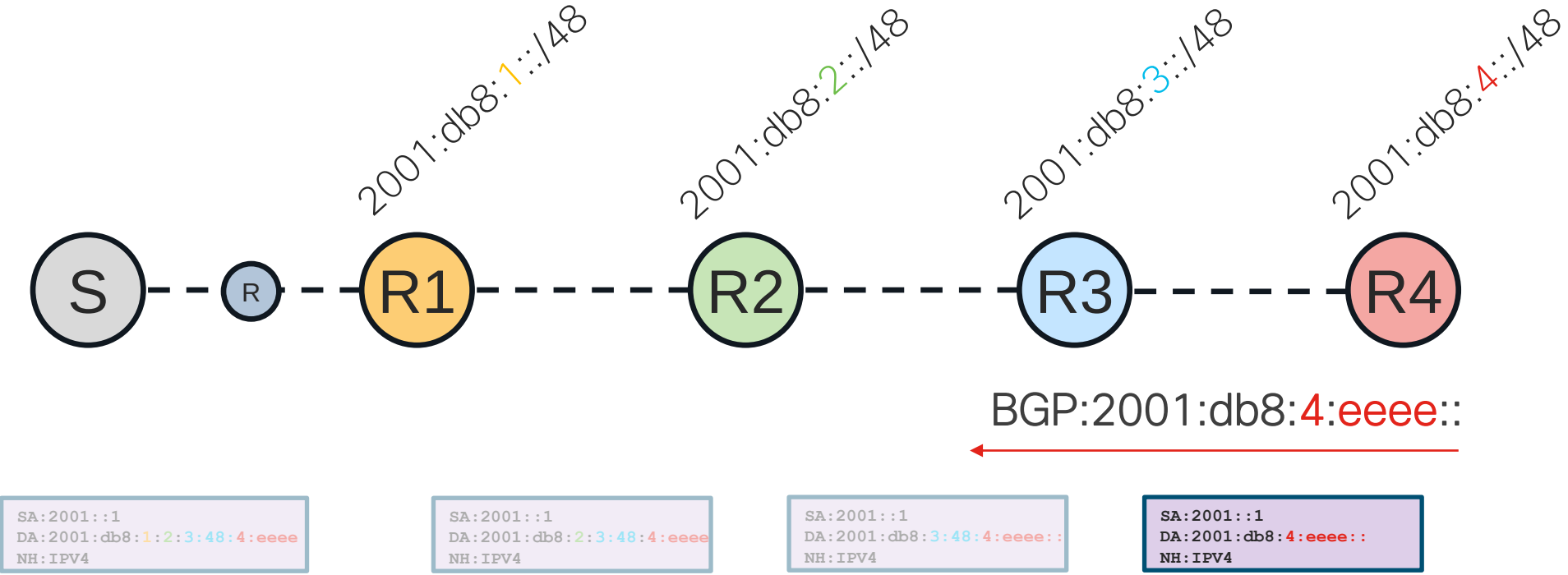
SRV6 uSID Encapsulation

```
SA:2001::1
DA:2001:db8:100:200:300:400:500::
NH:Ipv4

SA:7.5.4.3
DA:11.6.19.71
Port:UDP

UDP Header/Data
```

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

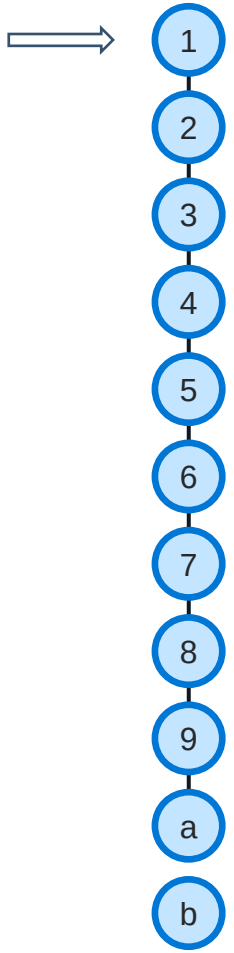
```
SA:2001::1
DA:2001:db8:[illegible]
NH:[illegible]
```

```
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
```

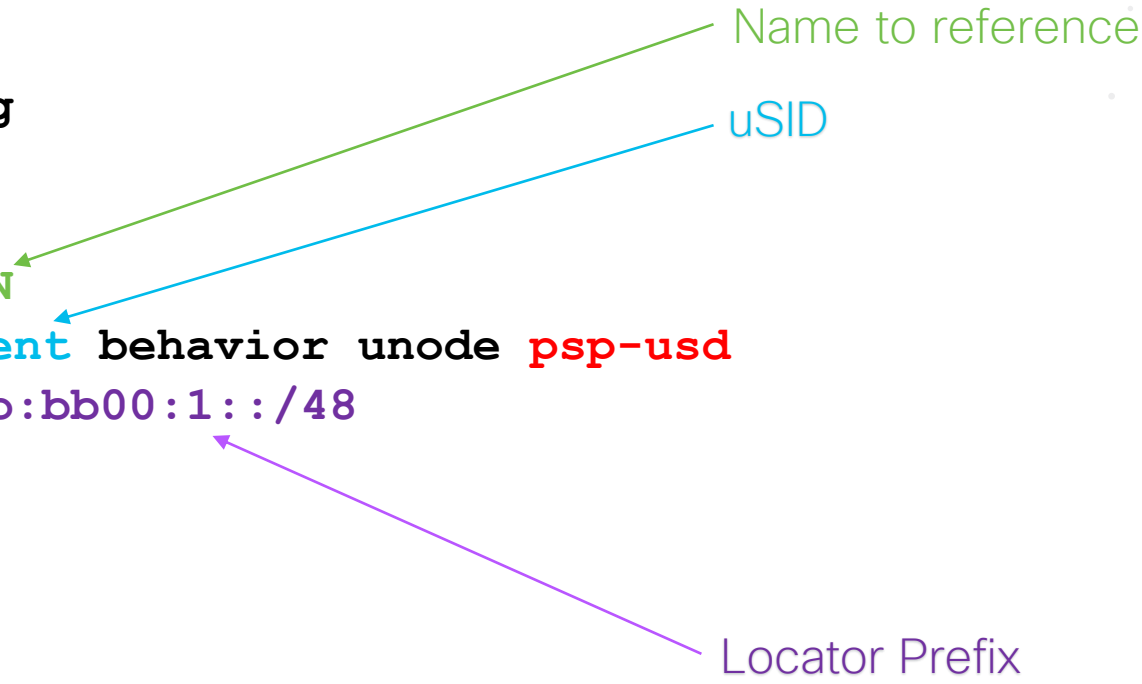
```
UDP Header/Data
```

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



SRv6 uSID Configuration

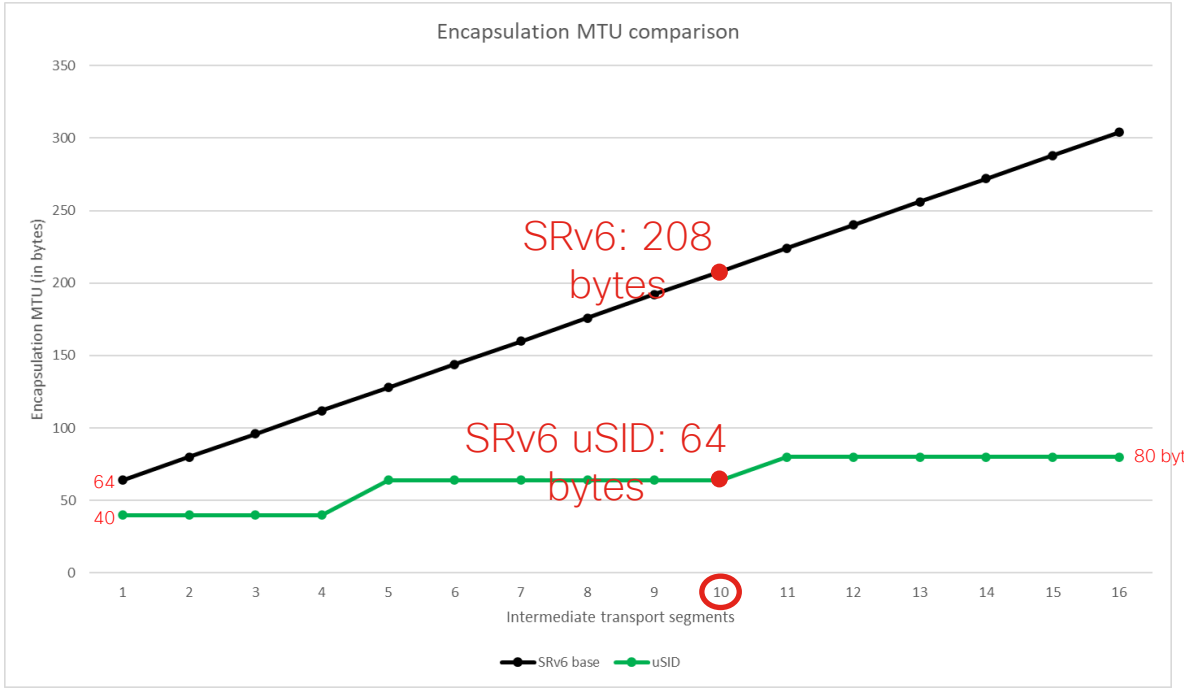
```
segment-routing
 srv6
  locators
   locator MAIN
    micro-segment behavior unode psp-usd
    prefix fcbb:bb00:1::/48
```



The Power of SRv6 uSID

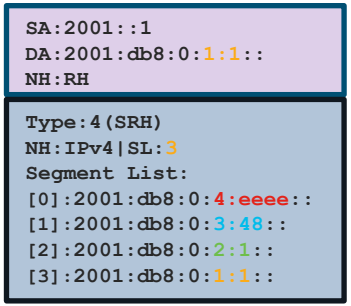
Best SRv6 Compression

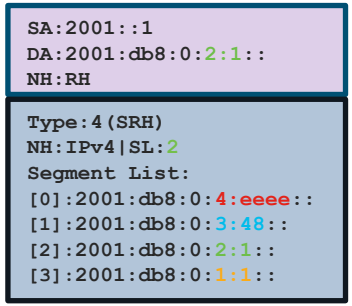
- Realizing a network program with “n” intermediate segments …



END– Default endpoint (Node SID)

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



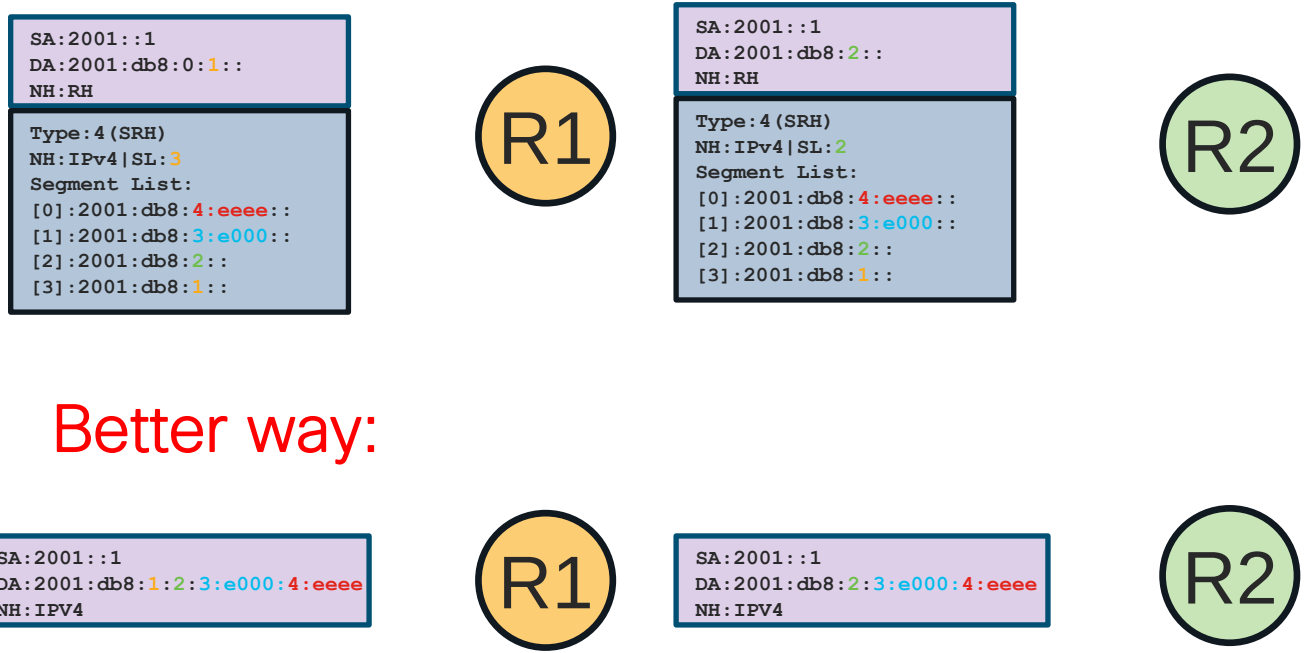


- Different Flavors:
  - End
  - End with PSP
  - End with USP
  - End with PSP & USP
  - End with USD
  - End with PSP & USD
  - End with USP & USD
  - End with PSP, USP & USD

- 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)

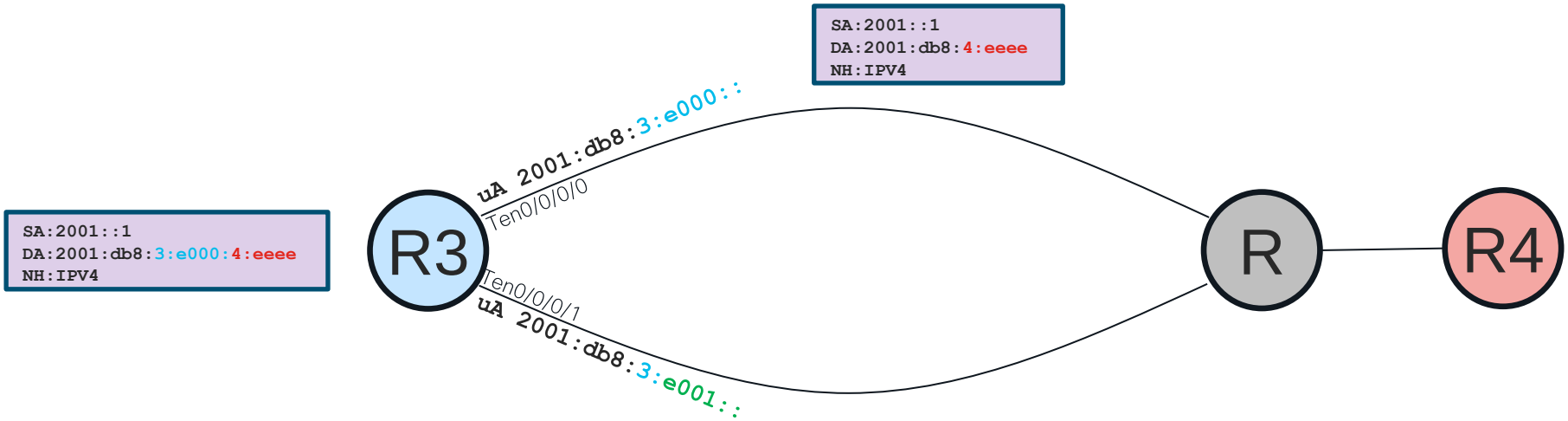
- *Decrement SL*
- *Copy Active SID*
- *Forward*



Better way:

- *Shift & Forward*

uA=END.X with Next – (Adjacency SID)



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

uDX4=END.DX4, uDX6=END.DX6, uDX2=END.DX2 Endpoint with Decapsulation and Xconnect

- *Decapsulate and Forward to SPECIFIC INTERFACE*
- *Same as Per CE Label Allocation*
- *Must be last function in SID list*

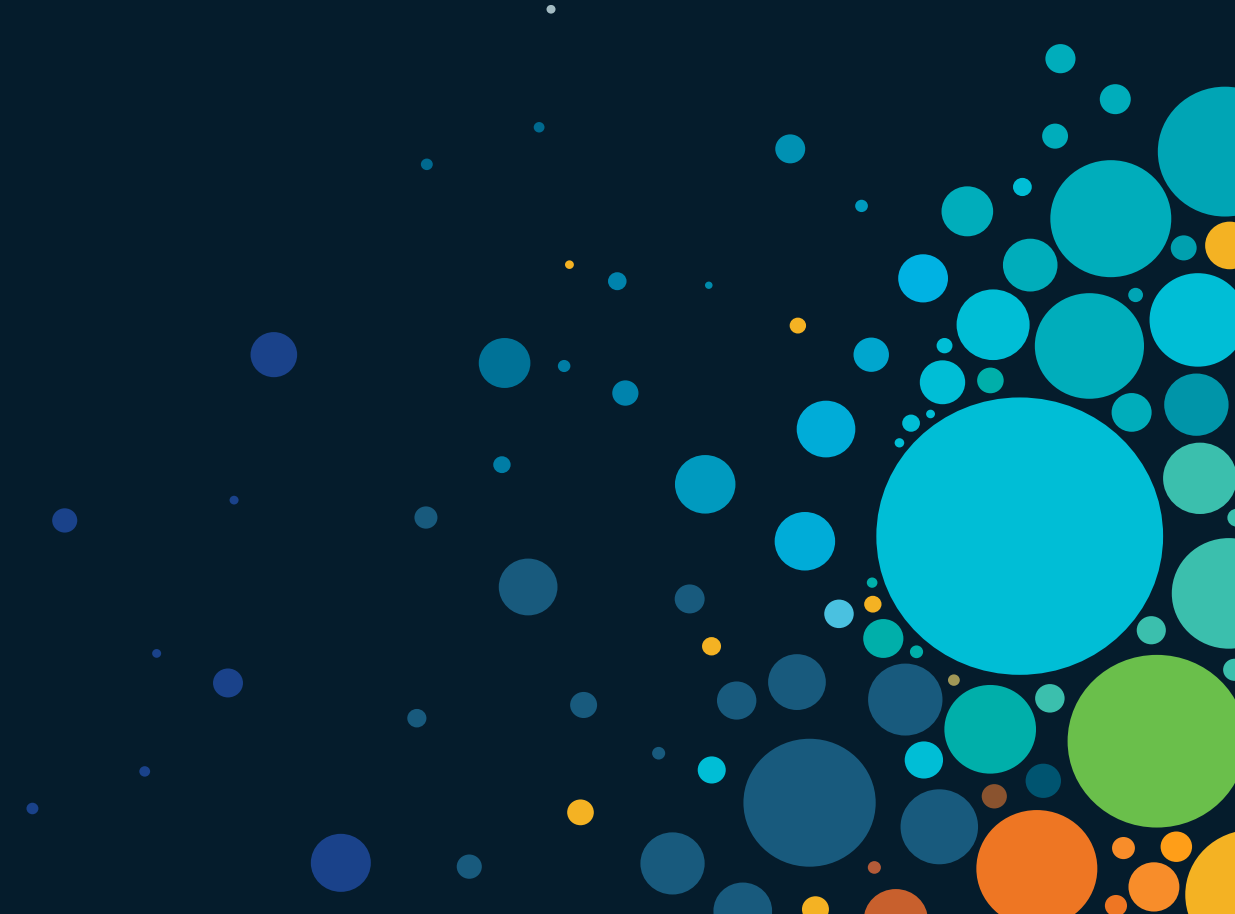
uDT4=END.DT4, uDT6=END.DT6 Endpoint with Decapsulation and Table Lookup

- *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]

Control Plane



Functions might be signaled differently

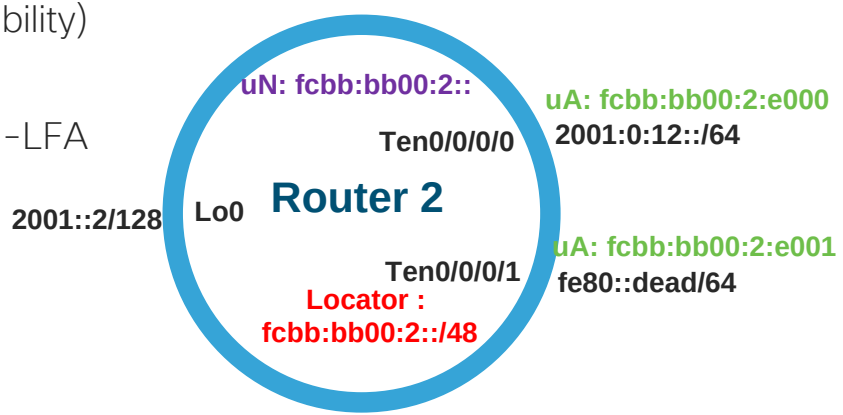
Signalling	IGP	BGP-LS	BGP-IP/VPN
End, uN	Yes	Yes	
End.X, uA	Yes	Yes	
End.T	Yes	Yes	
End.DX4,uDX4		Yes	Yes
End.DX6,uDX6	Yes	Yes	Yes
End.DX2,uDX2		Yes	Yes
END.DT4,uDT4		Yes	Yes
End.DT6,uDT6	Yes	Yes	Yes
End.B		Yes	

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

Locator – routing table

IGP for uSID

- Uses TLVs
- For Srv6:
  - Locator – for Reachability (twice for backward compatibility)
  - END function – TI-LFA and TE
  - END.X function for each interface in routing protocol TI-LFA and TE
  - Capabilities:
  - Max SID depth for different functions
- OSPF will follow



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

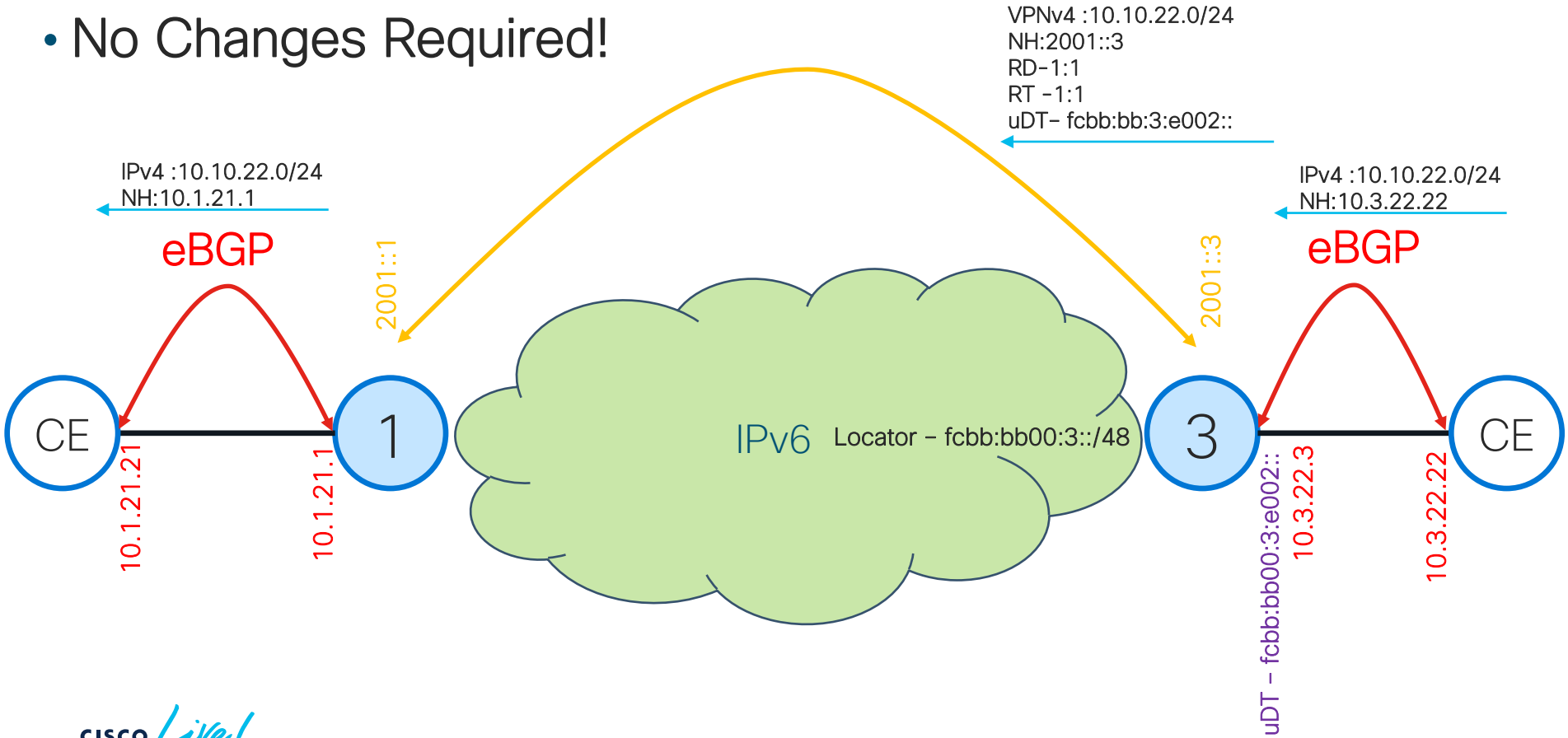
ISIS example

```
IS-IS 1 (Level-2) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL
r2.00-00              0x00000009   0x4f06        1145 /1200         0/0/0
  Area Address:   49
  NLPID:          0x8e
  Hostname:       r1
  IPv6 Address:   2001::2
  Metric: 10         MT (IPv6 Unicast) IPv6 2001::2/128
    Prefix Attribute Flags: X:0 R:0 N:1 E:0 A:0
  Metric: 1          MT (IPv6 Unicast) IPv6 fcbb:bb00:2::/48
    Prefix Attribute Flags: X:0 R:0 N:0 E:0 A:0
  MT:             IPv6 Unicast                                 0/0/0
  SRv6 Locator:   MT (IPv6 Unicast) fcbb:bb00:2::/48 D:0 Metric: 0 Algorithm: 0
    Prefix Attribute Flags: X:0 R:0 N:0 E:0 A:0
    END SID: fcbb:bb00:2:: uN (PSP/USD)
      SID Structure:
        Block Length: 32, Node-ID Length: 16, Func-Length: 0, Args-Length: 0
  Router Cap:     0.0.0.0 D:0 S:0
    IPv6 Router ID: 2001::2
    SR Algorithm:
      Algorithm: 0
      Algorithm: 1
    SRv6: O:0
    Node Maximum SID Depth:
      SRH Max SL:       3
      SRH Max End Pop:  3
      SRH Max T.insert: 3
      SRH Max T.encaps: 4
      SRH Max End D:    4
  Metric: 10         MT (IPv6 Unicast) IS-Extended r2.00
    Local Interface ID: 6, Remote Interface ID: 6
    Interface IPv6 Address: 2001:0:0:12::1
    Neighbor IPv6 Address: 2001:0:0:12::2
    END.X SID: fcbb:bb00:2:e000:: B:0 S:0 P:0 uA (PSP/USD) Alg:0
      SID Structure:
        Block Length: 32, Node-ID Length: 16, Func-Length: 16, Args-Length: 0
Total Level-2 LSP count: 1     Local Level-2 LSP count: 0
```

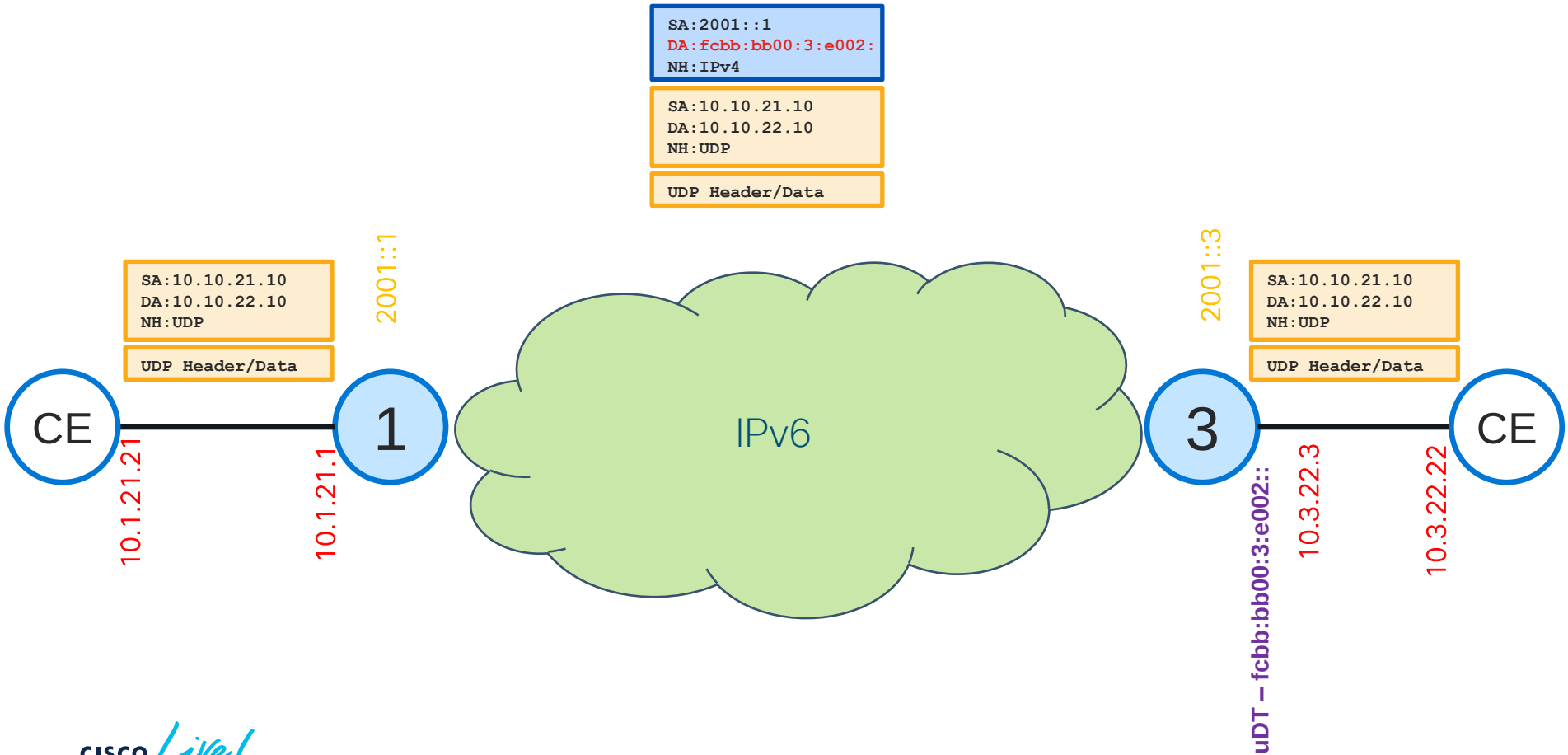
Locator
Capabilities
END
END.X
SID Structure

BGP

- No Changes Required!



BGP



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
```

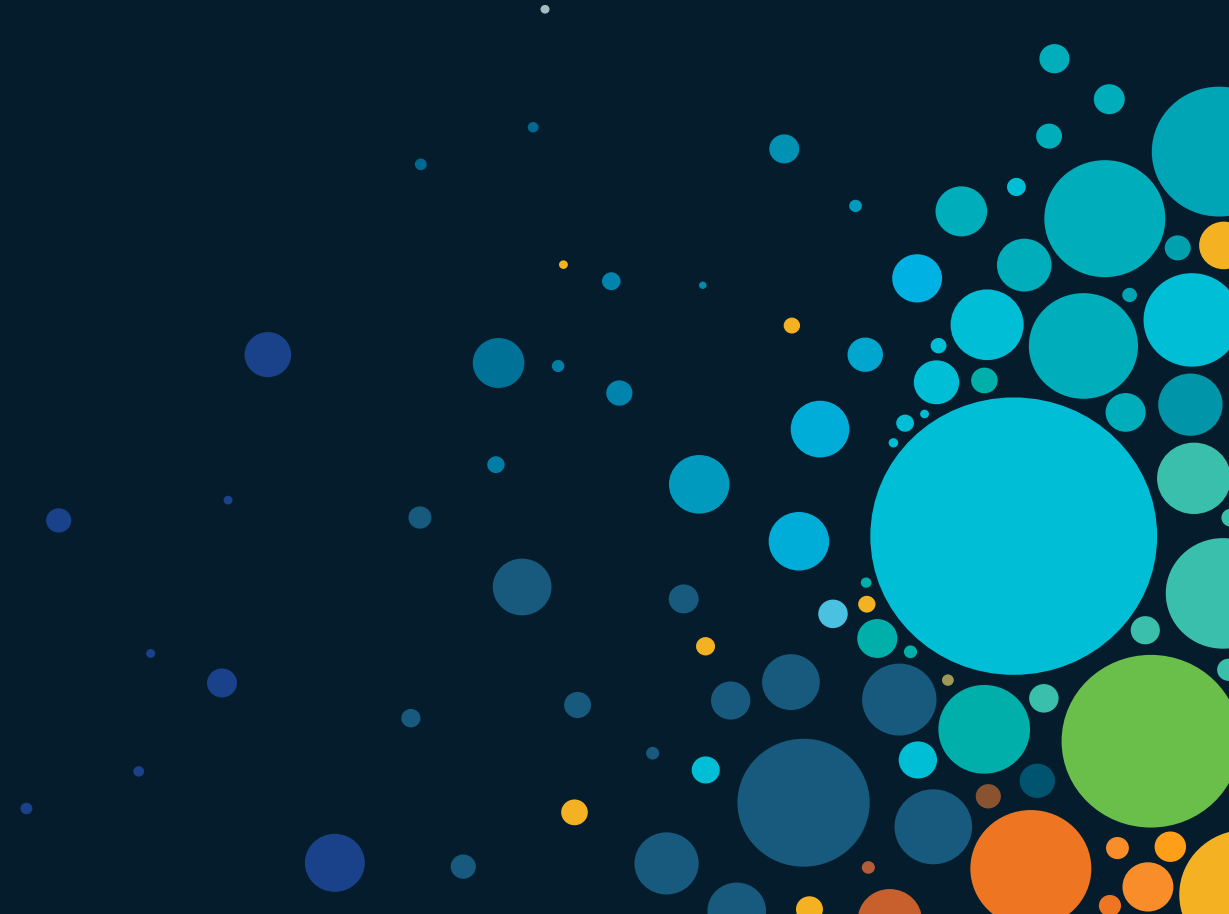
Name of the Locator

Single DT function is allocated per VRF and AF

This will result in:

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

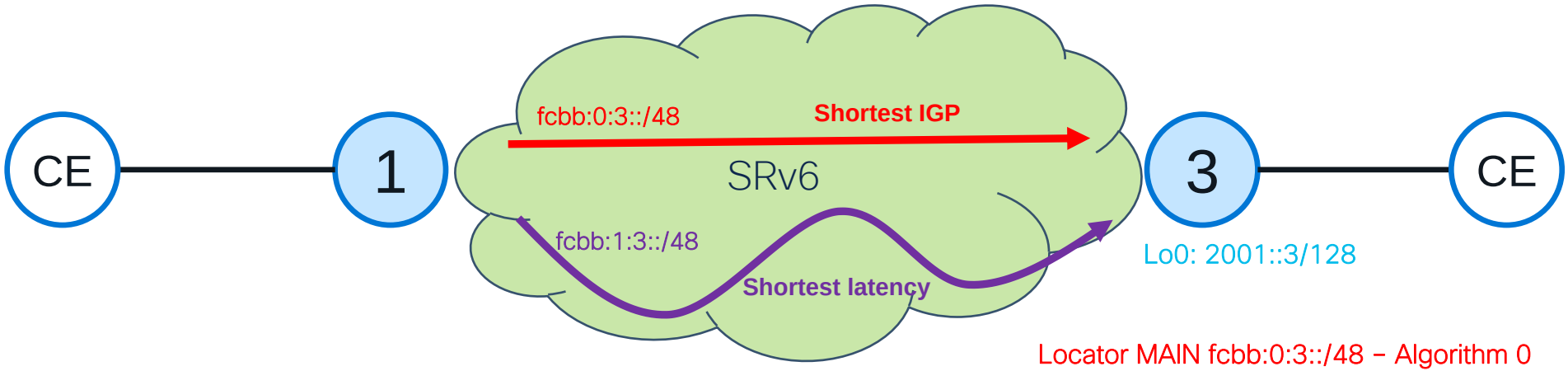
Flexible Algorithm



Flexible Algorithm

- We call “Flex-Algo”
  - The algorithm is defined by the operator, on a per-deployment basis
- Flex-Algo K is defined as
  - The minimization of a specified metric: IGP, delay, …
  - The exclusion of certain link properties: link-affinity, SRLG, …
- Example
  - Operator1 defines Flex-Algo 128 as “minimize IGP metric and avoid link-affinity “green”
  - Operator2 defines Flex-Algo 128 as “minimize delay metric and avoid link-affinity “blue”

SRv6 Flex Algo IGP

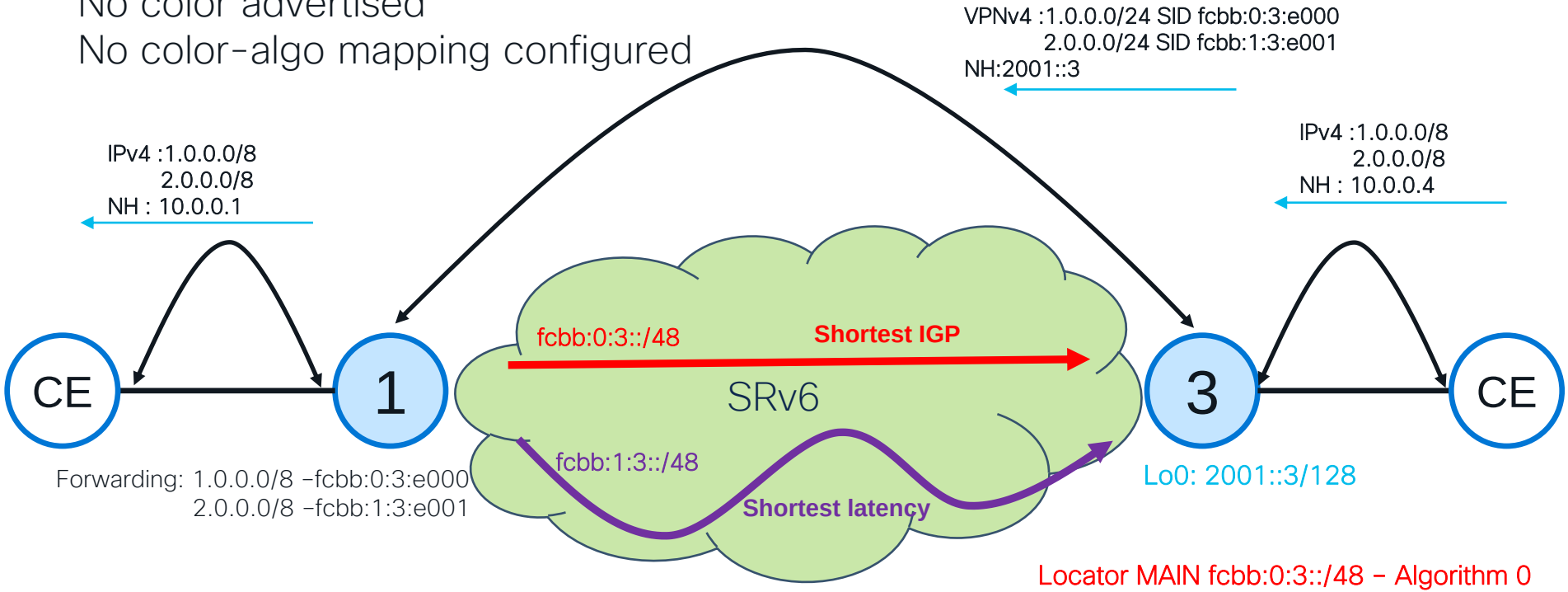


Locator MAIN fcbb:0:3::/48 – Algorithm 0
Locator LATE fcbb:1:3::/48 – Algorithm 128

BGP – SRv6

No color advertised

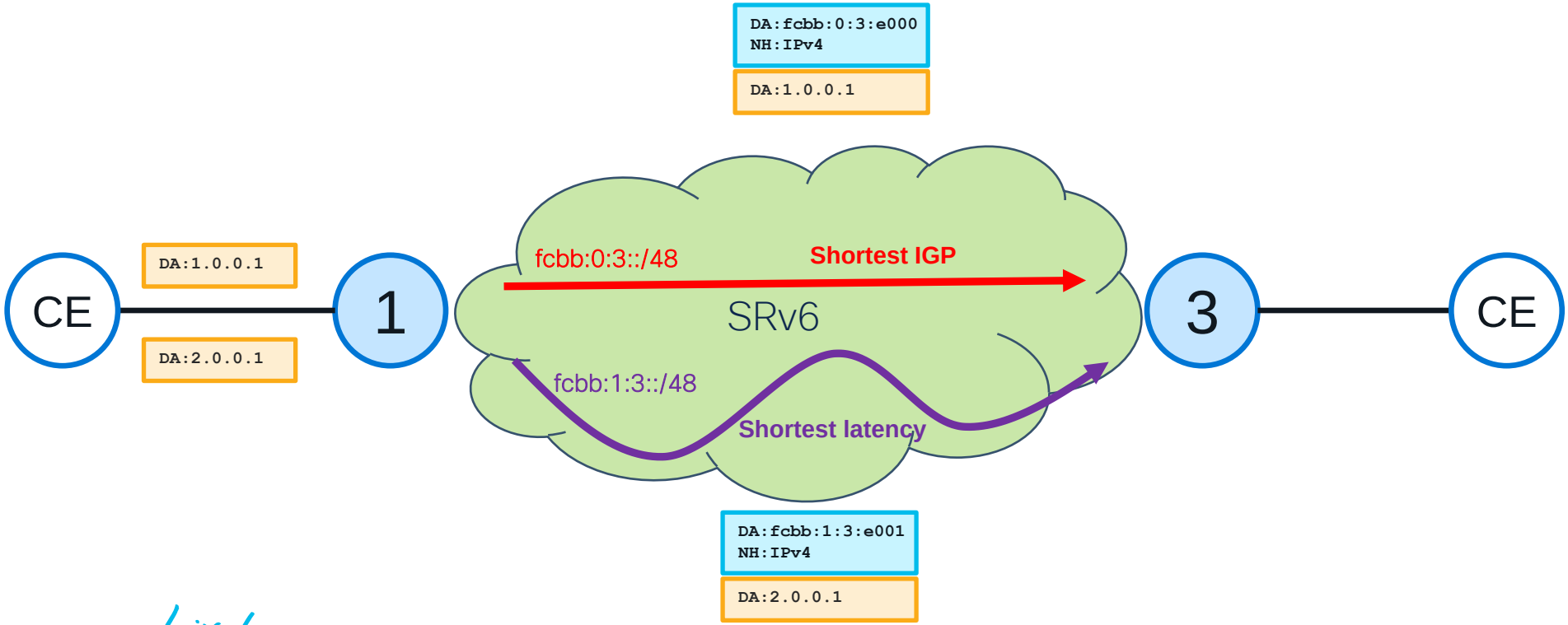
No color-algo mapping configured



Locator MAIN fcbb:0:3::/48 – Algorithm 0

Locator LATE fcbb:1:3::/48 – Algorithm 128

SRv6 DATAPLANE



SRv6 Flex Algo -IGP

```
segment-routing
 srv6
  locators
   locator LATENCY
    micro-segment behavior unode psp-usd
    prefix fcbb:bb01:1::/48
    algorithm 128
router isis 1
 flex-algo 128
  metric-type delay
  advertise-definition
 address-family ipv6 unicast
  segment-routing srv6
   locator LATENCY
```

New Locator Name

Locator Prefix (Different)

Flex Algo number 128-255

Definition of specific Flex Algo Latency metric for 128

This Router will advertise FA definition within the domain

This will result in:

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

SRv6 L3 VPN Flex Algo

```
router bgp 1
 address-family vpnv4 unicast
 vrf LowLatency
  rd 1:2
  address-family ipv4 unicast
   segment-routing srv6
    locator LATENCY
    alloc mode per-vrf
```

Name of the Locator

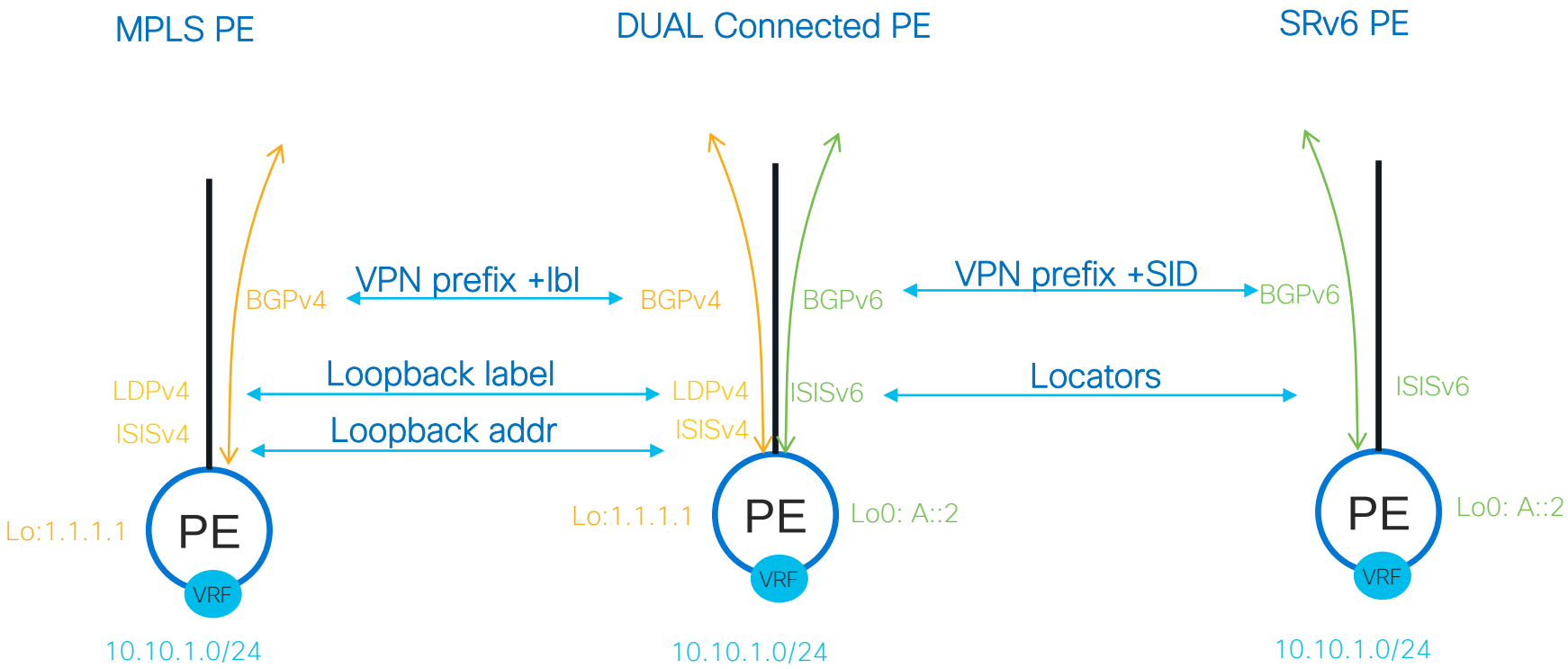
Single DT function is allocated per VRF and AF

This will result in:

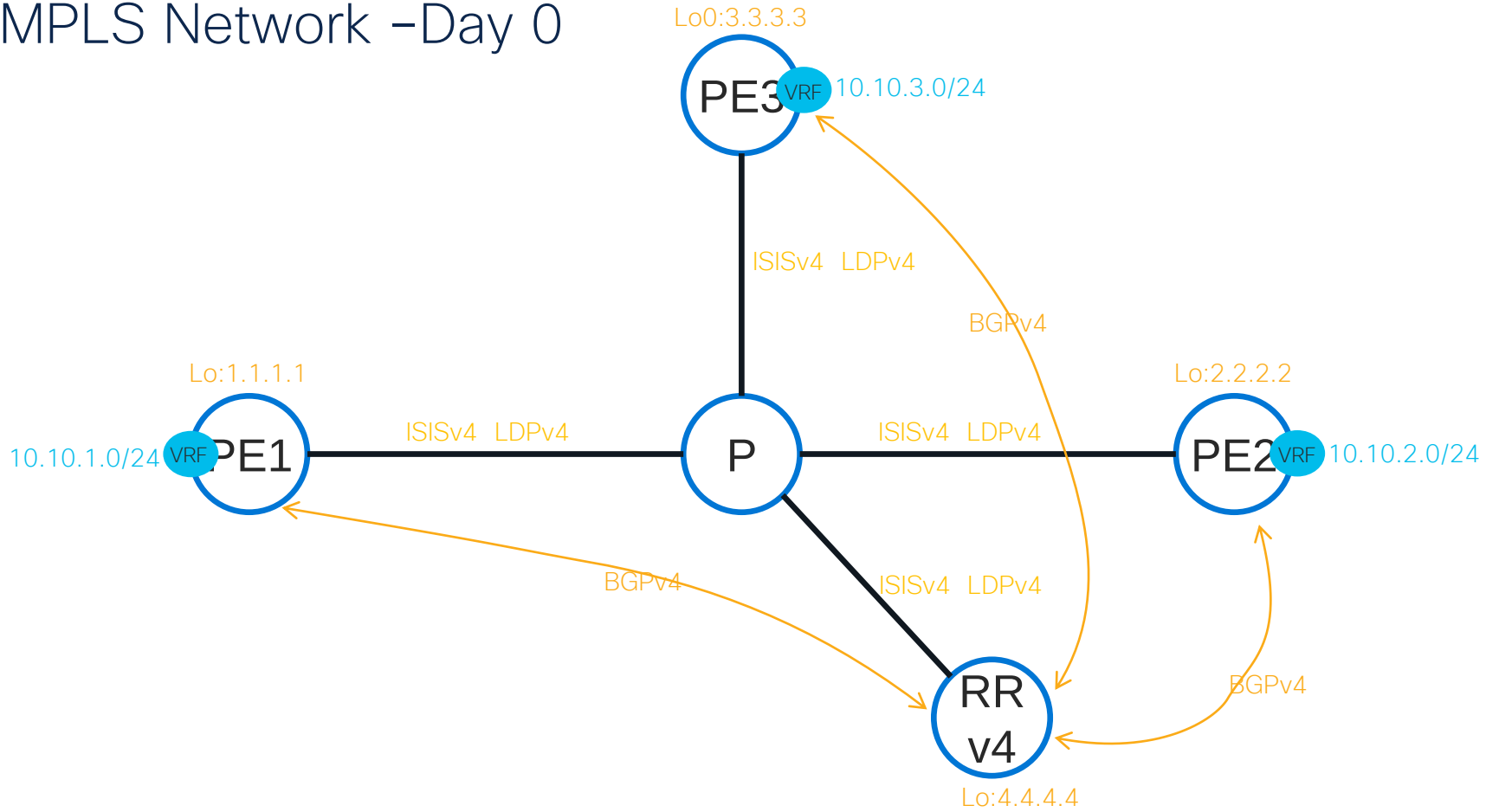
- uDT4 function is allocated from LATENCY locator
- All prefixes in VRF are advertised with uDT4 function

MPLS to SRv6 Migration

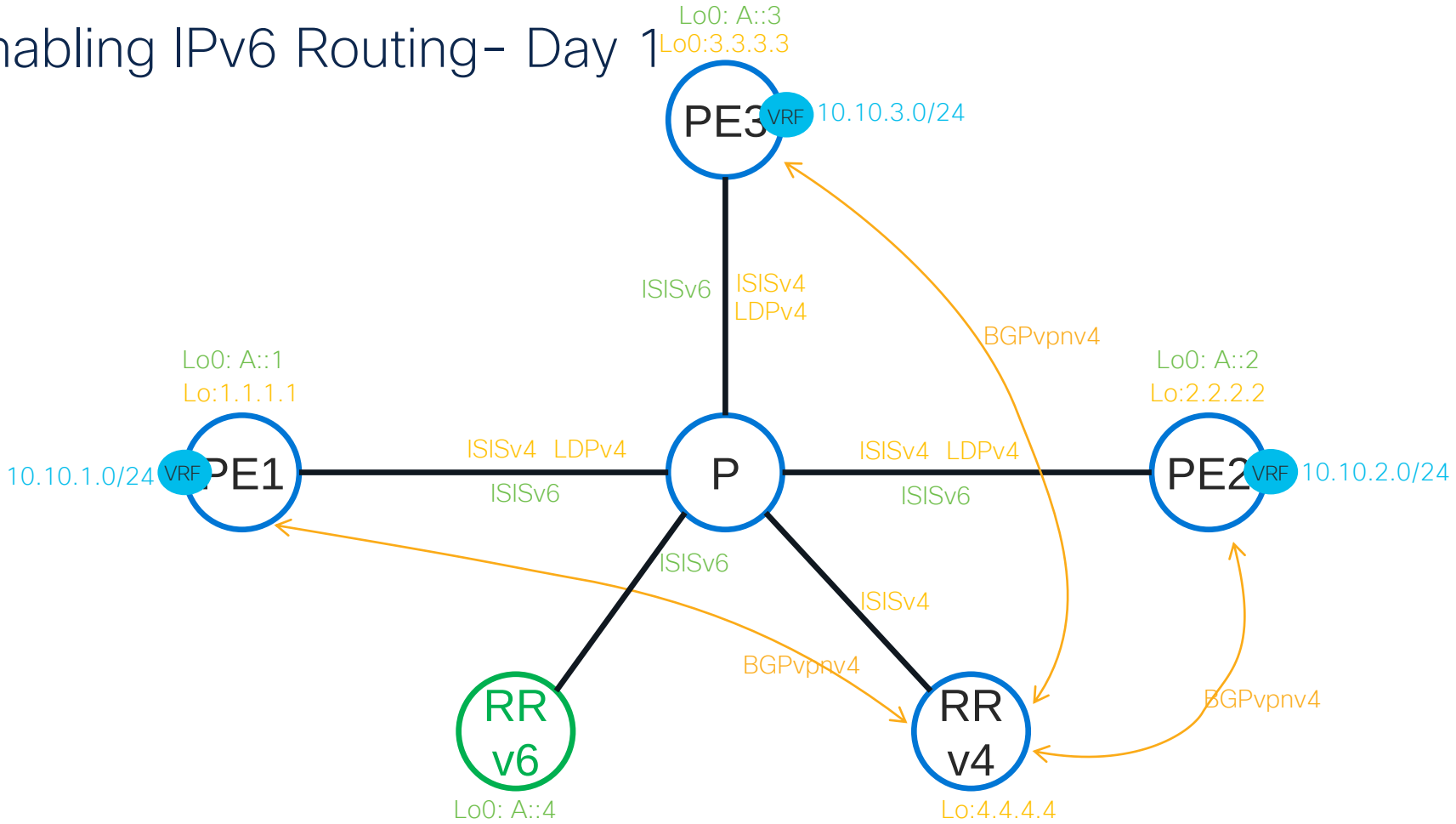
Dual Connected PE



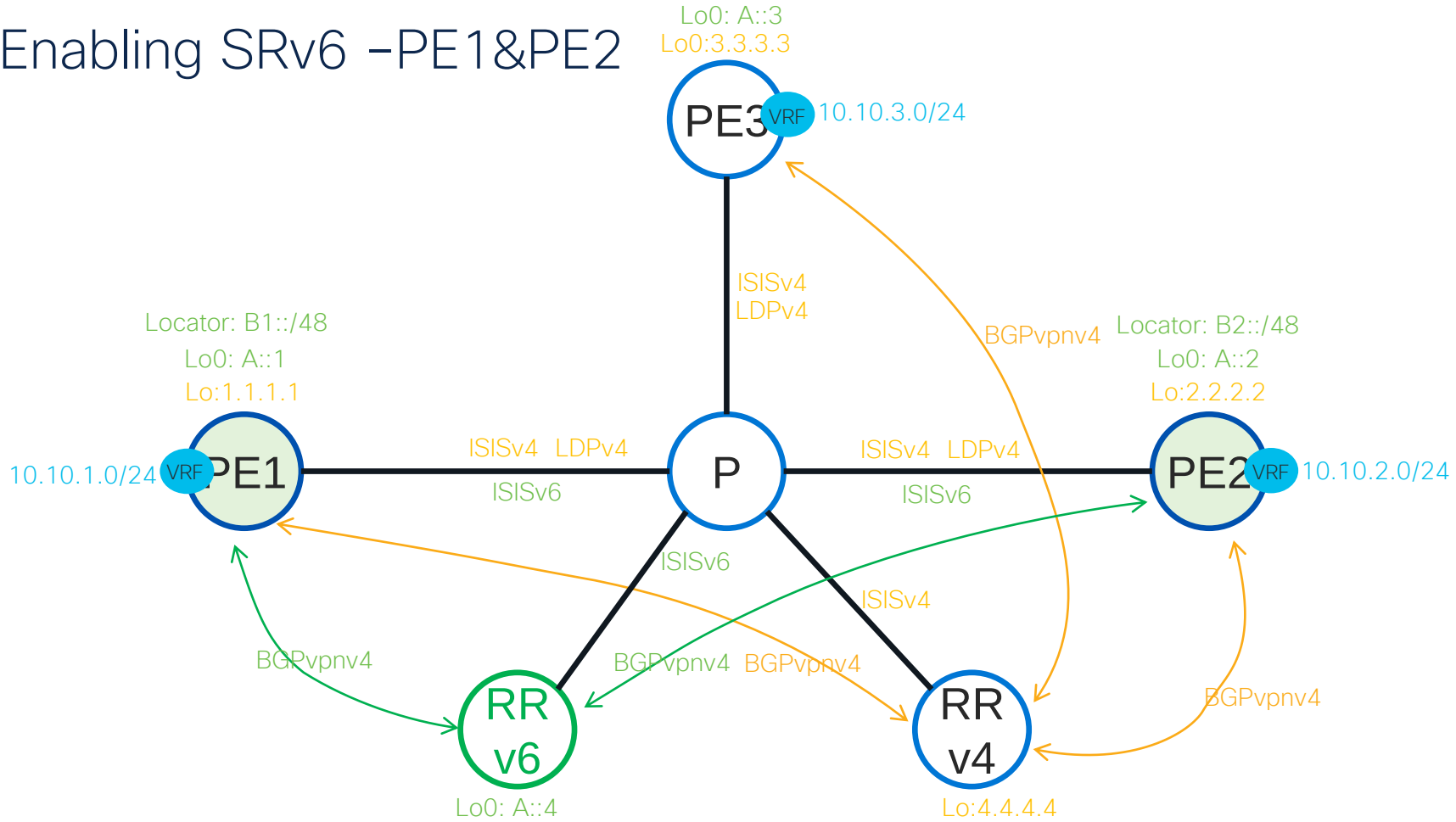
MPLS Network –Day 0



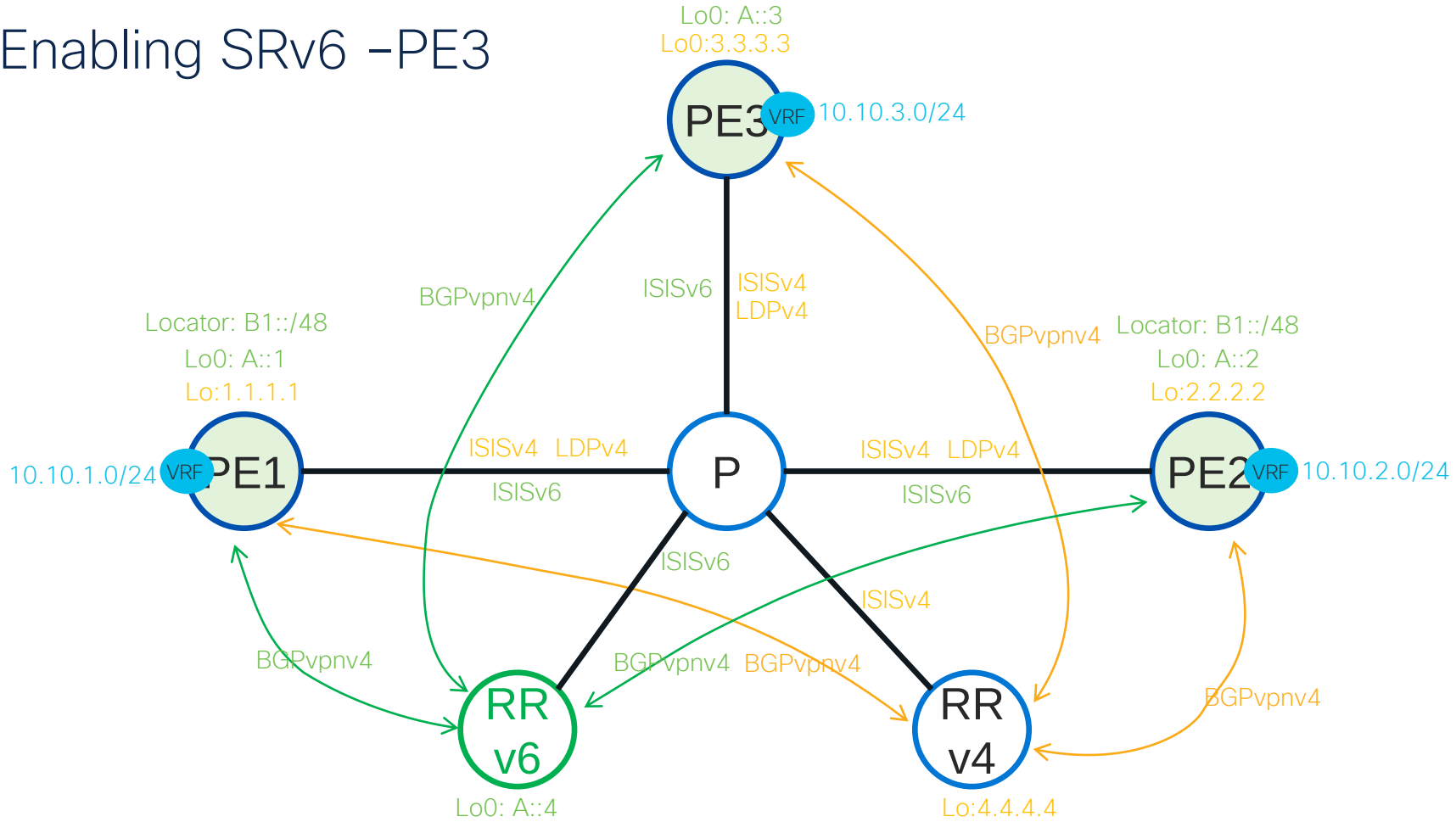
Enabling IPv6 Routing- Day 1



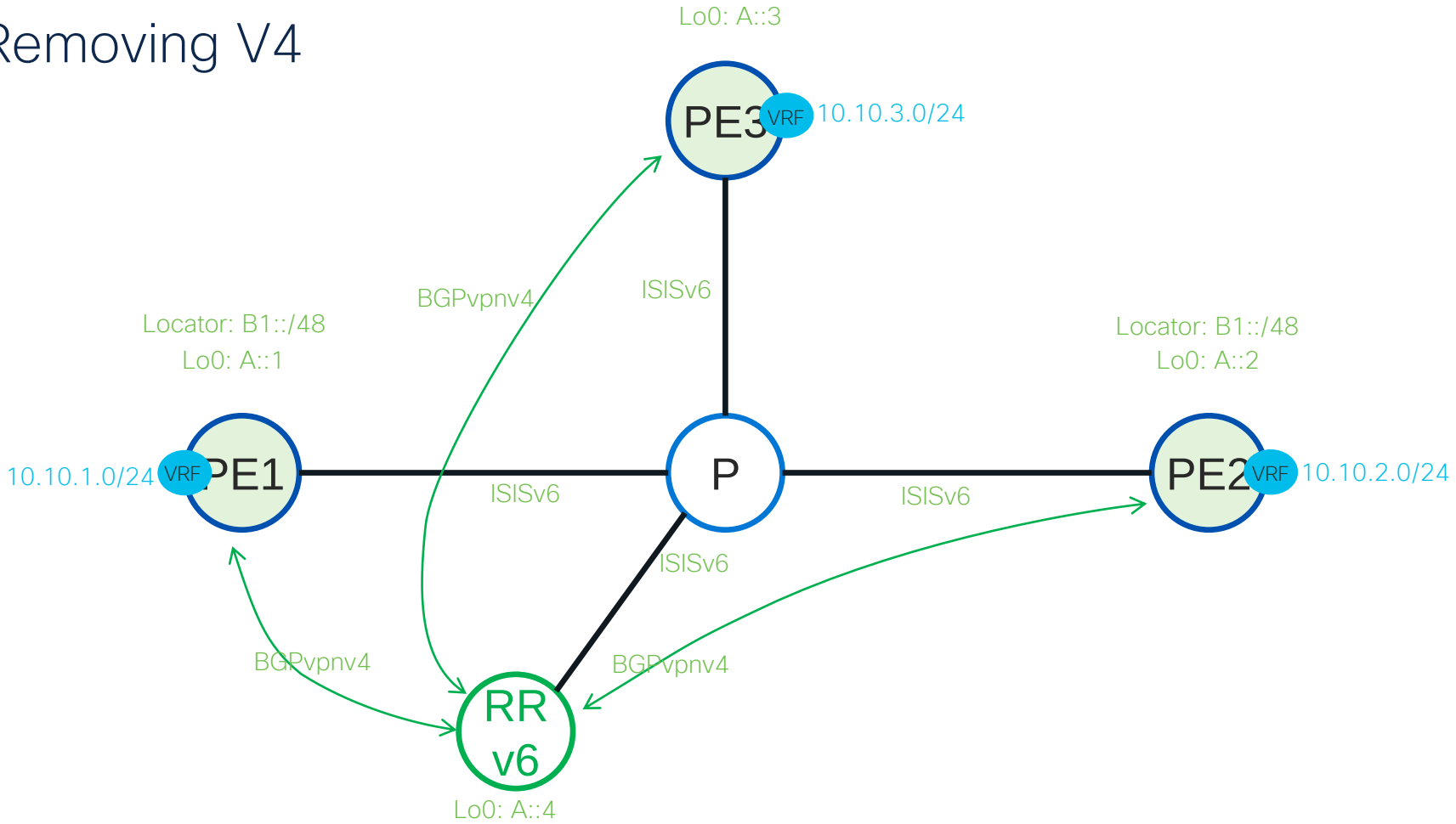
Enabling SRv6 –PE1&PE2



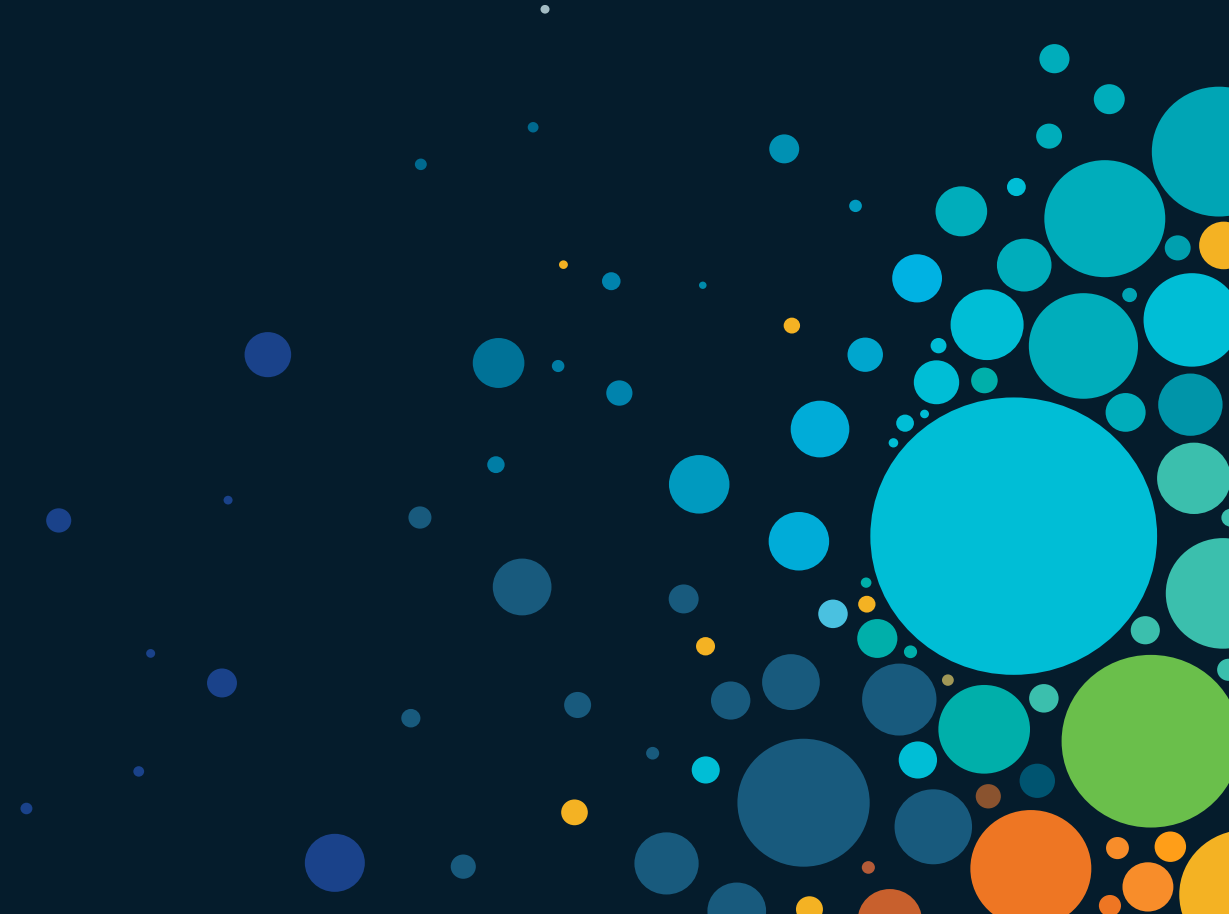
Enabling SRv6 –PE3



Removing V4



Conclusion



Rich Ecosystem

Network Equipment Manufacturers

Cisco, Huawei, Nokia, Ciena, Juniper Networks, Arrcus, ZTE, H3C

Merchant Silicon

Cisco, Broadcom, Barefoot Networks (Intel), Marvell

Open-Source Applications

Pyroute, iptables, SERA, GoBGP, exa, BGP, eBPF, tcpdump, Wireshark, Snort, BMP, cilium

SR v6 Segment Routing

Open-Source Networking Stacks

SONiC, Linux, fd.io, P4, Open Compute Project, Kubernetes, OpenStack

Smart NIC

Intel, Mellanox Technologies

Partners

kaloom, Trend Micro, ENEA Qosmos Division, NoviFlow, ixia A Keysight Business, Spirent Promise. Assured.

cisco Live!

Simplicity Always Prevails

~~LDP~~

~~RSVP-TE~~

~~BGP 3108~~

~~MPLS~~

~~UDP/VxLAN~~

~~NSH~~

Furthermore, with more scale

and functionality

Introducing SRv6 to an existing network

Martin Gysi, IP network and network automation architect

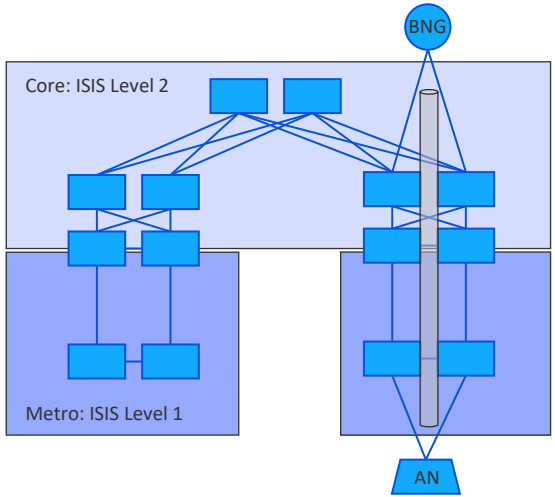
February 2023, Cisco Live

swisscom

At the beginning of the journey, we had an existing network: Swisscom Underlay Transport Network - SULTAN

Built for the needs of residential services:

- Backhaul of L2 between Access Nodes and BNG, IPTV multicast



Using VxLAN over IPv6 (!) to transport L2 frames between Access Node and BNG.

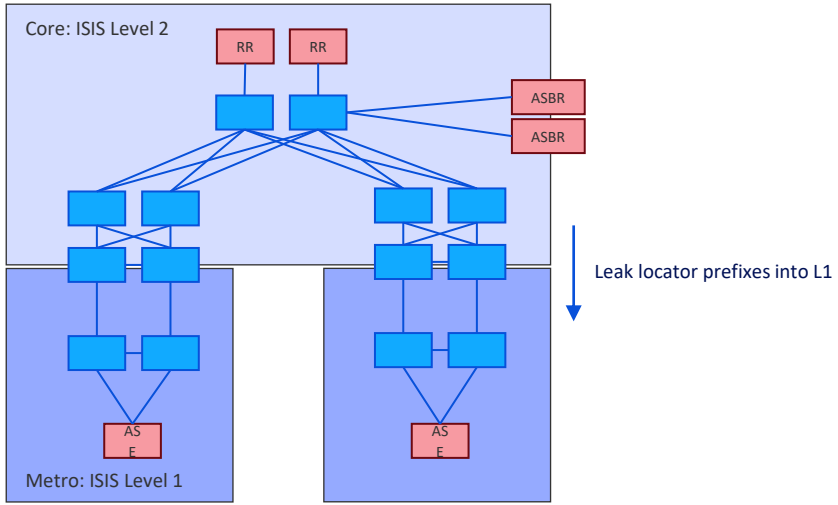
SRv6 was not ready, but already on our watch list when this network was built in 2018. IPv6 as the future-proof option.

ISIS concept	• IPv6/IPv4 multi-topology • Level-2 core • Level-1 metro
Network services	• L2 point-to-point transport • IPv4 multicast (PIM-SM)
VPN technology	• VxLAN over IPv6 • MPLS not supported in combination with VxLAN
Addressing	• IPv6 link-local between devices • Global (but internal) IPv6 address on Loopbacks
Network availability	• Outstanding
Capacity	• Plenty

Introducing business services to the SULTAN network: SRv6 as the obvious choice

On the existing network, we had to:

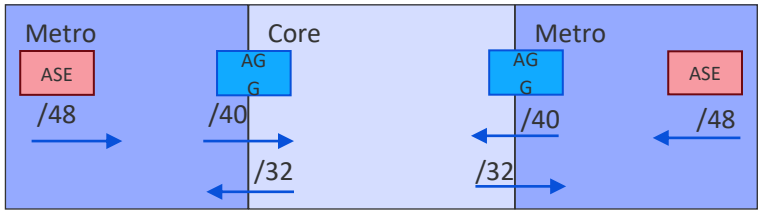
- Enable ISIS towards new (business) Access Service Edge, ASBR and Route Reflectors
- Leak SRv6 locator prefixes (/48) from ISIS L2 into L1



ISIS changes	• Leak locator prefixes into L1
VPN technology	• EVPN/SRv6 for L2 (p2mp, p2p) • L3VPN/SRv6 for L3
Business Access Service Edge	• NCS-540 „Tortin“ • 1200 devices rolled out • IOS-XR 7.7.1, targetting 7.8.2
AS Border Router	• To connect to external networks • ASR9906 • 2 devices rolled out • IOS-XR 7.7.1, targetting 7.8.2
RR	• ASR9904 • 2 devices rolled out • IOS-XR 7.5.2

Addressing concept:
Design for aggregation and security

Aggregation: We do not currently aggregate the SRv6 locator ranges but have assigned them to allow for aggregation.



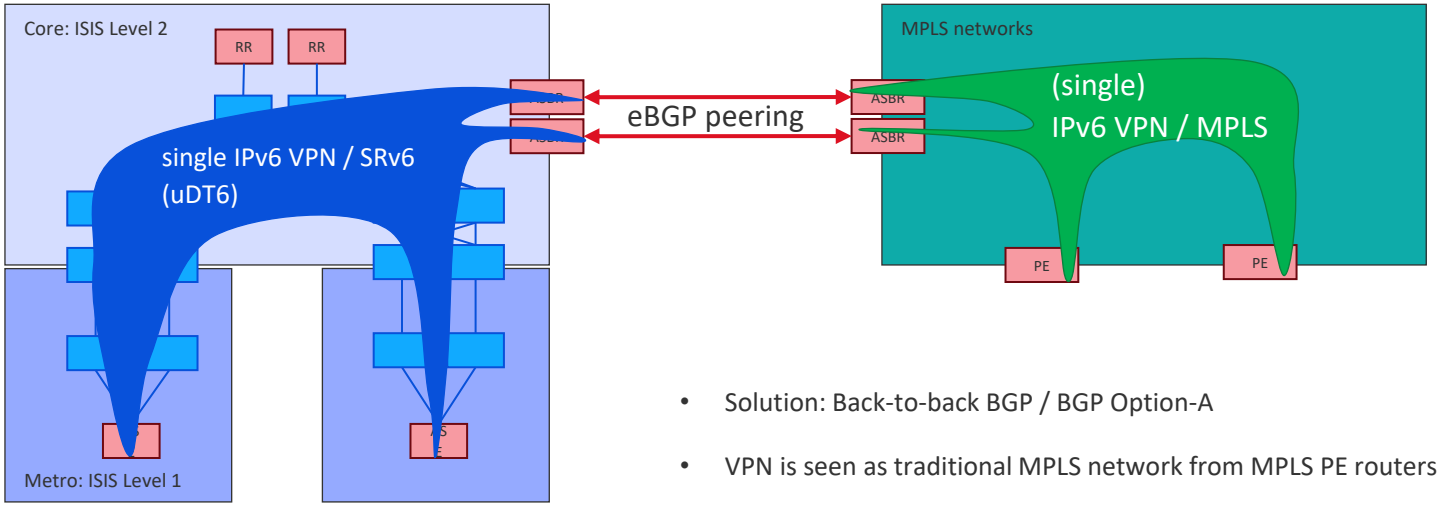
Security: No access to locator space must be possible, not even for management purposes.

- Loopback0 for SRv6: <locator>::1 → No external access
- Loopback1 for management, streaming telemetry, etc → Separate range using global space, encoding DD and NN to also allow for aggregation

uSID locator	`fdab:cd0<G>:<DD><NN>::/48`
<G>	Flex Algorithms `0-f`
<DD>	Domain ID `0x00 - 0xdf`
<NN>	Node ID `0x00 - 0xff`

Connecting to existing MPLS networks
Approach 1: Back-to-back connections

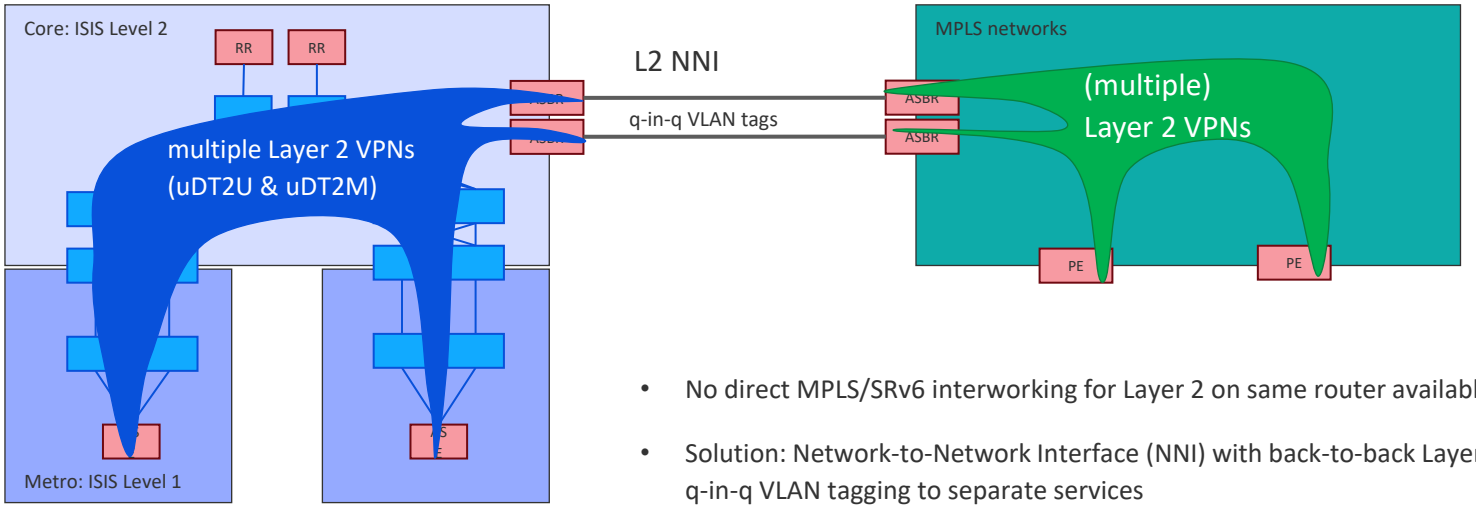
Case 1: **Single IPv6 VPN**



- Solution: Back-to-back BGP / BGP Option-A
- VPN is seen as traditional MPLS network from MPLS PE routers
- obvious, most simple choice

Connecting to existing MPLS networks
Approach 1: Back-to-back connections

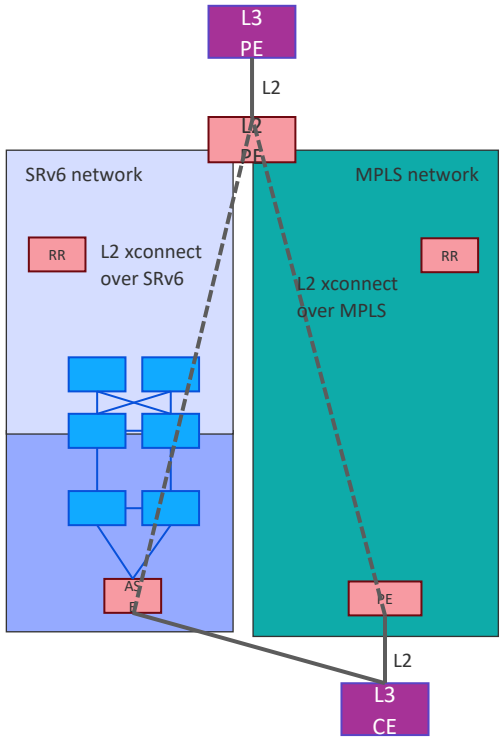
Case 2: **Multipoint Ethernet services**



- No direct MPLS/SRv6 interworking for Layer 2 on same router available yet
- Solution: Network-to-Network Interface (NNI) with back-to-back Layer 2 using q-in-q VLAN tagging to separate services
- Nicely separates IT stacks for provisioning (new IT stack only for SRv6 network elements)

Connecting to existing MPLS networks
Approach 2: Dual-connected PE

Case 3: **Point-to-point Ethernet services**



Network service is a p2p L2 connection between the L3 PE and the CE router

- Migration procedure must have no impact on L3 PE
- Solution: Dual-connect the L2 PE to both MPLS and SRv6 domains
- Two ISIS processes
- Two BGP processes with connections to two independent route reflectors
- During physical migration:
  - remove MPLS neighbor from p2p xconnect
  - add SRv6 neighbor to p2p xconnect
- Drawbacks:
  - obviously much more complex. Our OPS team prepares a new L2 PE instead of doing a software upgrade on the existing one.
  - L2 PE is now part of two networks. Which IT system should configure it?

Session Surveys

We would love to know your feedback on this session!

- Complete the session surveys in the Cisco Events mobile app. You'll earn some points in the Cisco Live Game and potentially win a prize.
- Complete a minimum of four session and the overall event surveys to claim a Cisco Live cable bag.

Agenda

Visit the Cisco Showcase for related demos

Book your one-on-one Meet the Expert meeting

Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs

Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

Cisco Learning and Certifications

From technology training and team development to Cisco certifications and learning plans, let us help you empower your business and career. www.cisco.com/go/certs

Pay for Learning with Cisco Learning Credits

(CLCs) are prepaid training vouchers redeemed directly with Cisco.

Learn

Cisco U.
IT learning hub that guides teams and learners toward their goals

Cisco Digital Learning
Subscription-based product, technology, and certification training

Cisco Modeling Labs
Network simulation platform for design, testing, and troubleshooting

Cisco Learning Network
Resource community portal for certifications and learning

Train

Cisco Training Bootcamps
Intensive team & individual automation and technology training programs

Cisco Learning Partner Program
Authorized training partners supporting Cisco technology and career certifications

Cisco Instructor-led and Virtual Instructor-led training
Accelerated curriculum of product, technology, and certification courses

Certify

Cisco Certifications and Specialist Certifications
Award-winning certification program empowers students and IT Professionals to advance their technical careers

Cisco Guided Study Groups
180-day certification prep program with learning and support

Cisco Continuing Education Program
Recertification training options for Cisco certified individuals

Complete your Session Survey

- Please complete your session survey after each session. Your feedback is important.
- Complete a minimum of 4 session surveys and the Overall Conference survey (open from Thursday) to receive your Cisco Live t-shirt.

- All surveys can be taken in the Cisco Events Mobile App or by logging in to the Session Catalog and clicking the "Attendee Dashboard" at https://www.ciscolive.com/emea/learn/sessions/session-catalog.html

Continue Your Education

Visit the Cisco Showcase for related demos.

Book your one-on-one Meet the Engineer meeting.

Attend any of the related sessions at the DevNet, Capture the Flag, and Walk-in Labs zones.

Visit the On-Demand Library for more sessions at ciscolive.com/on-demand.


cisco
The bridge to possible
Thank you
cisco Live!