
cisco Live!
ALL IN

The bridge to possible

SRv6 based Transport – Design, Deployment, Best Practices & Challenges

Ankush Arora, Principal Architect
Atahar Khan, Sr Delivery Architect

BRKMPL-2117

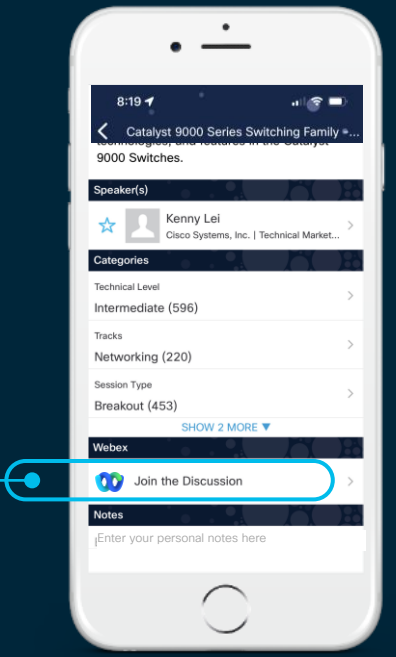
Cisco Webex App

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



https://ciscolive.ciscoevents.com/ciscolivebot/#BRKMPL-2117

Webex spaces will be moderated by the speaker until June 17, 2022.

Transport Fabric Evolution

Centralized Management, Leaner & Highly Scalable

Unified MPLS

Services
Transport

MP-BGP
LDP
BGP-LU
RSVP
LDP
IGP
MPLS

- Operational complexity
- Integrated HW & SW
- Limited data plane scaling

MPLS SR with controller

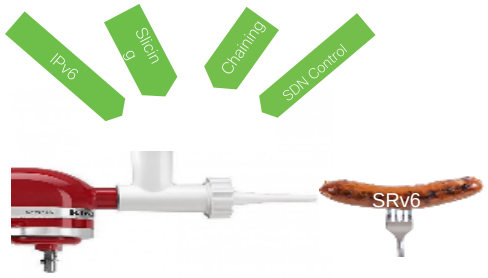
Services
Transport

MP-BGP
IGP/SR
MPLS

SDN

- Leaner & optimised routing
- Centralised orchestration
- Distributed control plane
- Limited data plane scaling

SRv6



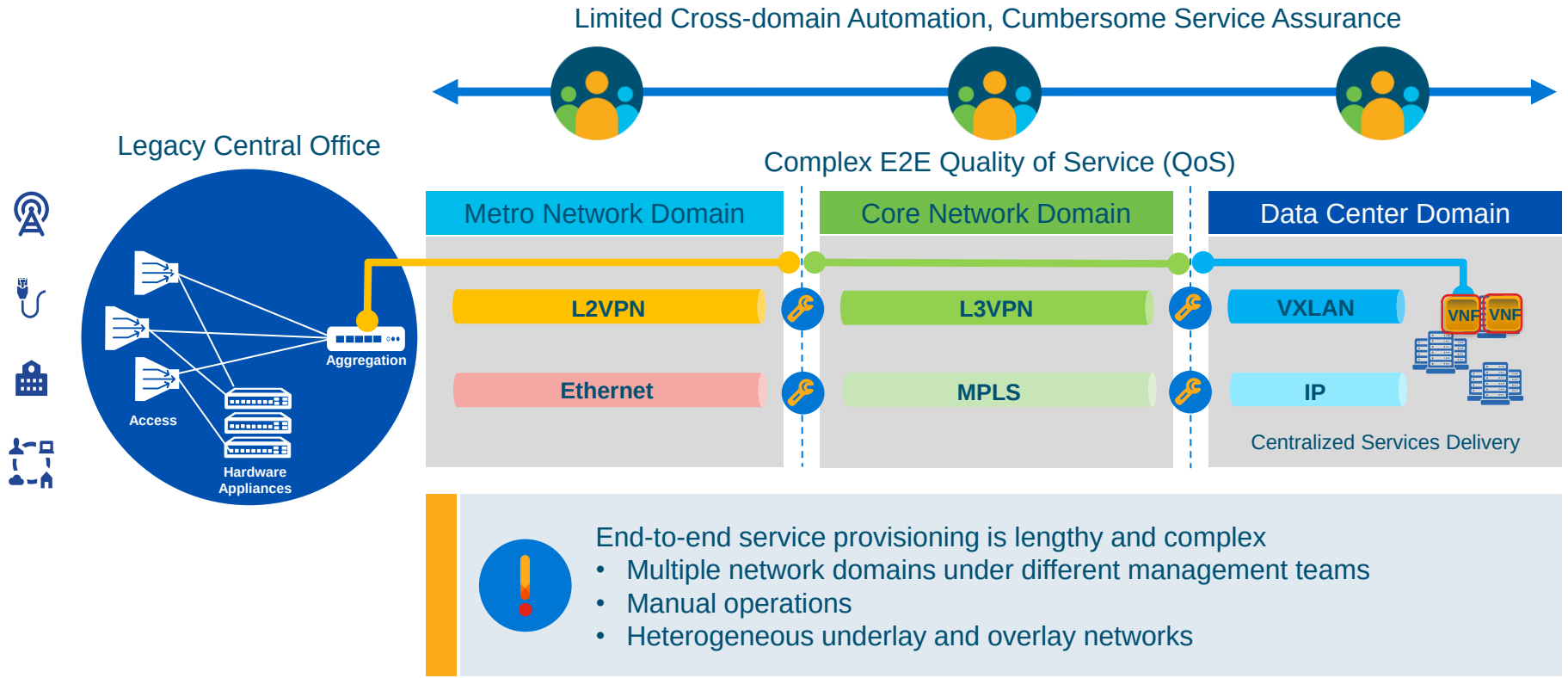
Services
Transport

MP-BGP
IGP/SR
IPv6

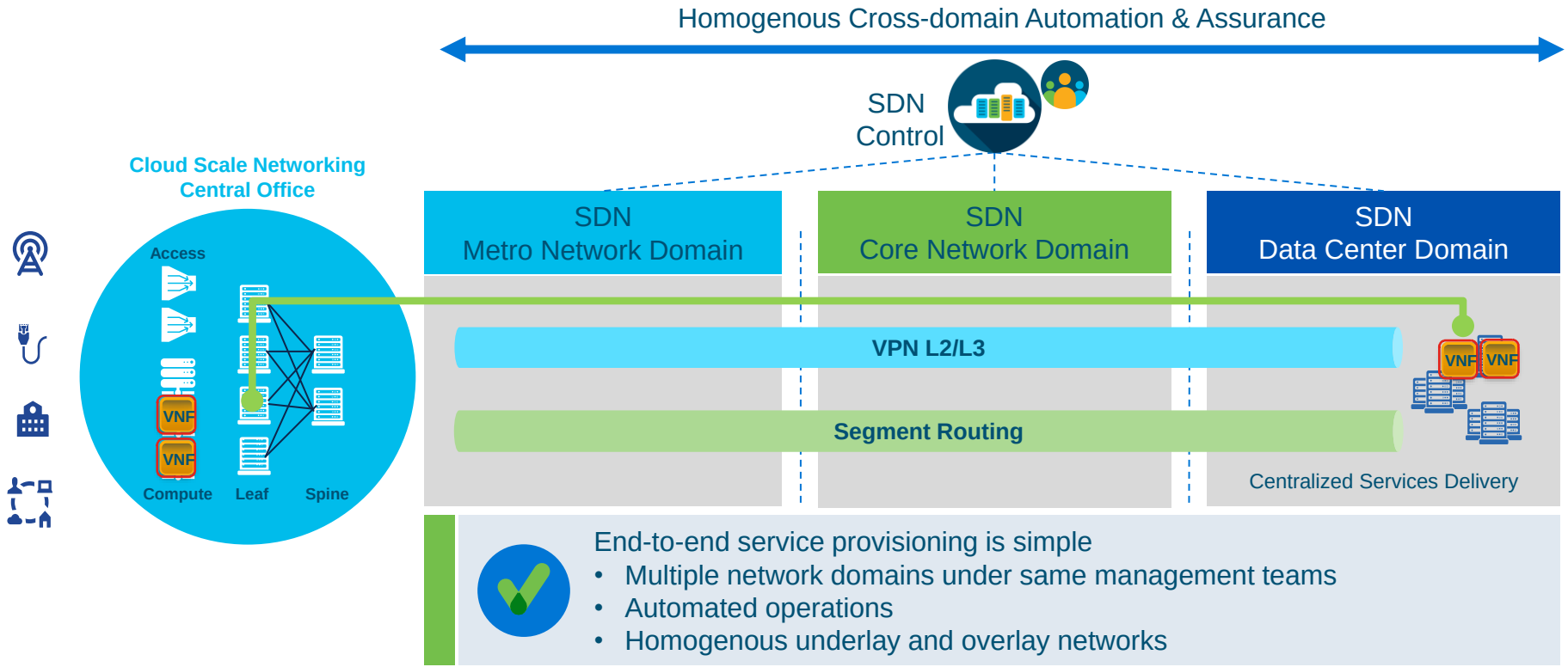
SDN

- All of SR-MPLS features plus
- Massive data plane scaling
- Programmable control plane
- Service chaining

Understanding Today's Service Creation



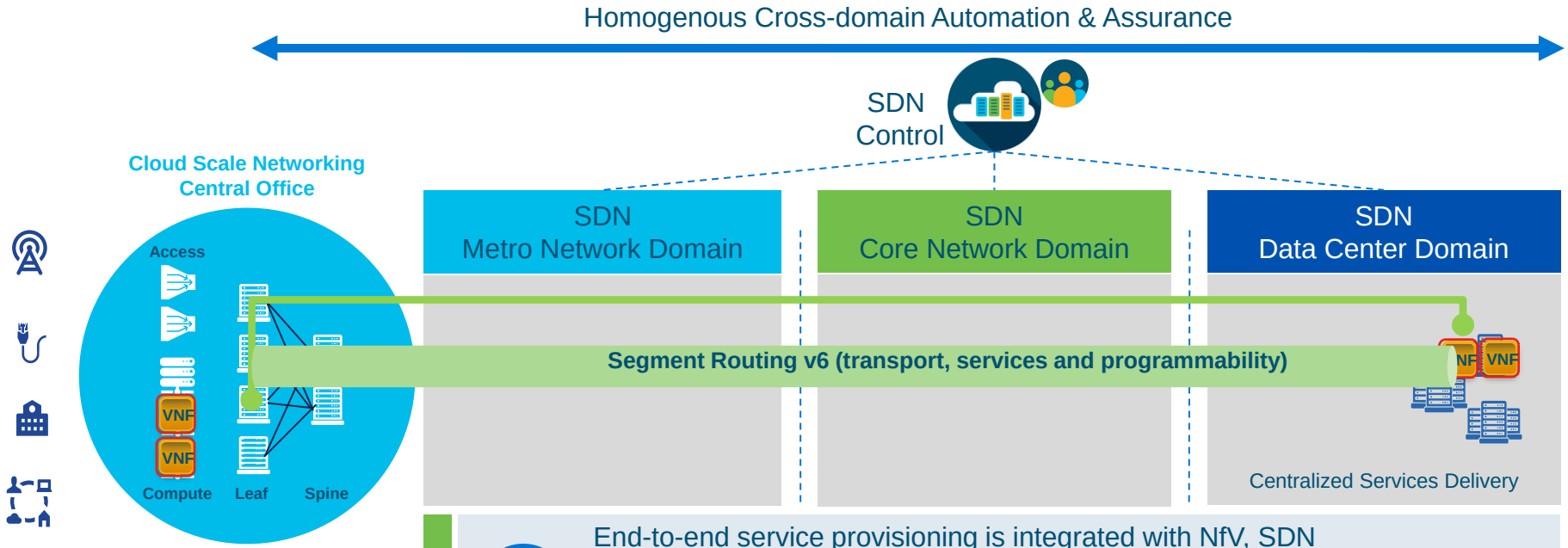
SR-MPLS: SDN ready
“Network as a Fabric” for Service Creation



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)

Agenda

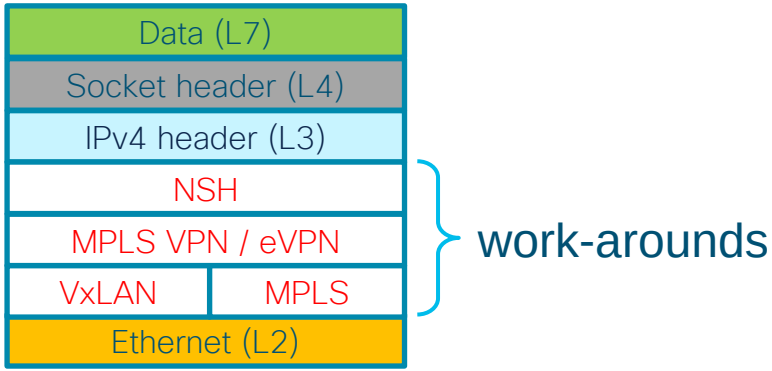
- Transport Challenges – SRv6 Opportunities
- SRv6 Recap
- Case Study : Native IPv6 GRT to SRv6
- Case Study : MPLS to SRv6
- SRv6 Design Best Practices
- Summary

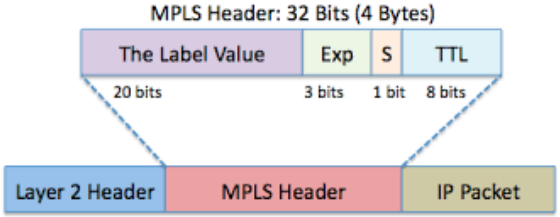
Transport Challenges - SRv6 Opportunities

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



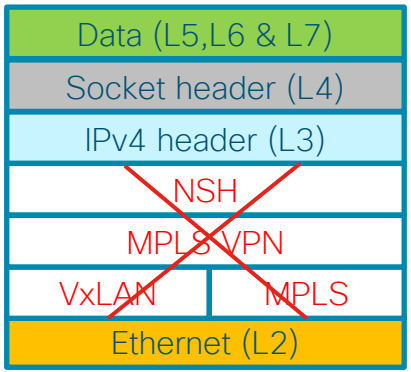


SRv6 Solution

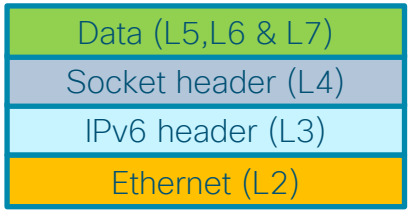
Network Functions	IPv6
Reachability	IPv6 Header
Engineered Load Balancing	IPv6 Header
VPN	IPv6 Header
Traffic Engineering	IPv6 Header
Source Routing	IPv6 Header
Service Chaining	IPv6 Header

IPv6 Address 128bits
IPv6 Flow Header
- Engineered Flow optimization

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

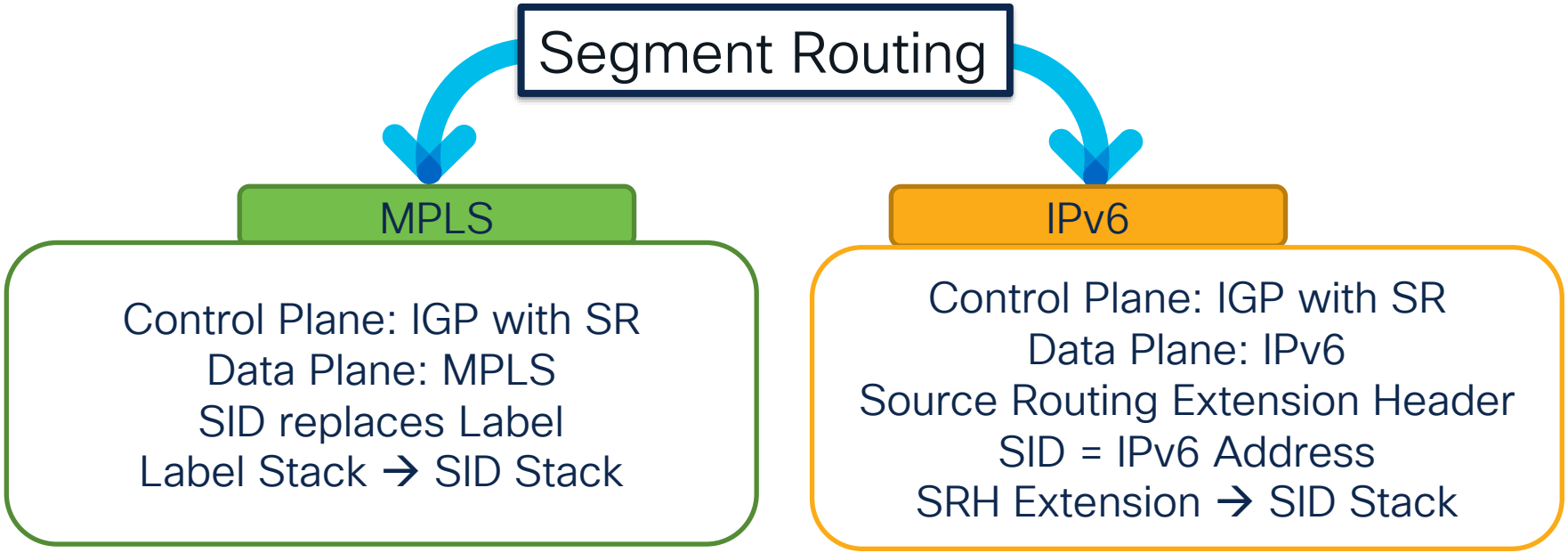


Simplicity
(back to OSI model)



SRv6 Recap

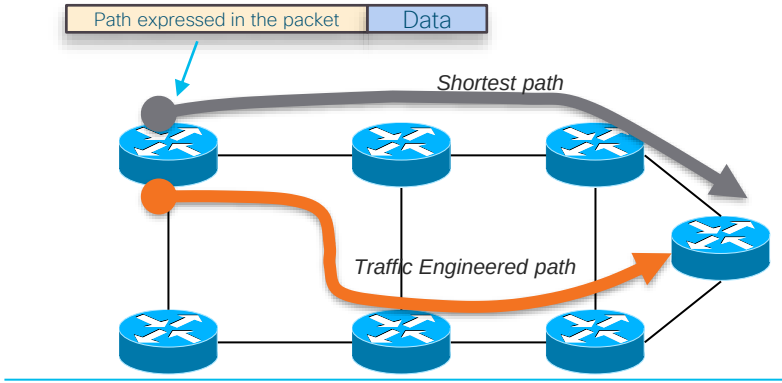
Segment Routing Data Plane with IPv6

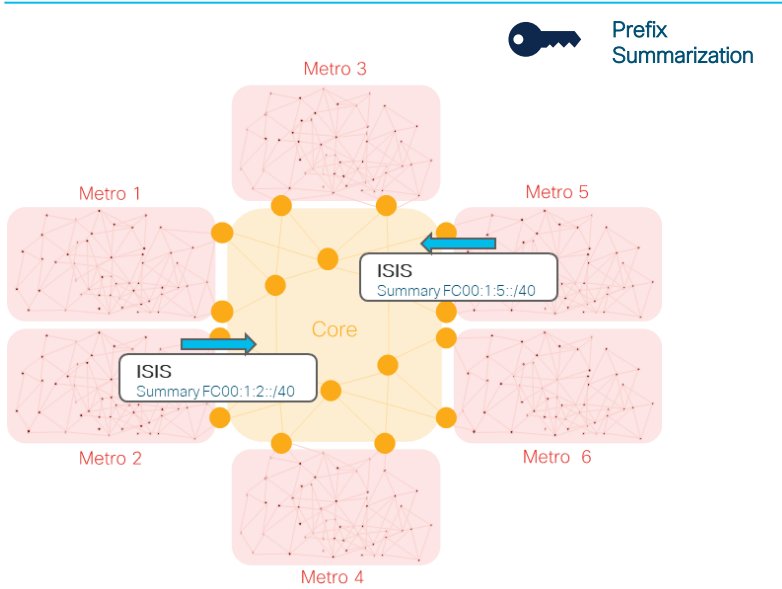


Segment = **Instructions** such as
"go to node N using the shortest path"

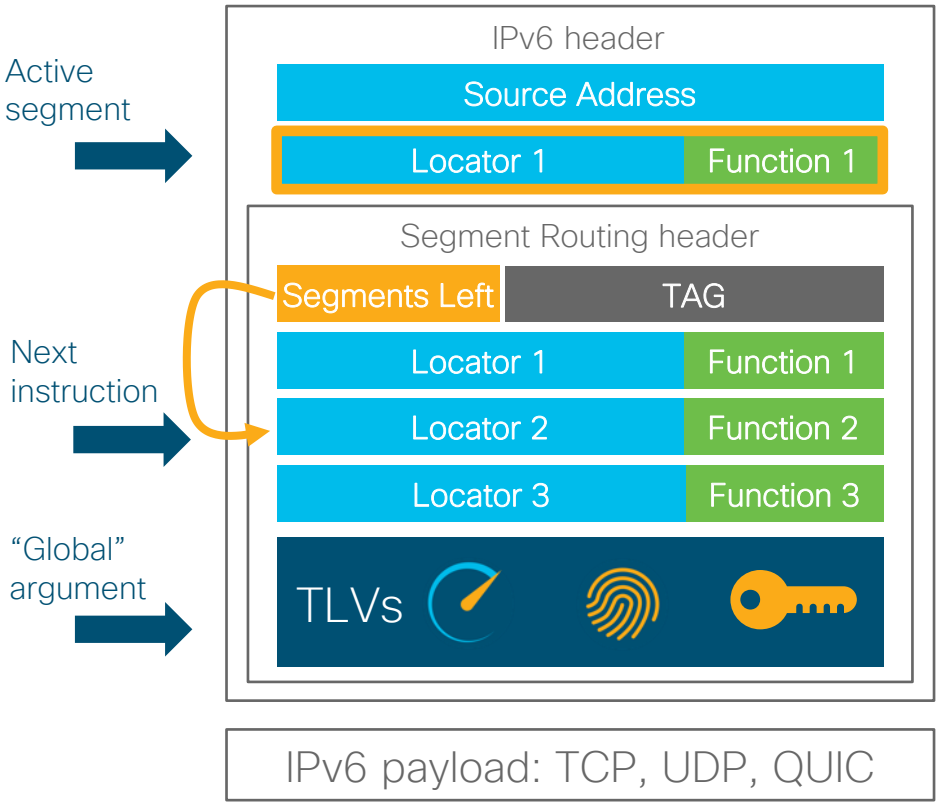
Routing with SRv6

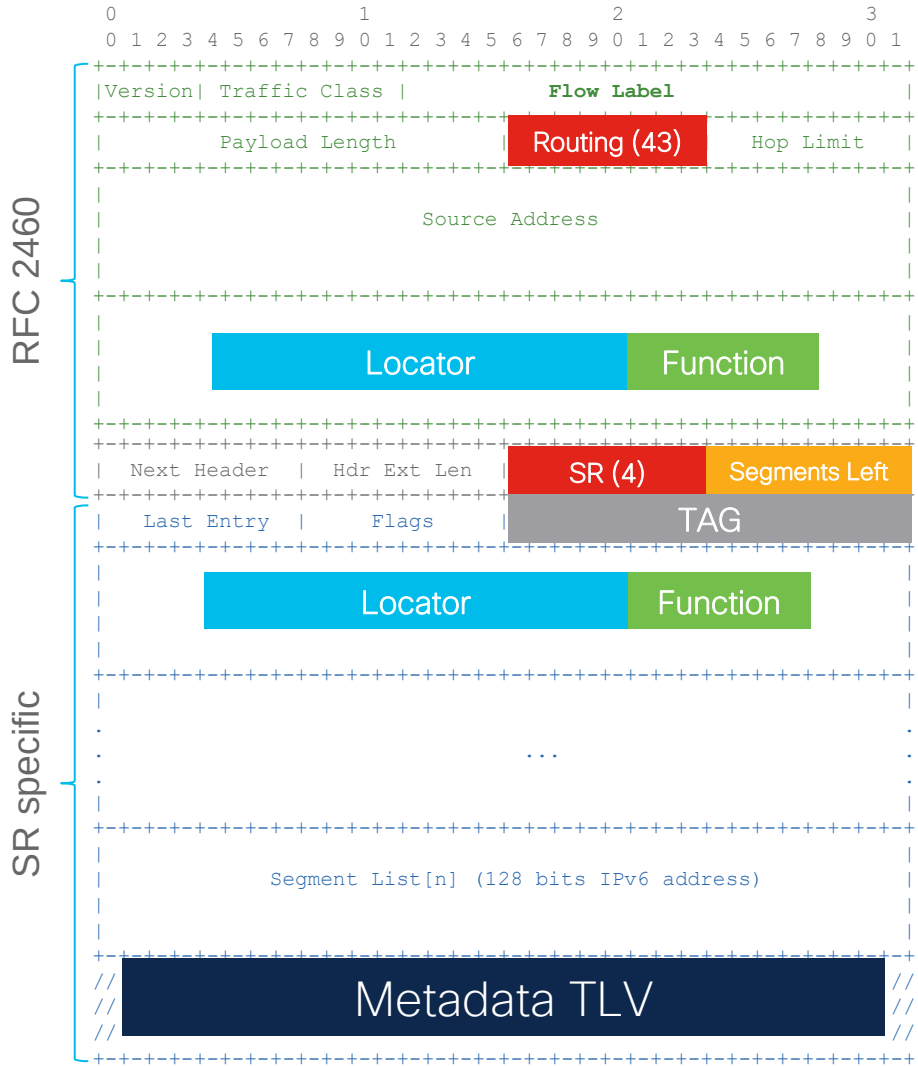
- Source Routing
  - the topological and service (NFV) path is encoded in packet header
- Back to basic IP routing and summarization
  - No BGP Labelled Unicast
- Scalability
  - the network fabric does not hold any per-flow state for TE or NFV
- Simplicity
  - automation: TILFA sub-50msec FRR
  - protocol elimination: LDP, RSVP-TE, VxLAN, NSH, GTP, ...
- End-to-End
  - DC, Metro, WAN





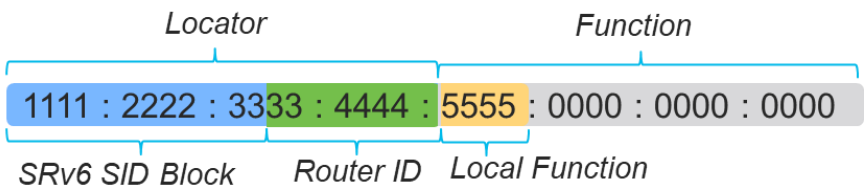
SRv6 Header – RFC8754





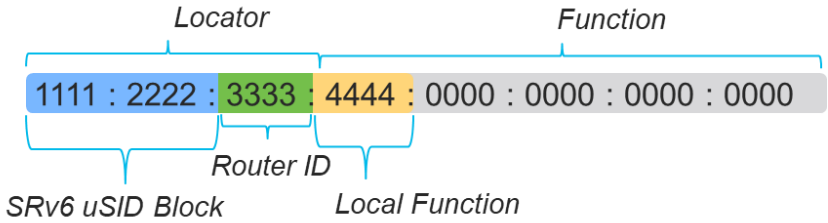
SRv6 SID Introduction

Base SID



- 128 bit Segment ID with Locator + Function
- Only 1 instruction included in 1 carrier (128 bits)
- 64 bits locator helps with addressing scheme

uSID



- Natural extension to SRv6 that optimizes it
- Upto 6 uSID in 1 carrier (128 bits)
- Bigger addressing space available for consumption with 48-bit locator & multiple uSID

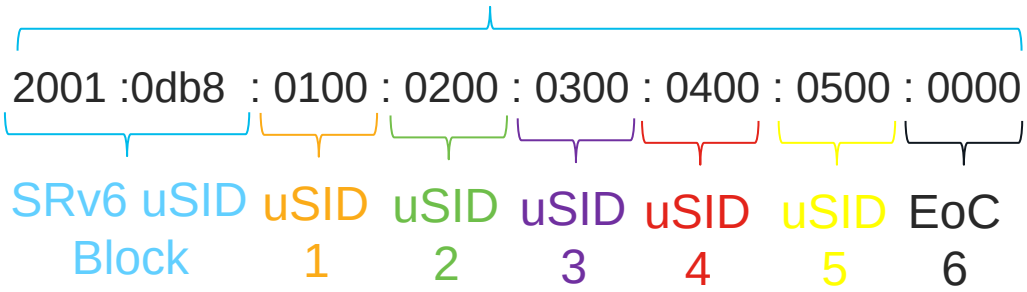
We will be using SRv6 uSID in further case study & best practices

Srv6 uSID format

: 0100 : = SRV6 uSID

16 bits here, but can be anything

SRV6 uSID Carrier



32 bits here,
but can be anything

SRv6 Base SID Encapsulation

```
SA:2001::1
DA:2001:db8:0:100:0:0:0:0
NH:RH

Type:4(SRH)
NH:IPv4|SL:1
Segment List:
[0]: 2001:db8:0:500:0:0:0:0
[1]: 2001:db8:0:400:0:0:0:0
[2]: 2001:db8:0:300:0:0:0:0
[3]: 2001:db8:0:200:0:0:0:0
[4]: 2001:db8:0:100:0:0:0:0

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 SID Examples

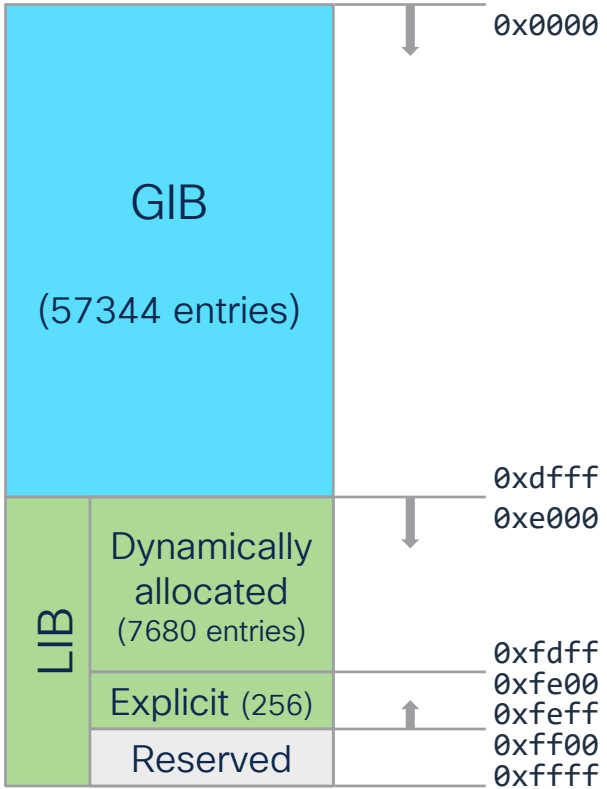
	SRv6 Base	SRv6 uSID	Difference
Locator	FCBB:BBBB:BBAA:AAAA::/64	FCBB:BBBB:AAAA::/48	16 bits
Node SID	END FCBB:BBBB:BBAA:AAAA:0001: :	uN FCBB:BBBB:AAAA::	No difference +shift &forward
Adj SID	END.X FCBB:BBBB:BBAA:AAAA:0042: :	uA FCBB:BBBB:AAAA:e000: :	No difference +shift &forward
Service SID	END.DX ,END.DT FCBB:BBBB:BBAA:AAAA:0043: :	uDX,uDT FCBB:BBBB:AAAA:e001: :	No difference

We will be using SRv6 uSID in further case study & best practices

uSID Summary

- Global ID block (GIB)
  - First nibble: `0x0` to `0xd` (57k entries)
    - `0x0000` is reserved for End-of-Carrier
  - uSIDs allocated from GIB are **block-specific**
  - Globally-significant uSIDs (e.g., node, anycast)

- Local ID block (LIB)
  - First nibble: `0xe` and `0xf` (8k entries), divided in:
    - Dynamic allocation
    - Explicit allocation (ELIB)
    - Reserved values (last 256 entries)
  - uSIDs allocated from LIB are **block- and node-specific**
  - Locally-significant uSIDs (e.g., adjacency, BSID, VPN)

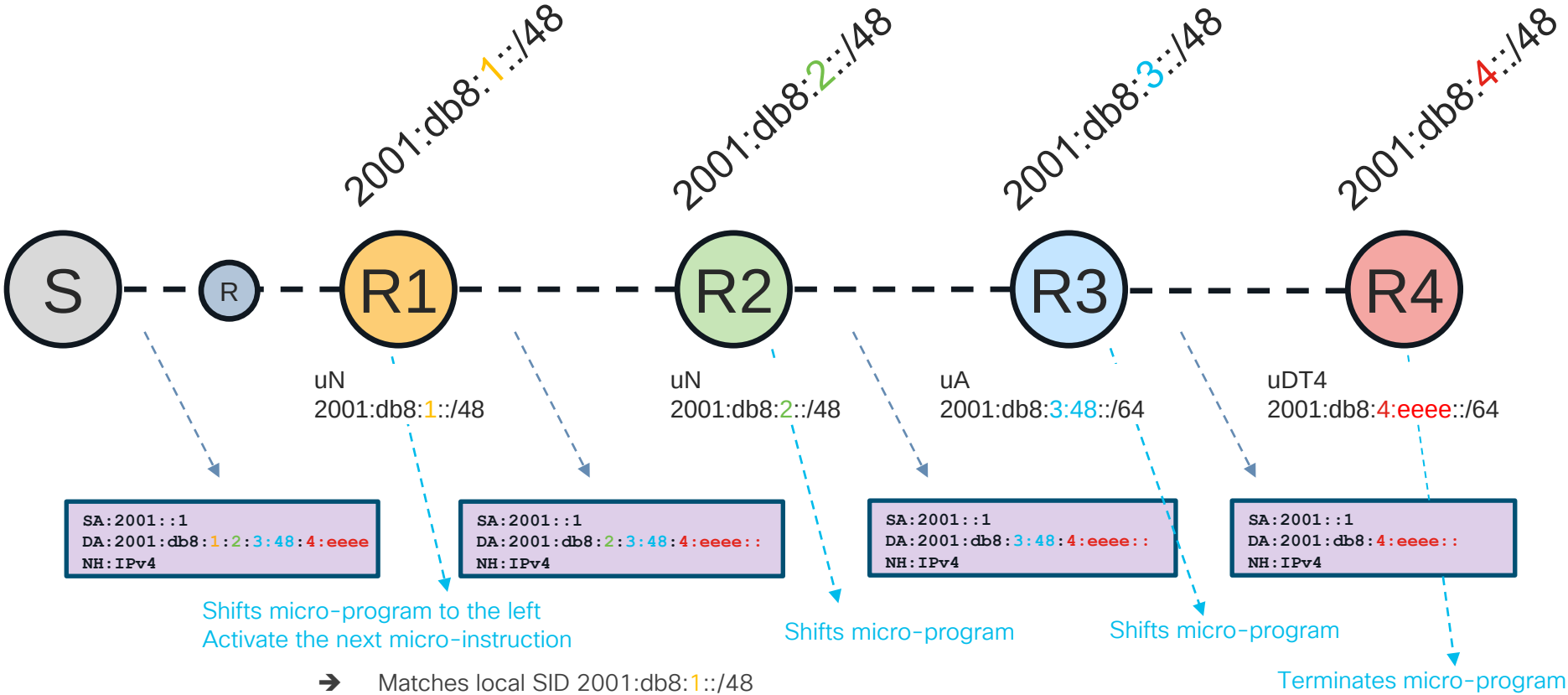


SRv6 functions: Steering and Services

(Refer to : draft-ietf-spring-srv6-network-programming)

Codename	Behavior	
uN_shift	Endpoint	[PSP/USP flavors]
uA_shift	Endpoint with Layer-3 cross-connect	[PSP/USP flavors]
uB6_Insert	Endpoint bound to an SRv6 policy	[BSID]
uB6.Encaps	Endpoint bound to an SRv6 encapsulation policy	[BSID]
uDX6	Endpoint with decapsulation and IPv6 cross-connect	[Per-CE VPN label]
uDX4	Endpoint with decapsulation and IPv4 cross-connect	[Per-CE VPN label]
uDT6	Endpoint with decapsulation and specific IPv6 table lookup	[Per-VRF VPN label]
uDT4	Endpoint with decapsulation and specific IPv4 table lookup	[Per-VRF VPN label]
uDX2	Endpoint with decapsulation and L2 cross-connect	[E-LINE]
uDT2U/M	Endpoint with decapsulation and L2 unicast lookup / flooding	[E-LAN]
uBM	Endpoint bound to an SR-MPLS policy	[Interworking]

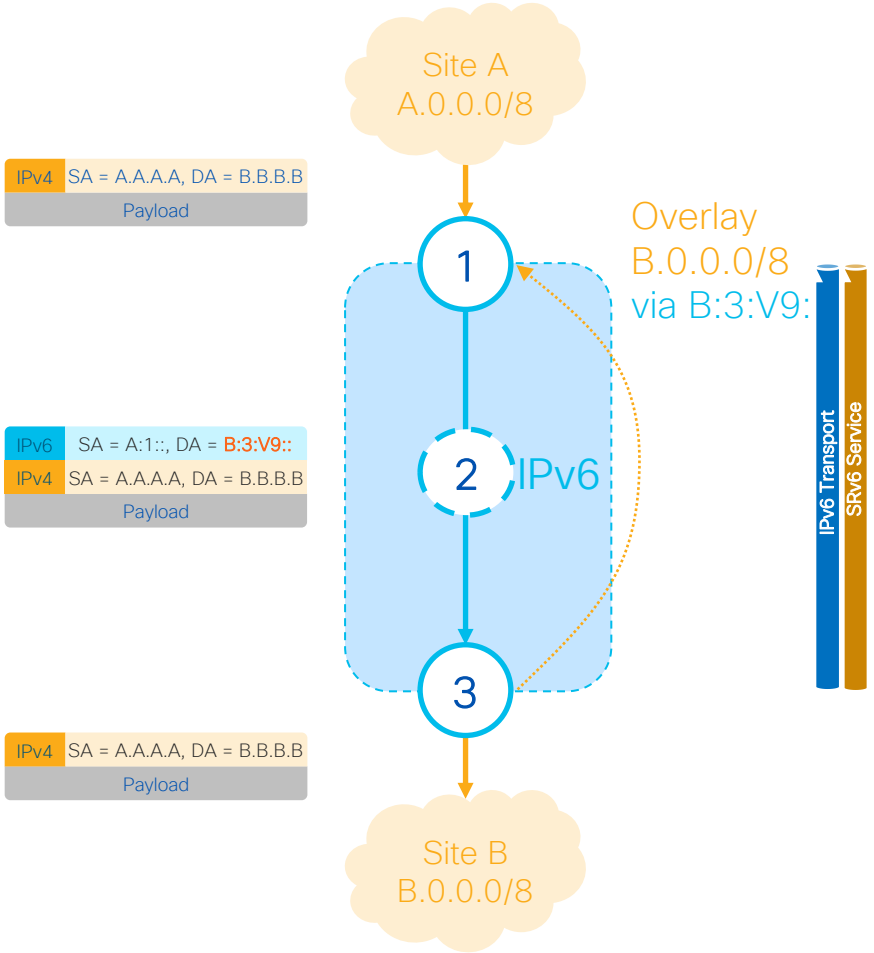
SRv6 uSID Forwarding Example



- ➔ Matches local SID 2001:db8:1::/48
- ➔ Applies “Next” Behavior
- ➔ DA becomes 2001:db8:2:3:48:4:eeee::

Overlay L3VPN Service

- One single SID is needed
  - B:3:V9
  - “go to 3, decaps and lookup in VRF 9”
- No new procol (just BGP)
  - No new SAFI
  - Light ext. to BGP Prefix-SID attribute
- Automated
  - No tunnel to configure
- Efficient
  - SRv6 for everything
  - No other protocol, just IPv6 with SRv6
    - In fact, SRH not even needed (one single SID fits DA)



Overlay Services (L2)

Shipping | Simplicity at scale

Applicability Examples

Extreme Real-time Communications — Tactile Internet

L2VPNs — Mobile, Business

Voice Communications — Fixed / mobile

Solution

IPv6 native L2VPN services overlay with intent-based underlay

SRv6 not only eliminates unneeded overlay protocols; SRv6 solves problems that these protocols cannot solve

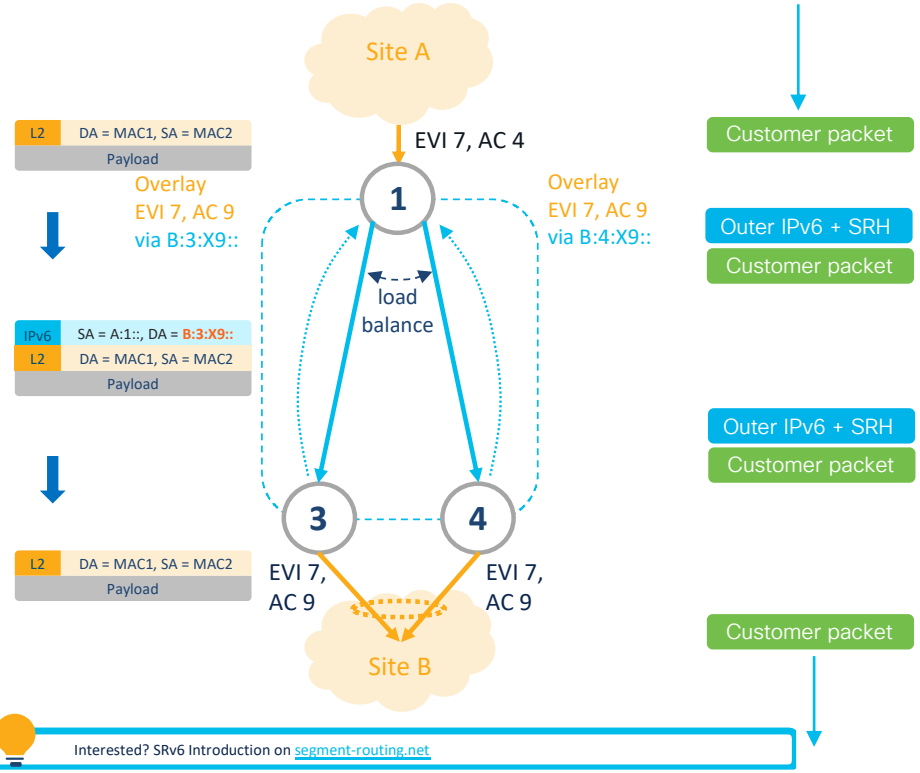
Benefits

Simplicity and Automation
- No tunnel to configure
- No new protocol (just BGP)

Efficiency
- SRv6 for everything
- Re-use BGP/EVPN signaling

Tight SLAs

L2VPN (EVPN-VPWS Multi-Homing)



Interested? SRv6 Introduction on segment-routing.net

SRv6 Locator with L3VPN Configuration

```
!
segment-routing
 srv6
  logging locator status
  encapsulation
   source-address FC00:7000:2001::1
  !
  locators
   locator Locator_SRv6
    micro-segment behavior unode psp-usd
    prefix FC00:7000:2001::/48
   !
!
router ISIS <process-id>
address-family ipv6 unicast
  metric-style wide
  segment-routing srv6      <<< Enable/Activate SRv6
   locator Locator_SRv6
   !
```

SRv6 uSID Locator

```
router bgp 100
 bgp router-id X.X.X.X
 bgp graceful-restart
 !
 address-family vpnv4 unicast
  nexthop trigger-delay critical 100
 !
 address-family vpnv6 unicast
  nexthop trigger-delay critical 100
 !
 address-family l2vpn evpn
  nexthop trigger-delay critical 100
 !
!
vrf SRv6
  rd auto
 address-family ipv6 unicast
   maximum-paths ibgp 2
   segment-routing srv6
    locator Locator_SRv6
    alloc mode per-vrf
     !
```

EVPN Single-Homed L2VPN with SRv6 Configuration

EVPN Single-Homed

```
interface <Interface>.<ID> l2transport
  encapsulation dot1q <dot1q ID>
  rewrite ingress tag dot1q <dot1q ID> symmetric
!
evpn
 evi <EVI ID> segment-routing srv6
  locator Locator_SRv6
 !
 segment-routing srv6
 !
!
l2vpn
 xconnect group 1
  p2p 1
   interface <Interface>
   neighbor evpn evi <EVI ID> service <ID> segment-routing srv6
   !
!
```

EVPN MH L2VPN with SRv6 Configuration

EVPN MH Port Active

```
 interface Bundle-Ether1
 lacp system mac 1213.1213.1213
!
evpn
 evi <EVI ID> segment-routing srv6
  locator Locator_SRv6
 !
 interface Bundle-Ether1
  ethernet-segment
   identifier type 0 00.11.03.11.11.11.00.00.5D
   load-balancing-mode port-active
  !
  !
l2vpn
xconnect group 1
  p2p 1
   interface Bundle-Ether1.1
   neighbor evpn evi <EVI ID> service <Service ID> segment-
routing srv6
   !
!
```

EVPN MH All Active

```
 interface Bundle-Ether1
 lacp system mac 1213.1213.1213
!
evpn
 evi <EVI ID> segment-routing srv6
  locator Locator_SRv6
 !
 interface Bundle-Ether1
  ethernet-segment
   identifier type 0 00.11.03.11.11.11.00.00.5D
  !
L2vpn
load-balancing flow src-dst-ip
xconnect group 1
  p2p 1
   interface Bundle-Ether1.1
   neighbor evpn evi <EVI ID> service <Service ID> segment-
routing srv6
   !
!
!
```

Case Study : Native IPv6-GRT to SRv6

Tier-1 MNO : Native IPv6 GRT to SRv6 Transition

Challenge

- Network Scale
- Configuration Complexity
- No VPN Service Technology
- Complex service options

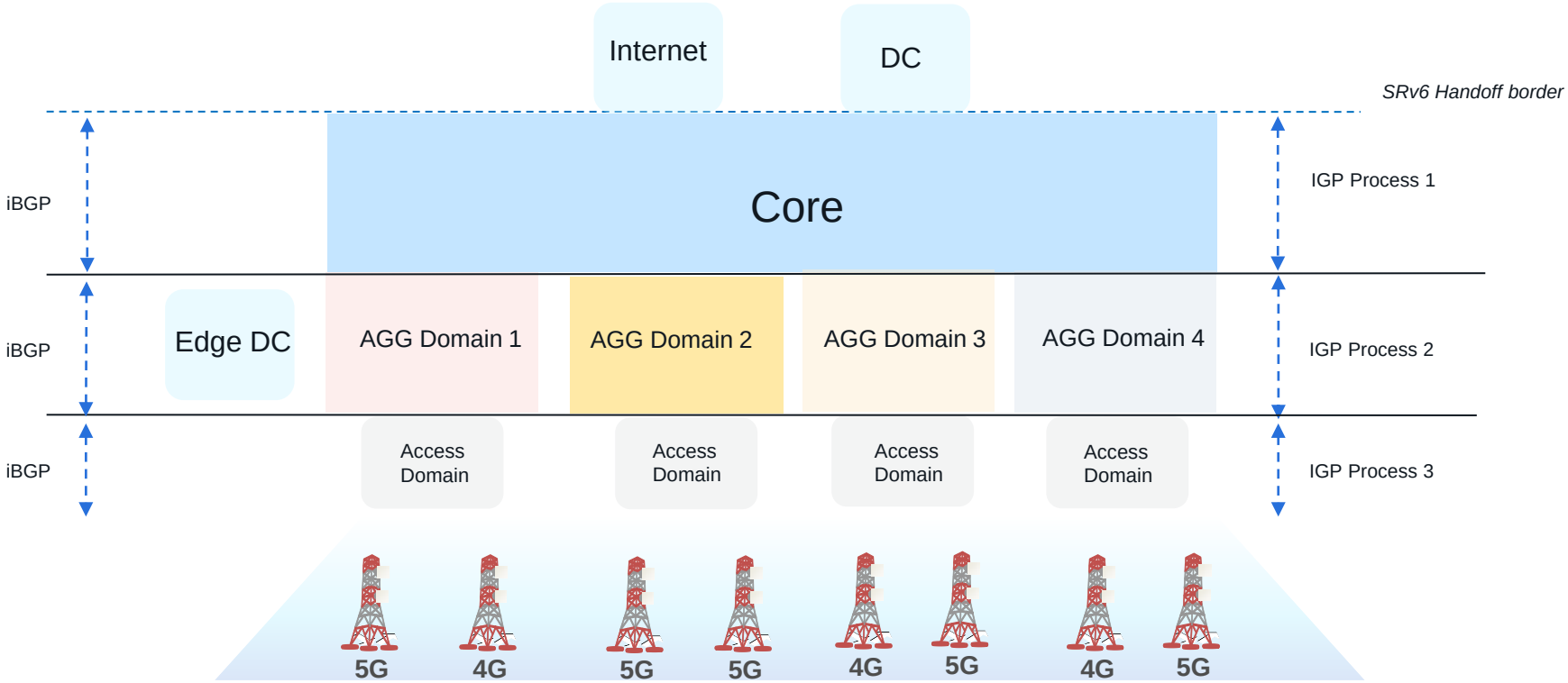
Solution

- SRv6 data plane
- IPv6 Summarization
- EVPN based overlay service

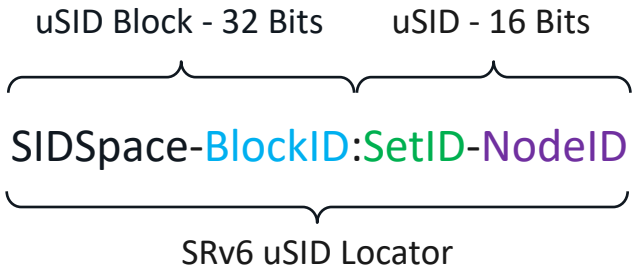
Outcomes

- Simplified Underlay
- Improved convergence
- New Service avenues
- Seamless migration

Existing network with Native IPv6

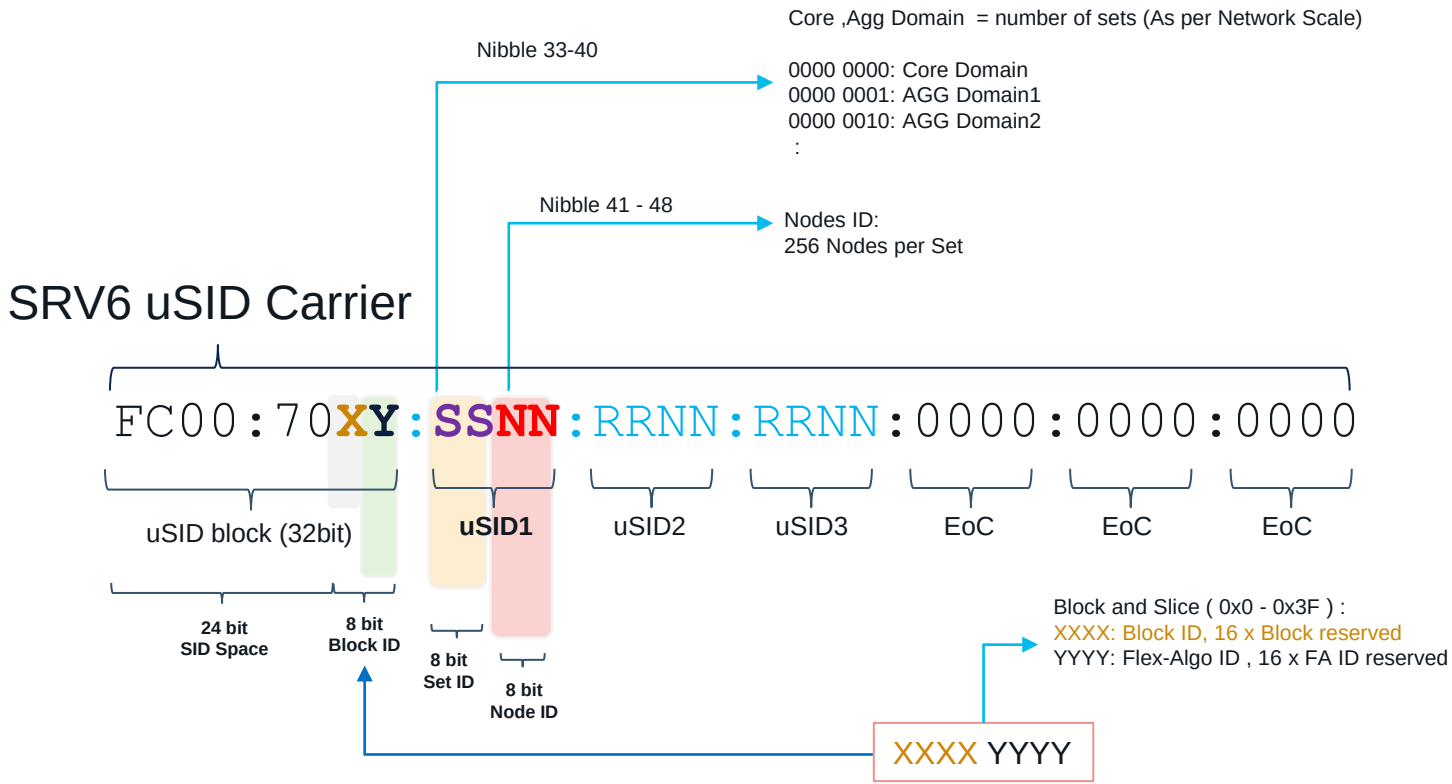


SRv6 Locator Planning

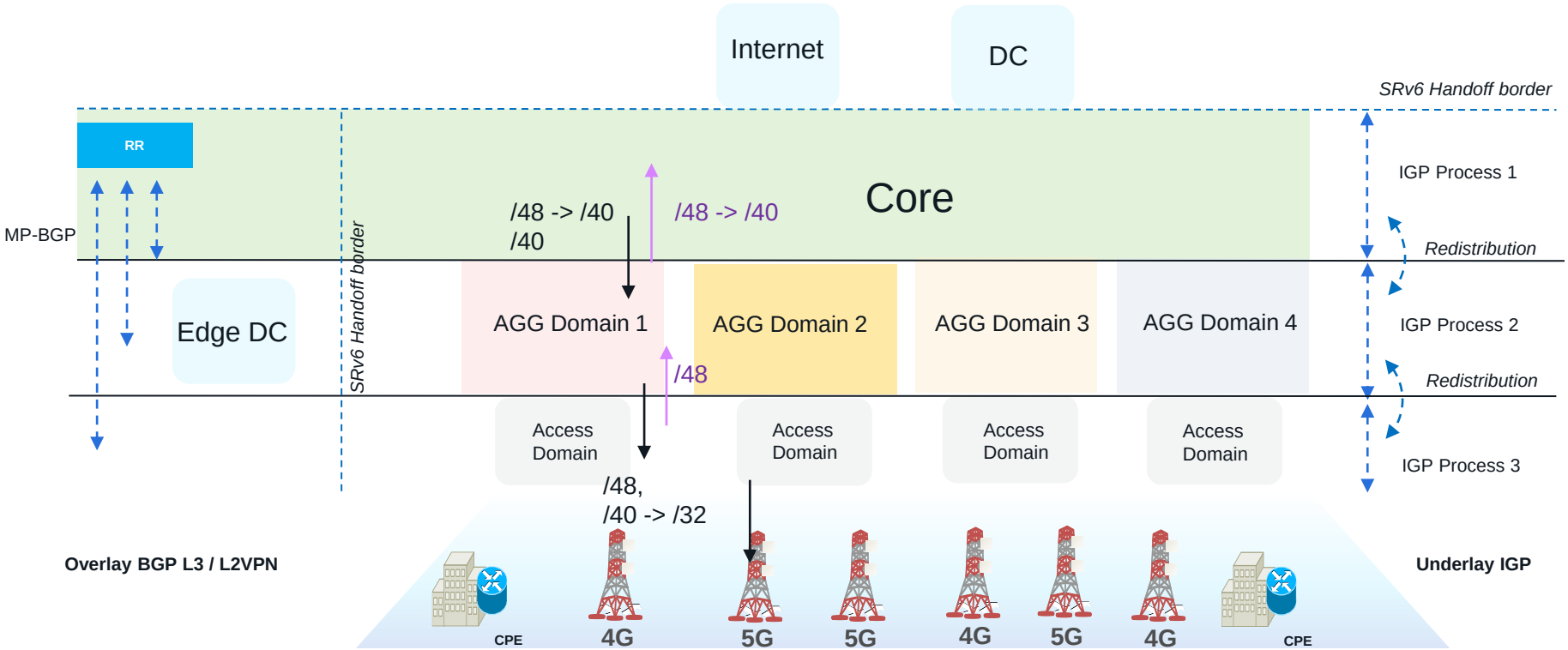


- **SID Space**: The IPv6 address block used to allocate the SID locator. All SID Blocks in the network must come from the same 24-bit SID space
- **Block ID**: Common prefix of a block of uSIDs. Its size depends on the uSID format, which is 8-bits in uSID format
- **Set IDs:** Any group of uSIDs that share a certain value for the first two nibbles of the ID. A 16-bit uSID space contains 256 sets. Each set represents 256 uSID values. A set is uniquely bound to an algorithm
- **Node ID:** Global node SID, Adjacency SID or IP overlay service SID.

SRv6 uSID Planning Example



SRv6 Design



Case Study : MPLS to SRv6

Tier-1 SP : MPLS to SRv6 Transition

Challenge

- Network Scale
- Complex Protocol stack
- Legacy service options

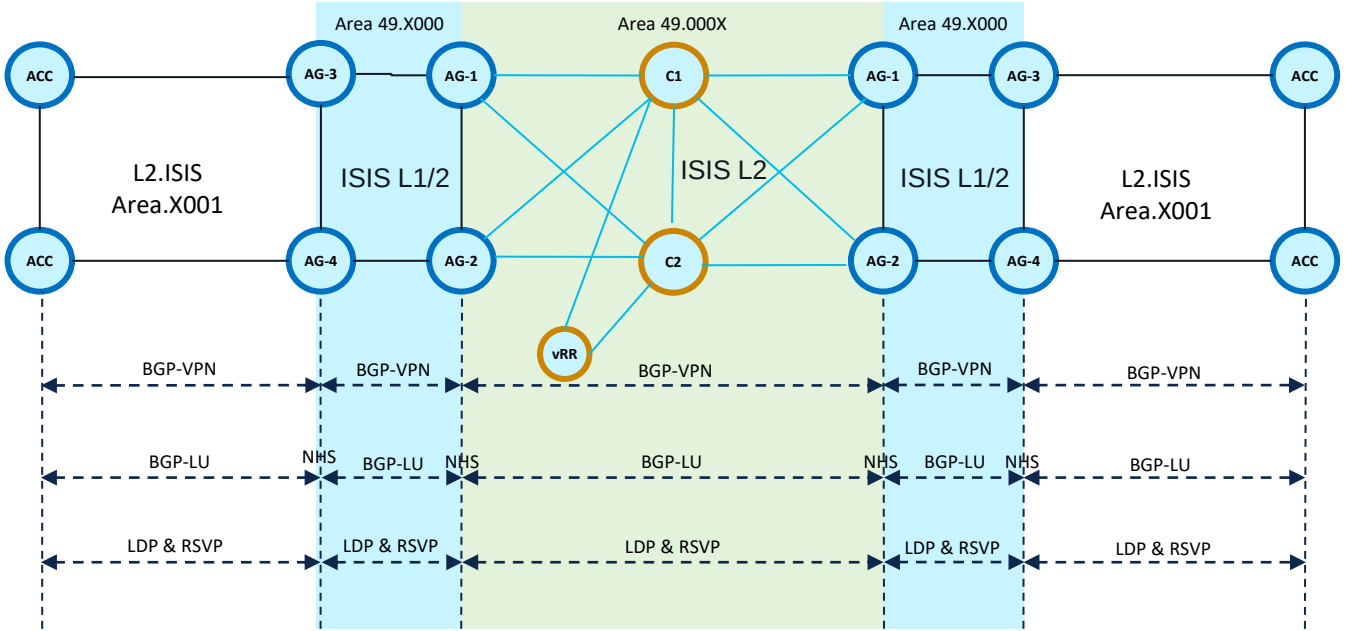
Solution

- SRv6 data plane
- EVPN based overlay service
- MPLS to SRv6 GW function

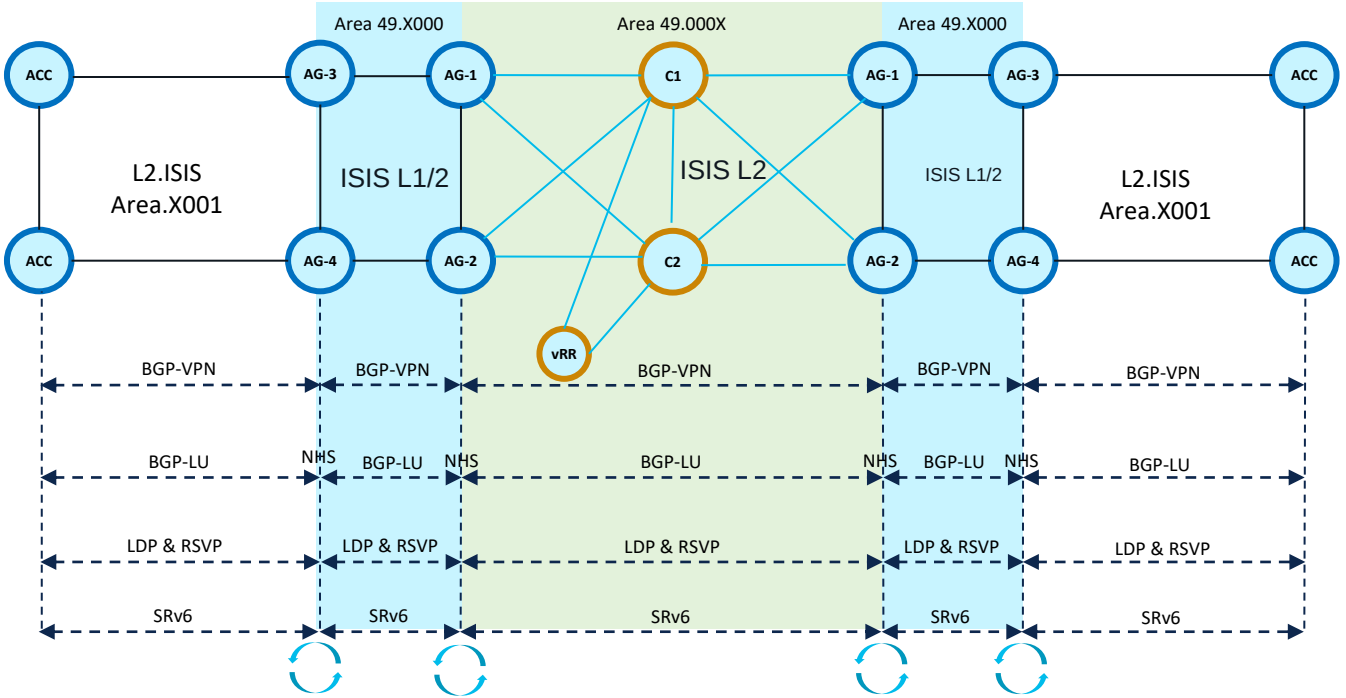
Outcomes

- Simplified protocol stack
- Improved convergence
- Seamless migration

Initial State – MPLS with BGP LU



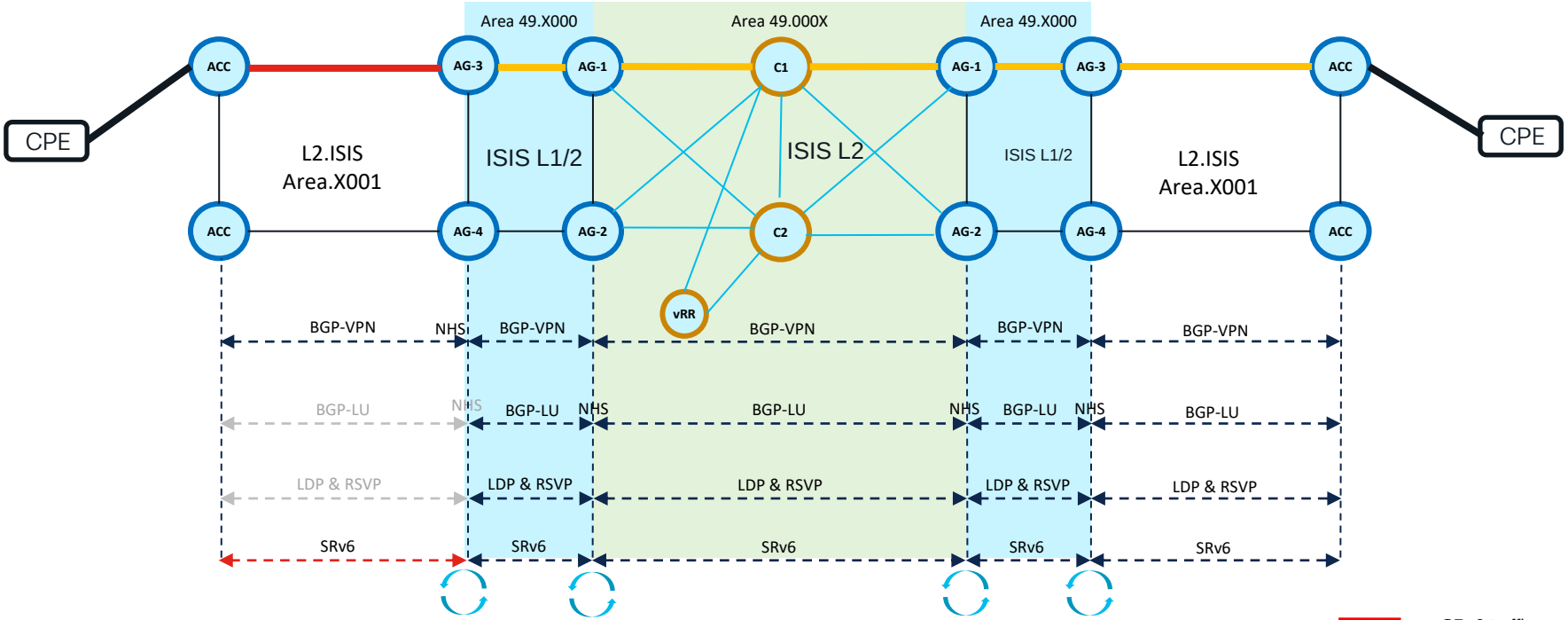
SRv6 parallel Setup with MPLS



- SRv6 with TI-LFA will be configured parallel with existing network
- SRv6 Locator blocks will be redistributed between the domains
- As of now, services will be on MPLS based

SRv6 Locator Redistribution

SRv6 co-exist with MPLS



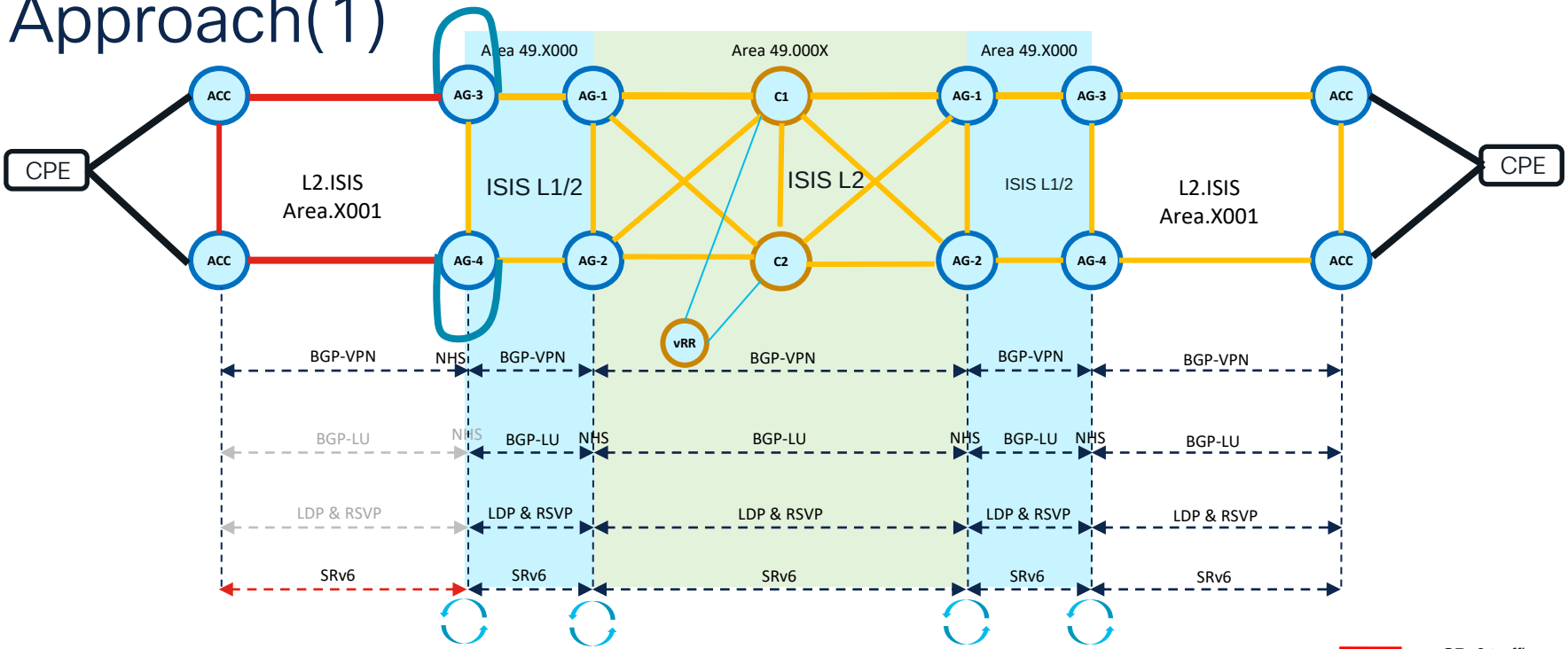
- Migration of services will be customer/VPN based on priority.
- West ring will be running on SRv6 /w TI-LFA , and from AG-1 onwards MPLS/LDP/BGP-LU till east ACC.
- IGP separation will be there in the ring eventually.

SRv6 traffic

MPLS traffic

SRv6 Locator Redistribution

MPLS to SRv6 – Loop Method Approach(1)



- With loop method approach, we will migrate customers from MPLS to SRv6 partially with VRF-to-VRF Inter-AS option A.
- From Left ACC to AG3/4, services will be on SRv6 and from AG3/4 it will run on Legacy MPLS/LDP-RSVP/BGP-LU
- Eventually, few services will be running on SRv6, and few will be running on legacy MPLS

SRv6 traffic

MPLS traffic

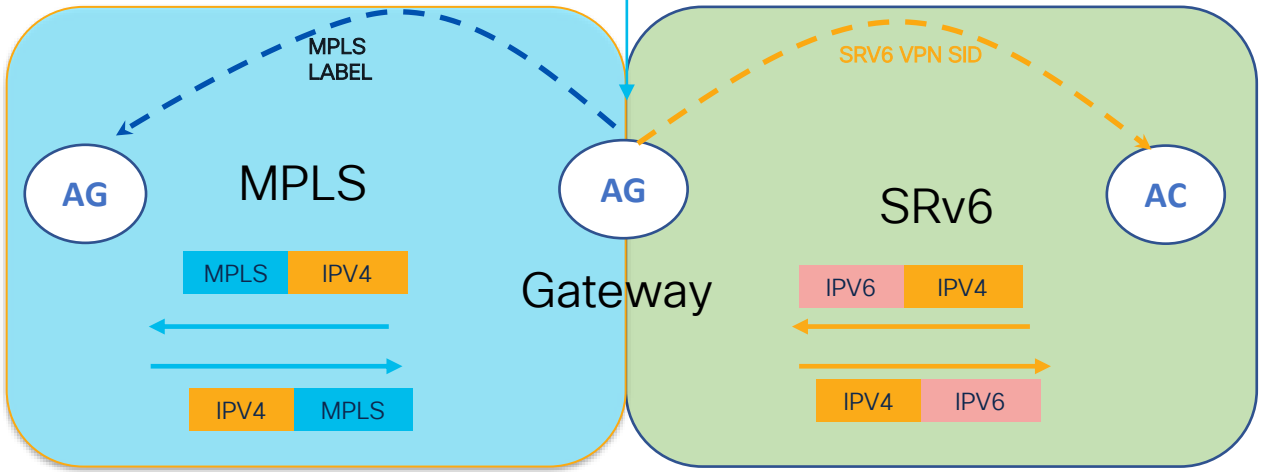
SRv6 Locator Redistribution

How SRv6/MPLS Interworking Gateway Works?

The SRv6/MPLS L3 Service Interworking Gateway provides both transport and service termination at the gateway node.

The gateway generates both SRv6 VPN SIDs and MPLS VPN labels for all prefixes under the VRF configured for re-origination.

SRv6 domain to MPLS domain, the gateway removes the outer IPv6 header, looks up the destination prefix, and pushes the VPN and next-hop MPLS labels.

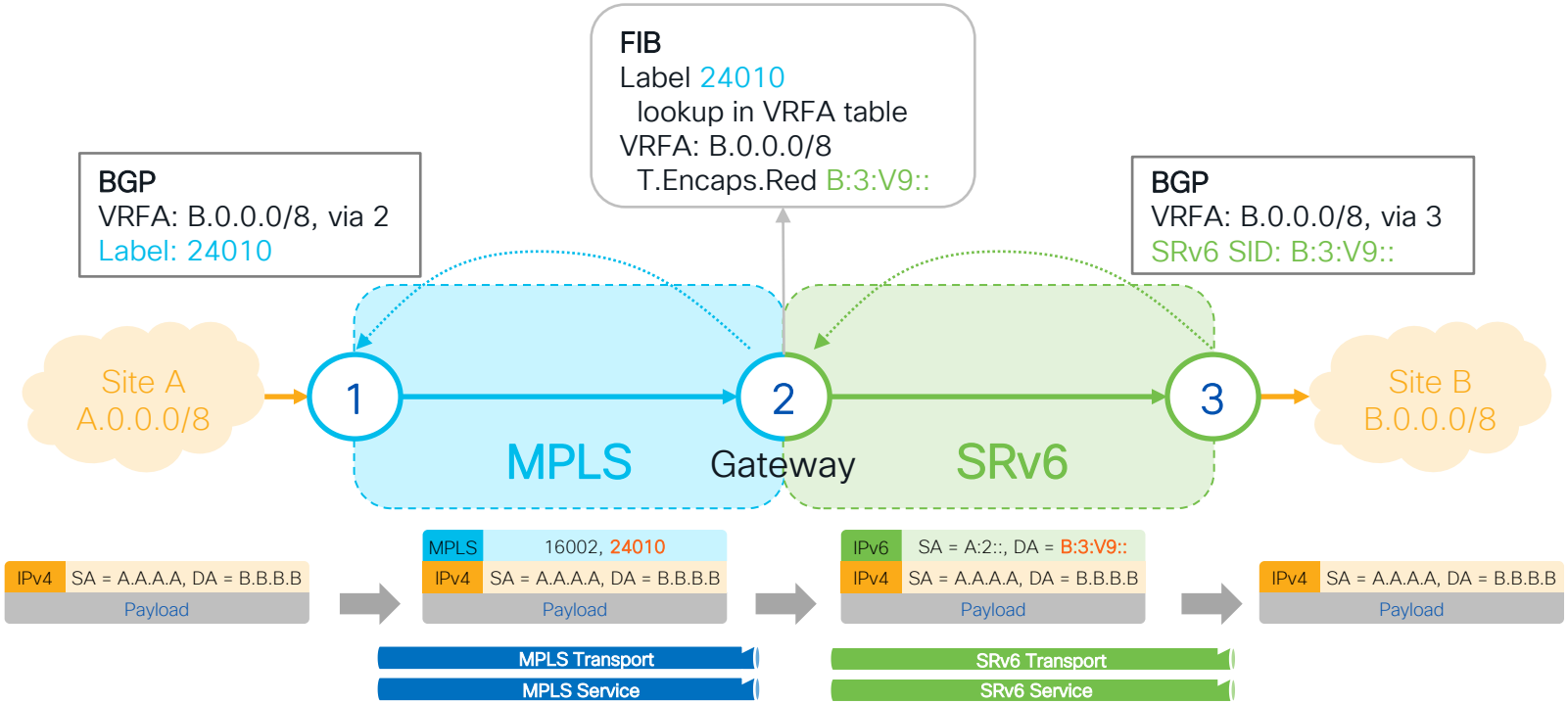


The gateway supports traffic forwarding from MPLS domain to SRv6 domain by popping the MPLS VPN label, looking up the destination prefix, and pushing the appropriate SRv6 encapsulation.

L3VPN service interworking

- Gateway acts as intermediary for interworked L3VPN services
  - GW terminates the L3VPN services
- GW has the VRFs configured that need SRv6/MPLS interworking with 2 sets of RTs
  - MPLS L3VPN RTs
  - SRv6 L3VPN RTs (called “stitching RTs”)
- GW imports service routes received from one domain (MPLS | SRv6)
- GW re-advertises exported service routes to the other domain (next-hop-self)
- GW stitches the service on the data plane (using VRF IP lookup of service route)
- Illustration shows VPNv4 example – also applies to VPNv6

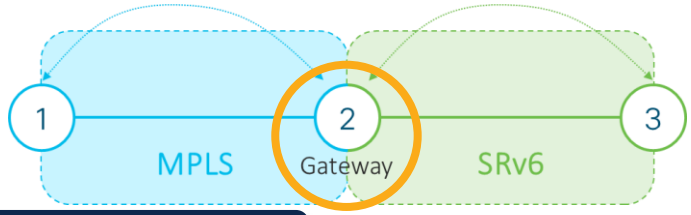
MPLS to SRv6 Interworking (Gateway)



Key Points:

- The L3 service SRv6/MPLS gateway enables customers to extend their L3 services between MPLS and SRv6 domains by providing service continuity on the control plane and data plane
- Gateway acts as intermediary for L3 services on control plane and data plane

SRv6/MPLS L3 Service Interworking Gateway




```
vrf ACME
 address-family ipv4 unicast
  import route-target
   1:1            ; MPLS
   2:2 stitching  ; SRv6
  !
  export route-target
   1:1            ; MPLS
   2:2 stitching  ; SRv6
```

Stitch MPLS domain RTs to SRv6 domain (“stitching”) RTs (note: MPLS RTs can also be stitching with SRv6 RTs non-stitching)

```
router bgp 100
 segment-routing srv6
  locator LOC1
 !
 neighbor 1.1.1.1
  address-family vpnv4 unicast
   import re-originate stitching-rt
   route-reflector-client
   advertise vpnv4 unicast re-originated
 !
 neighbor b:3::1
  address-family vpnv4 unicast
   import stitching-rt re-originate
   route-reflector-client
   encapsulation-type srv6
   advertise vpnv4 unicast re-originated stitching-
rt
 !
 vrf ACME
  address-family ipv4 unicast
   mpls alloc enable
   segment-routing srv6
```

MPLS VPN peer or RR

Import “MPLS” RT and re-originate with “SRv6” “stitching” RT

Advertise with “MPLS” RT

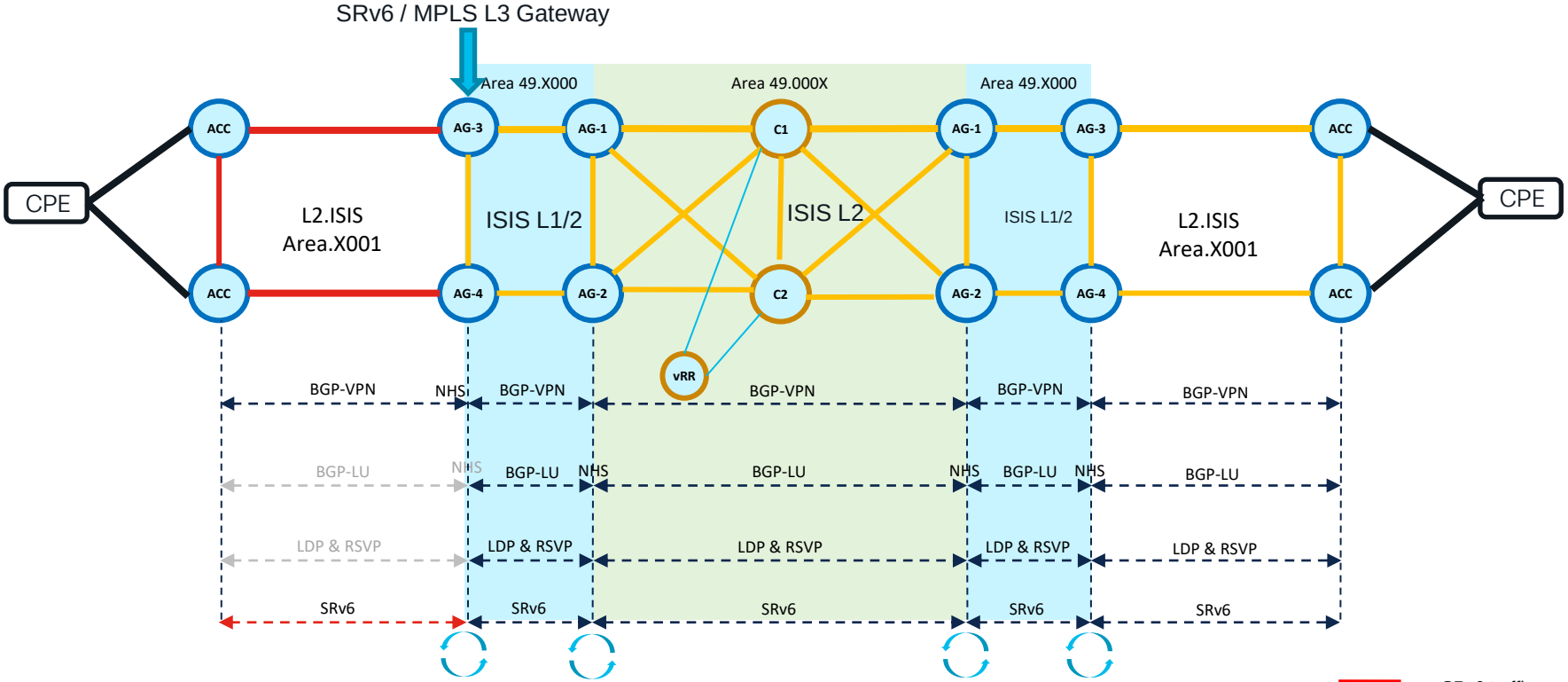
Import “SRv6” “stitching” RT and re-originate with “MPLS” RT

send the SRv6 SID to the neighbor

Allocate VPN label and SRv6 SID

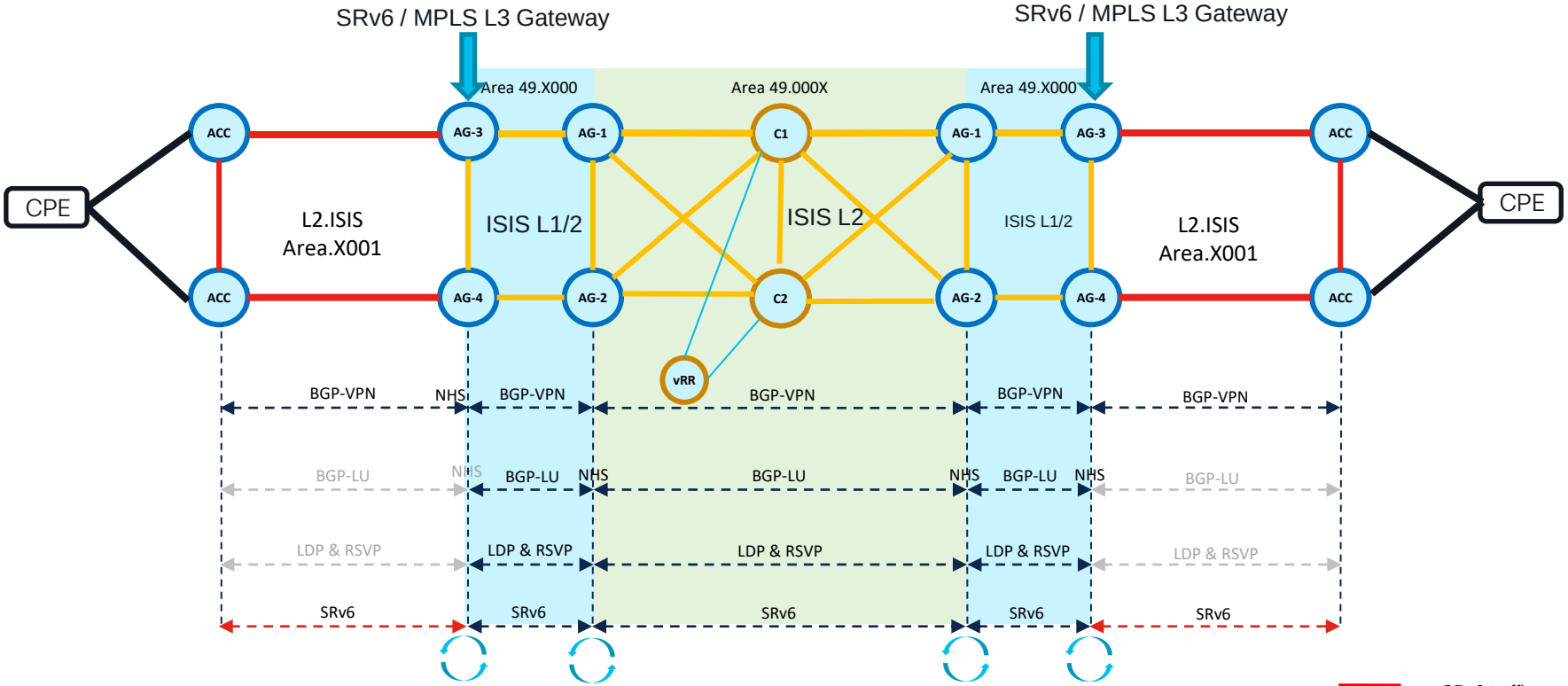
Advertise with “SRv6” “stitching” RT

MPLS to SRv6 – SRv6 Gateway Function



- In SRv6 gateway, L3VPN services are supported.
- Left ring will be running on SRv6 with TI-LFA and from Gateway, it will take legacy MPLS
- Few services will be running on SRv6, and L2VPN will be running on legacy MPLS
- *SRv6/MPLS L3 Service Interworking Gateway provides both transport and service termination at the gateway node*

SRv6 co-exist with MPLS



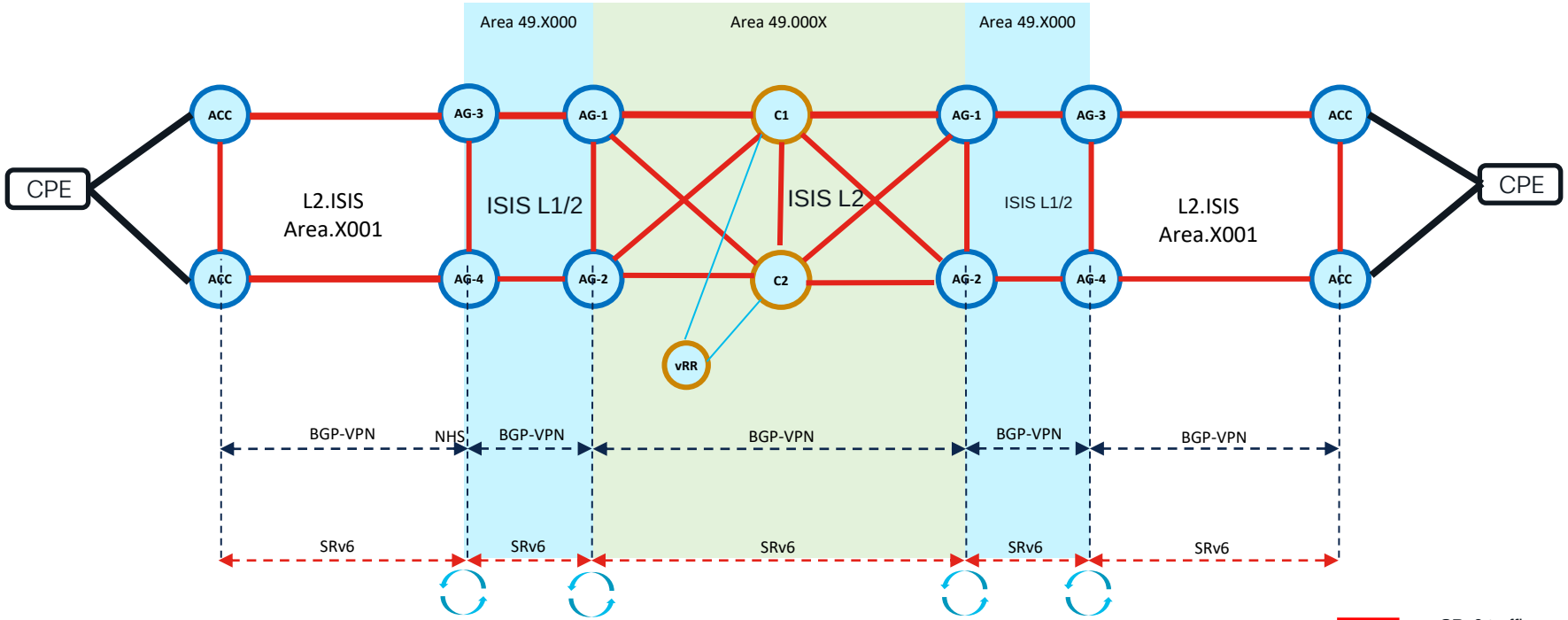
- When running half services on SRv6 and rest services on MPLS, is known as Dual stack
- The East & the West ring will be running on SRv6 and from AG, while the AG & Core will continue with MPLS/LDP/BGP-LU.
- There will not be any impact on the services with this dual stack approach

SRv6 traffic

MPLS traffic

SRv6 Locator Redistribution

Target Architecture



- All the services will move to SRv6 with TI-LFA
- SRv6 summary prefix will be exchanged.
- Removal of LDP,RSVP, MPLS, BGP-LU at later stage

SRv6 traffic

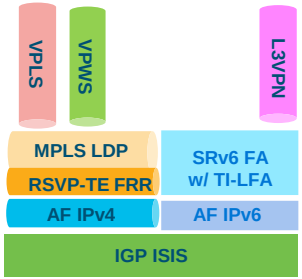
MPLS traffic

SRv6 Locator Redistribution

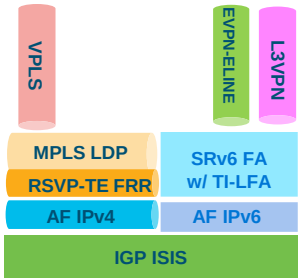
SRv6 Services Transition

- 3 Steps services transition to SRv6

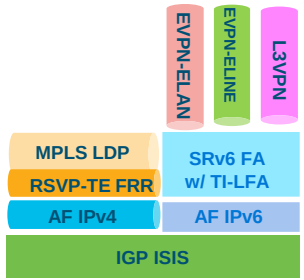
  - L3VPN (VPNv4 & VPNv6)
  - L2VPN VPWS to EVPN ELINE
  - L2VPN VPLS to EVPN ELAN



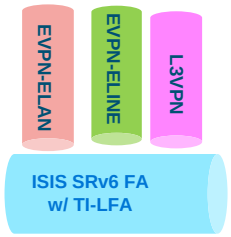
Step 1



Step 2



Step 3

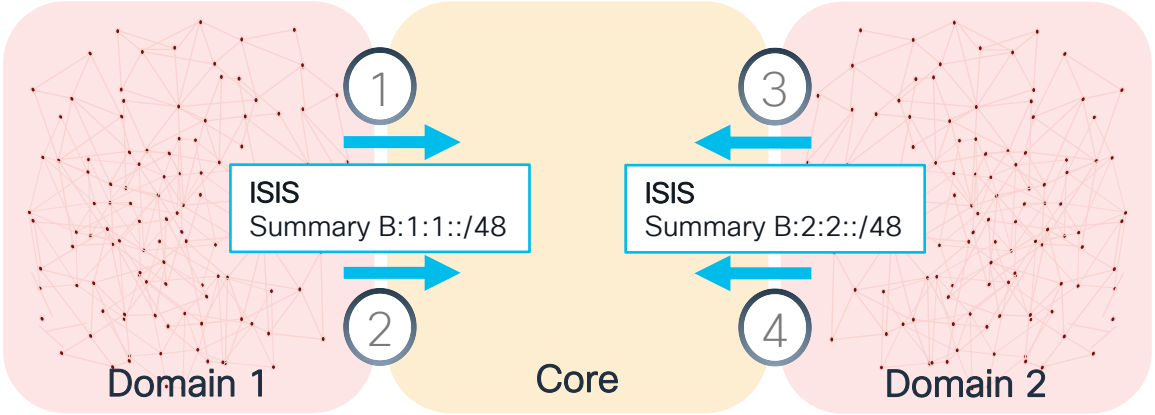


Target State

SRv6 Design Best Practices

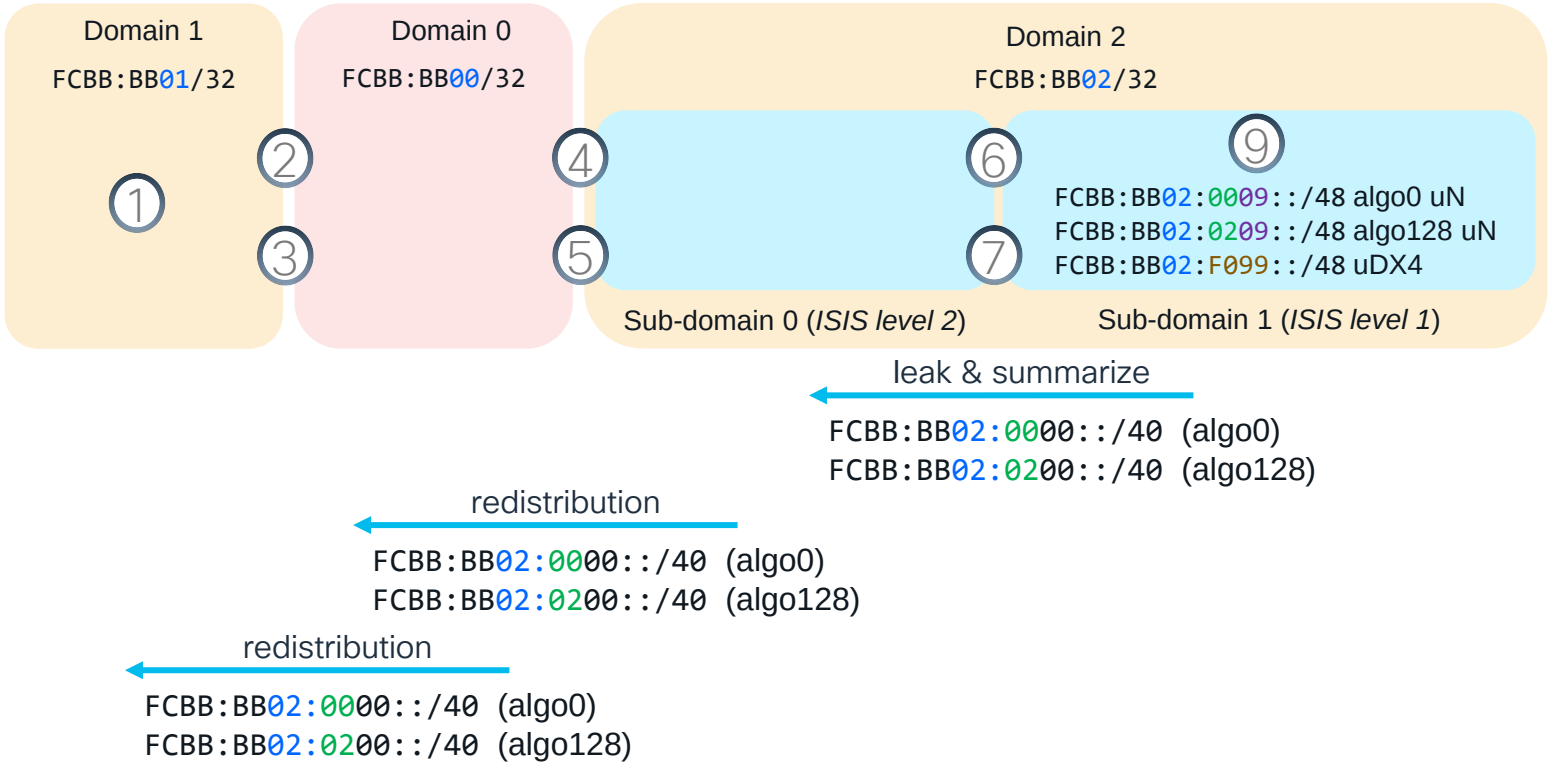
cisco Live!

Best Practise#1 : Prefix Summarization



- Back to basic IP routing and summarization
- No BGP inter-AS Option A/B/C

Multi-domain Summerization with FlexAlog



Best Practise#2 : Loopback from uSID Locator

- Allocate a loopback address within the uSID locator prefix
  - E.g. uSID locator BBBB:BB00:0001/48
    → loopback address can be BBBB:BB00:0001::L/128 with L=1..F
- ISIS advertises locator (locator + prefix for algo 0)
- Loopback under locator can be reachable via locator prefix, does not have to be separately advertised as /128 prefix

Key Takeaways

SRv6 Advantages for Converged SDN Transport

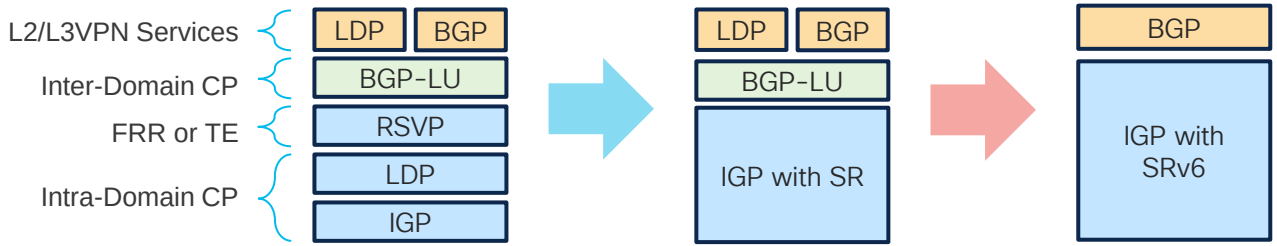
Flexibility

- Any service (L3VPN,ELINE & ELAN) over SRv6 data plane
- Seamless Migration from IPv6 GRT or MPLS to SRv6

Network Efficiency

- Hyper scale with network summarization
- Simplified protocol stack

Network Simplicity



Technical Session Surveys

- Attendees who fill out a minimum of four session surveys and the overall event survey will get Cisco Live branded socks!
- Attendees will also earn 100 points in the Cisco Live Game for every survey completed.
- These points help you get on the leaderboard and increase your chances of winning daily and grand prizes.

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

Here at the event? Visit us at **The Learning and Certifications lounge at the World of Solutions**

Continue your education

- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer 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 Live!

Thank you


cisco Live!
ALL IN