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The bridge to possible

SRv6 for Next-Generation Transport Networks

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BRKMPL-2205

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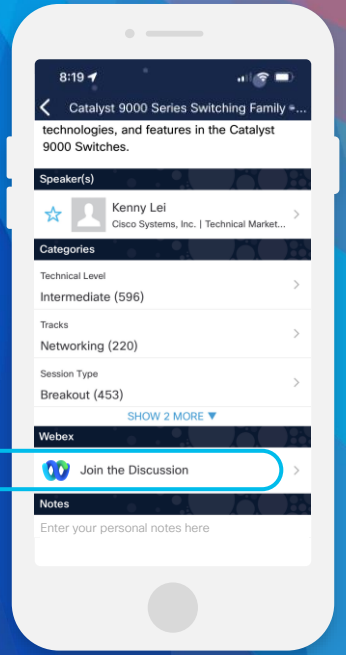

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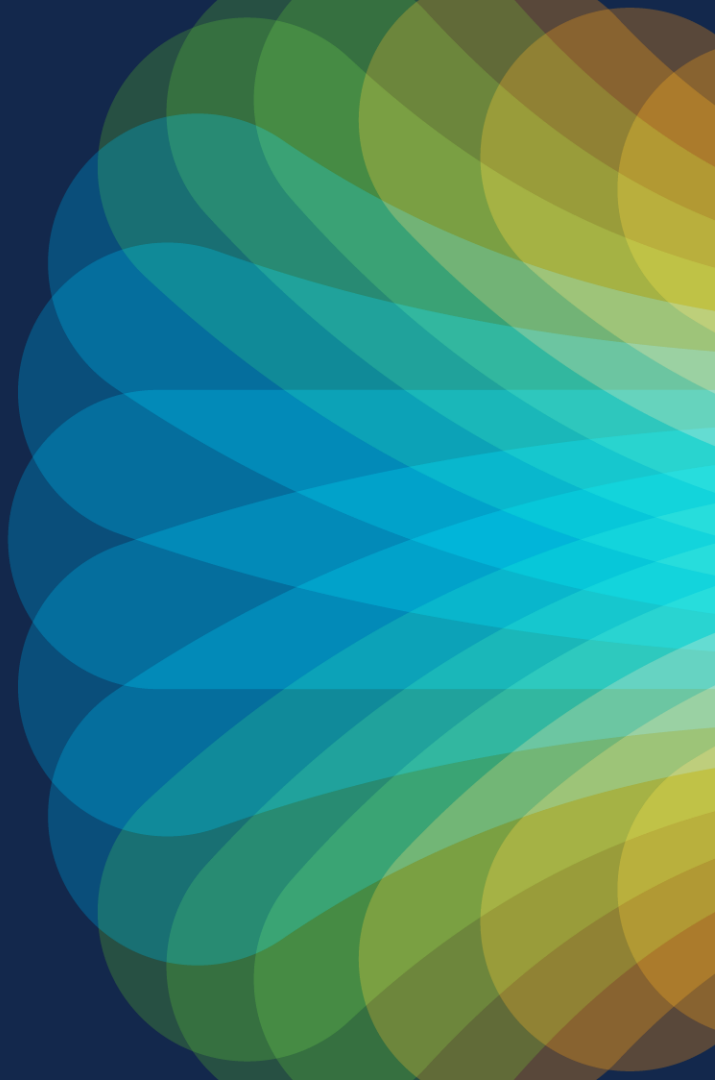
It’s time to put MPLS in the rear-view mirror!

Agenda

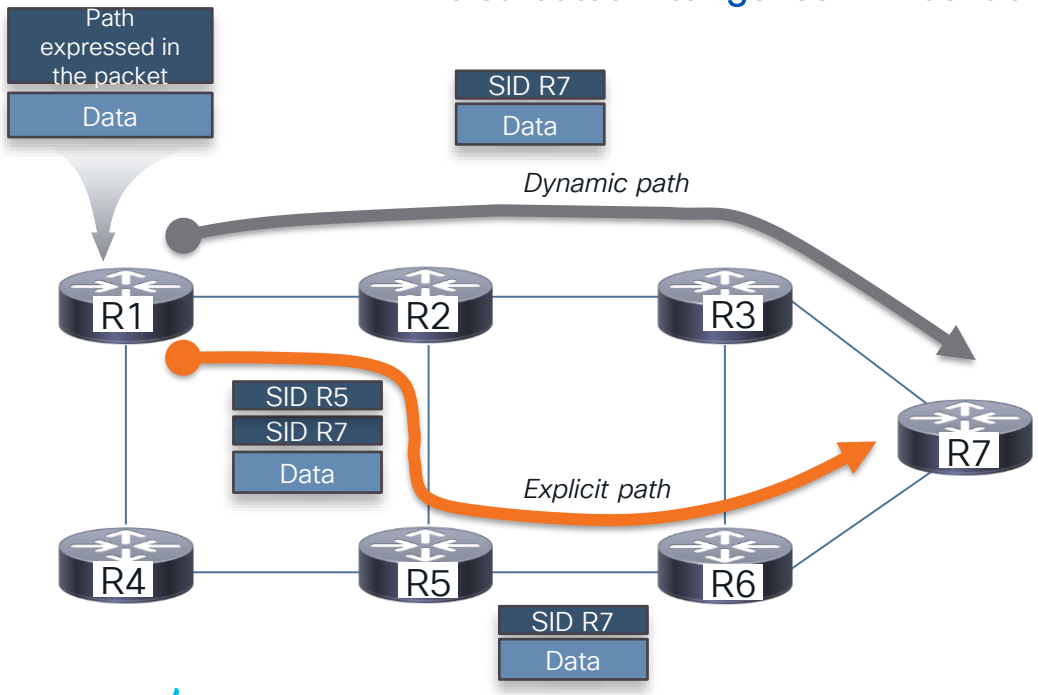
- Introduction
- Comparing MPLS and SRv6 (plus SRv6 101)
- SRv6 Architecture Advantages
- SRv6 Test-Cases
- Cisco Platform Support for SRv6
- Conclusion

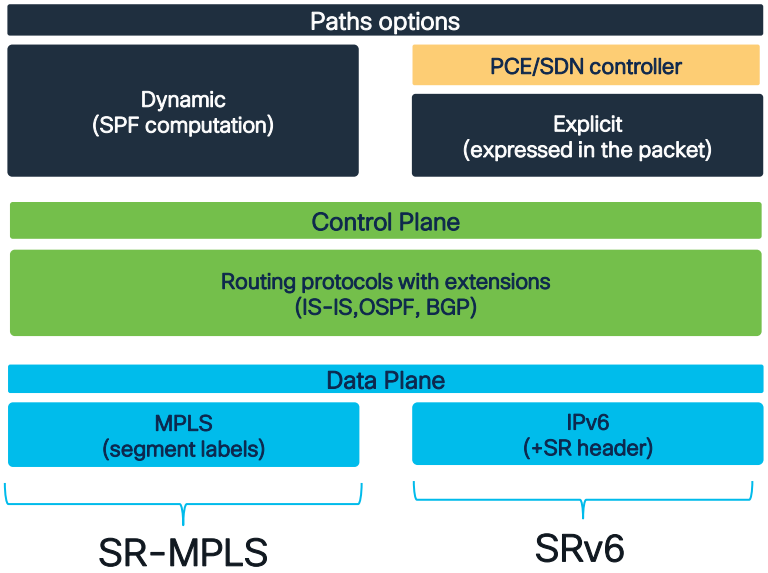
Introduction



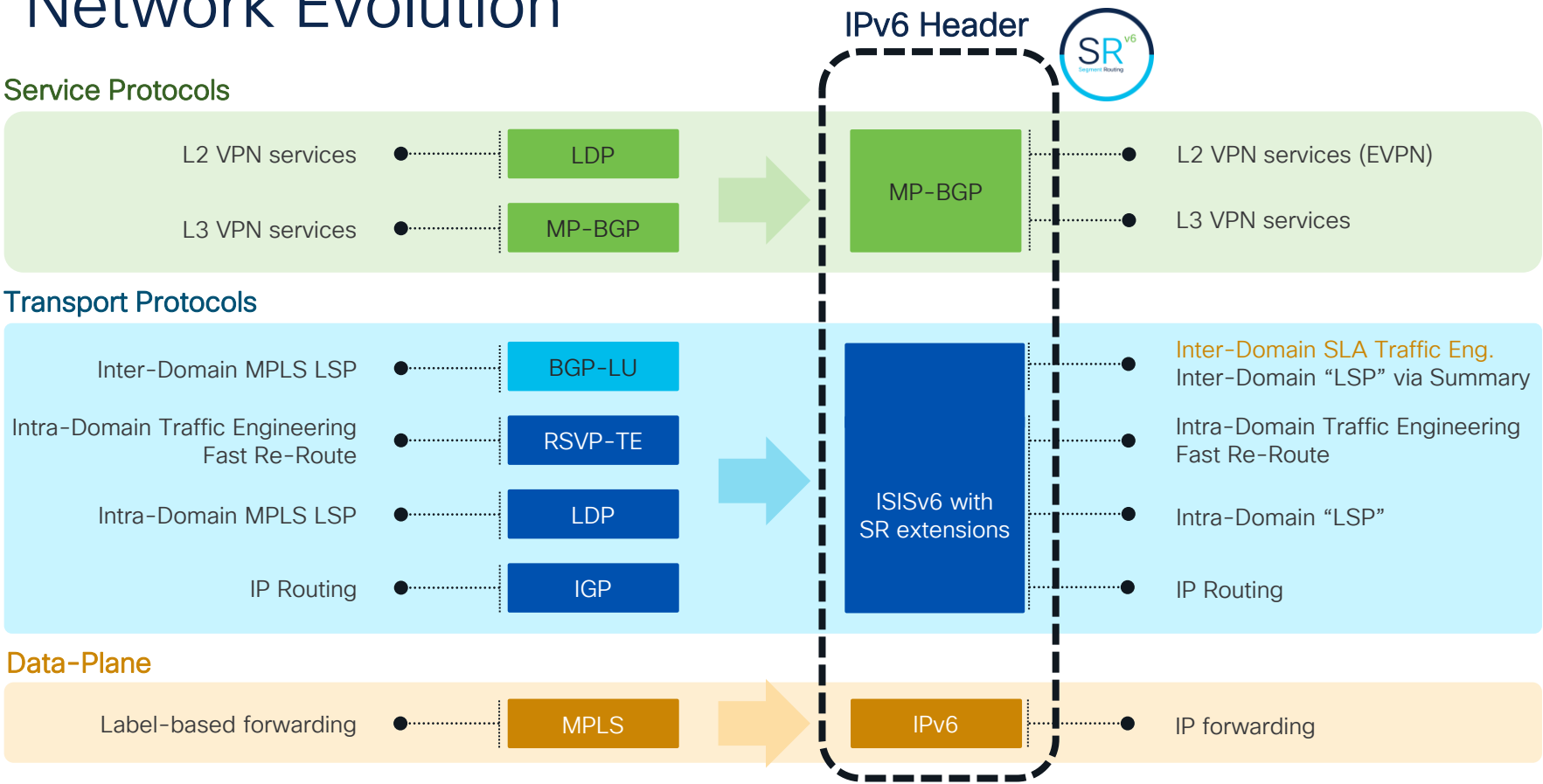
Segment Routing 101

An **IP** source-routing architecture that seeks the **right balance** between **distributed intelligence** and **centralized optimization**





Network Evolution



LDP: Label Distribution Protocol, **MP-BGP**: Multi-protocol BGP, **BGP-LU**: BGP Labeled-Unicast, **RSVP-TE**: Reservation Protocol Traffic Engineering

Rich SRv6 uSID Ecosystem

Network Equipment Manufacturers

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

Merchant Silicon

Broadcom, Marvell, Barefoot Networks (Intel)

SR v6
Segment Routing

Open-Source Networking Stacks

Linux, fd.io, P4, OPEN Compute Project, Kubernetes, SONiC, FRRouting

Smart NIC

Intel, Mellanox Technologies

Open-Source Applications

Pyroute2, IPTABLES SERA, GoBGP, exaBGP, eBPF, cilium, TCPDUMP, WIRESHARK, SNORT, GoBMP

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Partners

kaloom, TREND MICRO, ENEA Qosmos Division, NoviFlow, ixia A Keysight Business, Spirent Promise. Assured

SRv6 Mature Standardization

Record-speed standardization
Strong sign of industry endorsement

- Proposed Standard RFCs
  - RFC8402 SR Architecture
  - RFC8754 SRv6 Data Plane
  - RFC8986 SRv6 Network Programming
  - RFC9352 SRv6 ISIS Extensions
  - RFC9350 IGP Flexible Algorithms
  - RFC9252 SRv6 BGP Extensions
  - RFC9256 SR Policy Architecture
  - RFC9259 SRv6 OAM
- WG Document: Proposed Standard
  - WG draft Compressed SRv6 Segment List encoding in SRH
  - WG draft SRv6 BGP Link State Extensions

RFC 8986 — *SRv6 Network Programming*

RFC 8754 — *IPv6 Segment Routing Header*

Strong Cisco Commitment to IETF

Editor of	96% IETF RFCs
Co-author of	100% IETF RFCs
Editor of	77% IETF WG Drafts
Co-author of	84% IETF WG Drafts

Over 70 RFCs/ Drafts spanning 13 working groups

EANTC 2023

- Published on April 18th at MPLS-WC
- Industry endorsement of uSID solution
  - L3VPN over uSID
  - SRv6 OAM over uSID
  - BGP GRT with uSID
  - EVPN VPWS (Multihoming), ELAN, RT5
  - SRv6 Locator (and FA) summarization with uSID
  - SR TE Policy with uSID
- Arista, Arrcus, Huawei, Juniper, Nokia

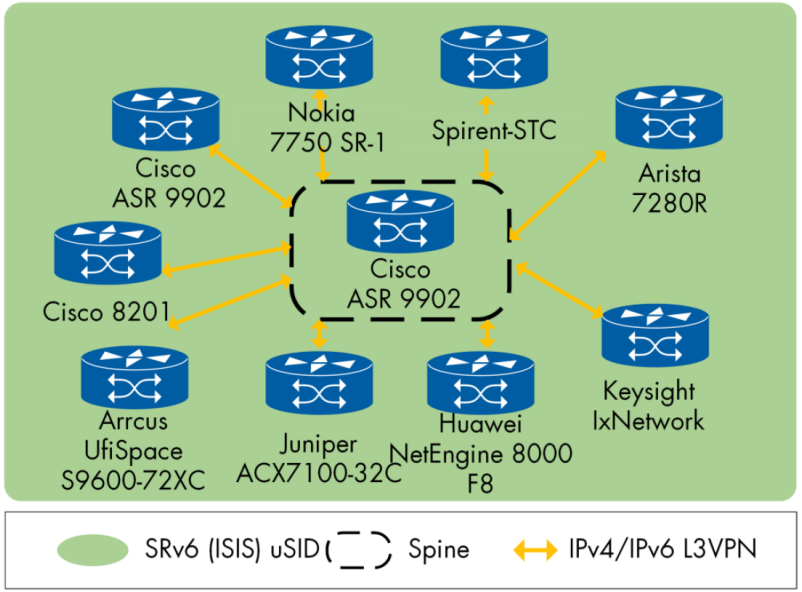


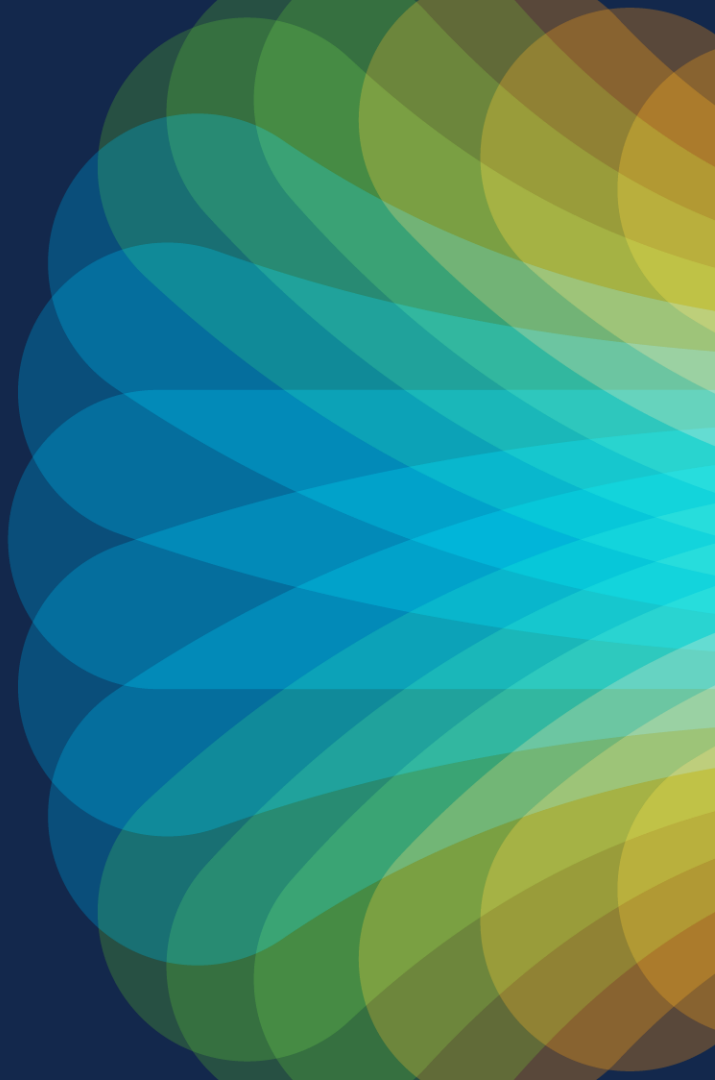
Figure 36: L3VPN over SRv6 (µSID)

These devices participated successfully as:

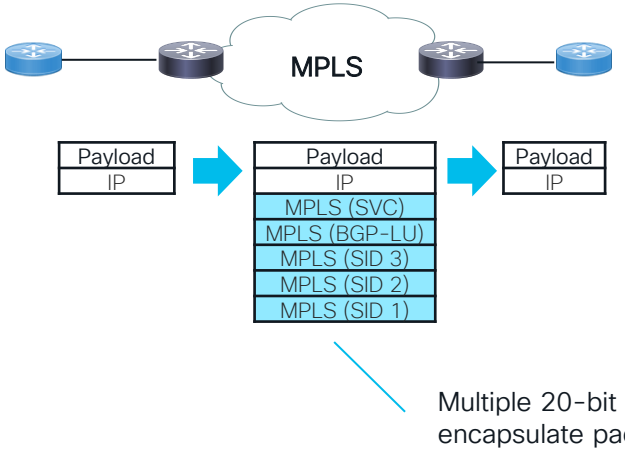
PE: Arista 7280R, Arrcus UfiSpace S9600, Cisco 8201, Cisco ASR 9902, Huawei NetEngine 8000 F8, Juniper ACX7100-32C, Keysight IxNetwork, Nokia 7750 SR-1, Spirent-STC

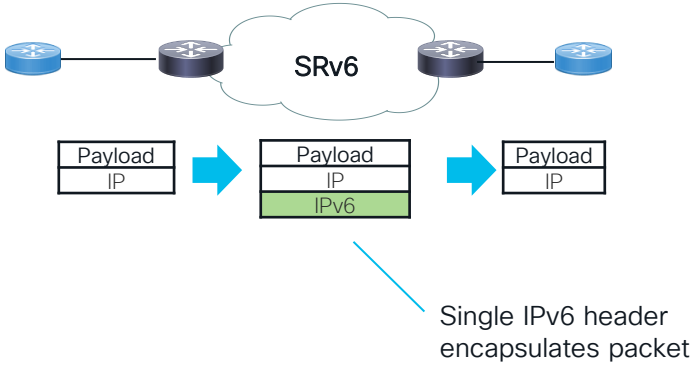
Whitepaper: https://eantc.de/de/showcases/2023/mpls_sdn_interop.html

Comparing MPLS and SRv6 (plus SRv6 101)



Comparing (SR-)MPLS and SRv6



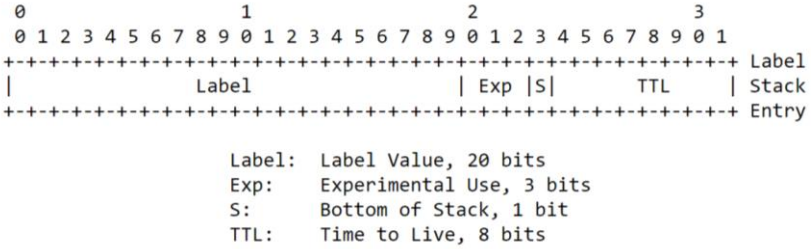


- MPLS provides a transport service by applying one or more labels to a service packet
- Segment lists require one label per segment
- MPLS requires 1:1 label to /32 prefix

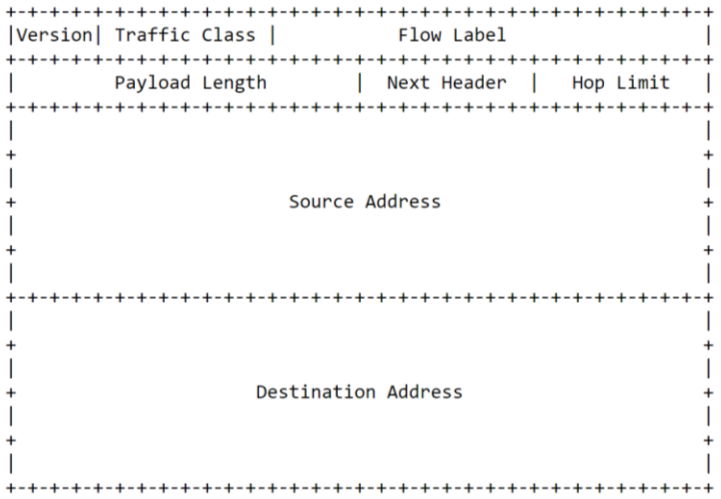
- SRv6 provides a transport service by encapsulating the packet with IPv6
- Segment lists are encoded as uSID in the IPv6 header
- SRv6 enables summarization (huge benefit!)

Comparing MPLS and IPv6 Headers

MPLS Label Format (RFC 3032)



IPv6 Header (RFC 2460)



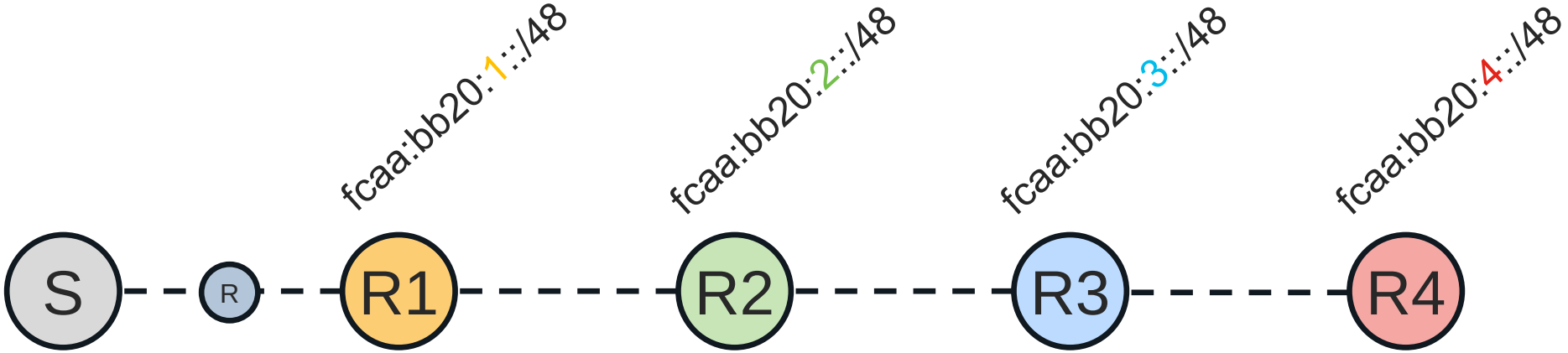
MPLS vs IPv6 Headers

Function	MPLS	IPv6
Path/Service encoding	20-bit Label	128-bit DA
Flow Identification	FAT/Entropy Label(s)	20-bit Flow Label
QoS Identification	3-bit EXP	8-bit Traffic Class
Loop prevention	8-bit TTL	8-bit Hop Limit

IPv6 Addressing Review

- Representation of prefix is similar to IPv4, except length is 128 bits vs 32 bits
  - v4 address:
    - 198.10.0.0/16
  - v6 address:
    - 2001:db8:12::/48
- Leading zeros in contiguous block could be represented by (::)
  - 2001:0db8:0000:130F:0000:0000:087C:140B → 2001:0db8:0:130F::87C:140B
- Double colon only appears once in the address
- Only leading zeros are omitted. Trailing zeros are not omitted
  - 2001:0db8:0012::/48 = 2001:db8:12::/48
  - 2001:db8:1200::/48 ≠ 2001:db8:12::/48

SRv6 Addressing (F3216)Overview



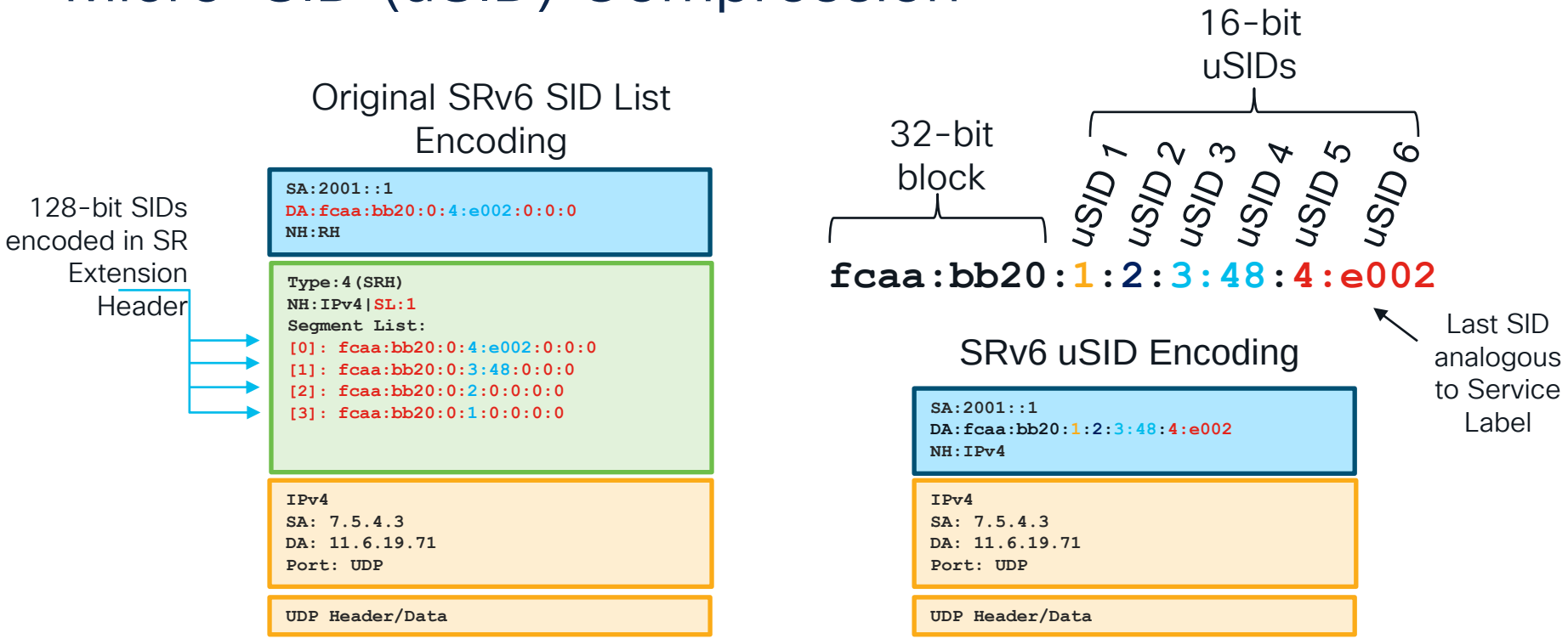
48-bit Locator Format

fcaa:bb20:0001::/48

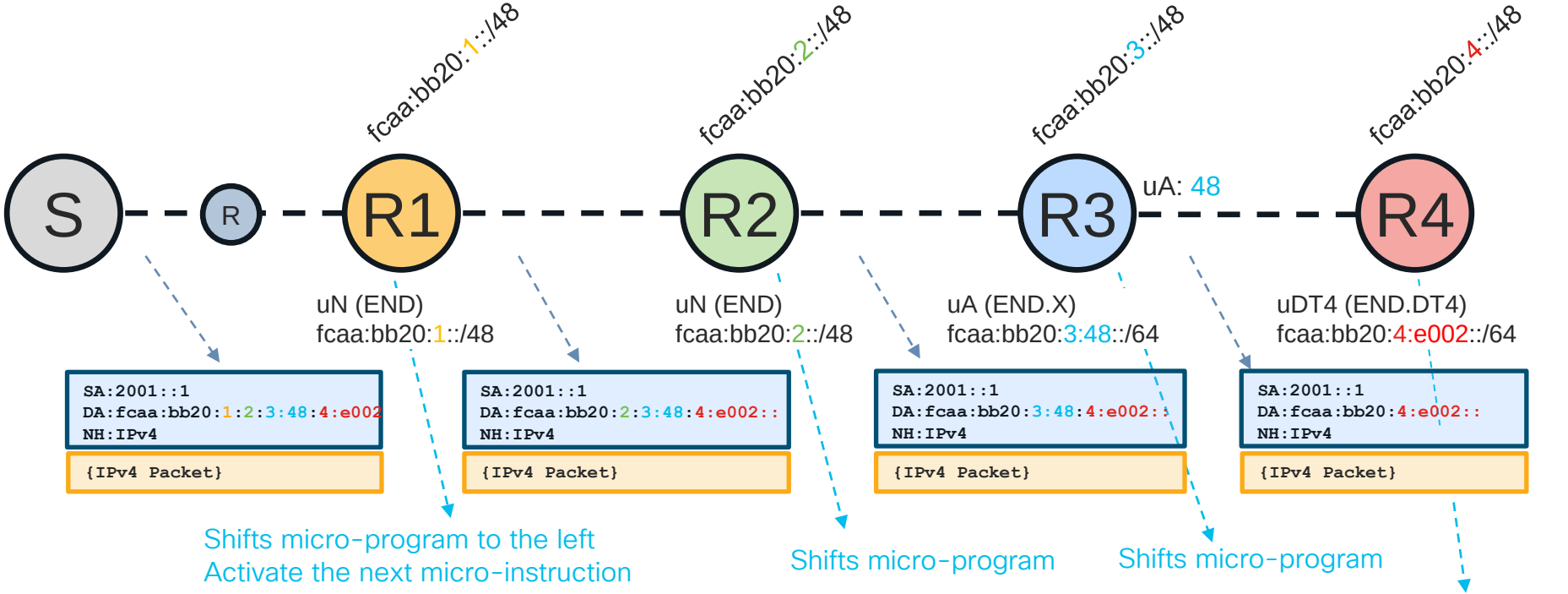
32-bit block 16-bit Identifier

- Each node is assigned a 48-bit (/48) “locator”
  - /16 and /48 are also possible
  - Analogous to the v4 Loopback address used in SR-MPLS
- The first 32 bits (/32) will be common among all nodes in the same ISIS topology
- The next 16 bits are unique per node
- Recommended to use IPv6 Unique Local Address (FC00::/7)

SRv6 Segment List Encoding and Micro-SID (uSID) Compression



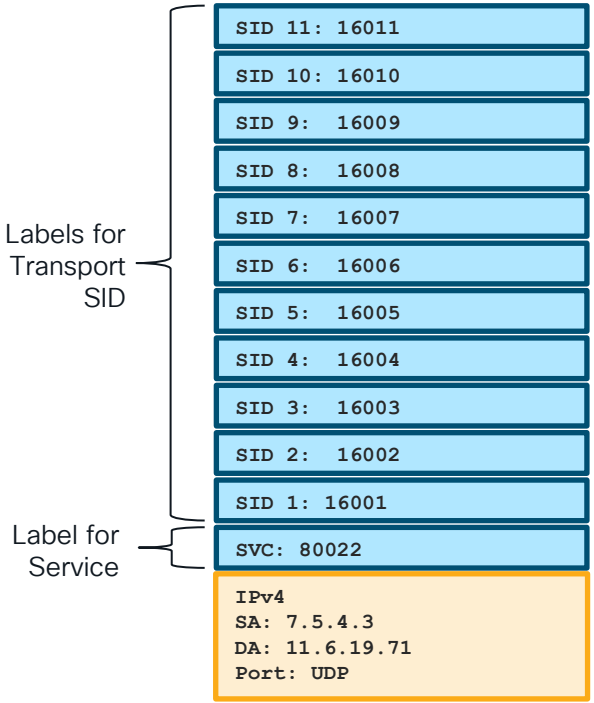
SRv6 uSID Example



- ➔ Matches local SID fcaa:bb20:1::/48
- ➔ Applies "Next" Behavior
- ➔ DA becomes fcaa:bb20:2:3:48:4:e002::

Comparing SRv6 and MPLS SID Imposition

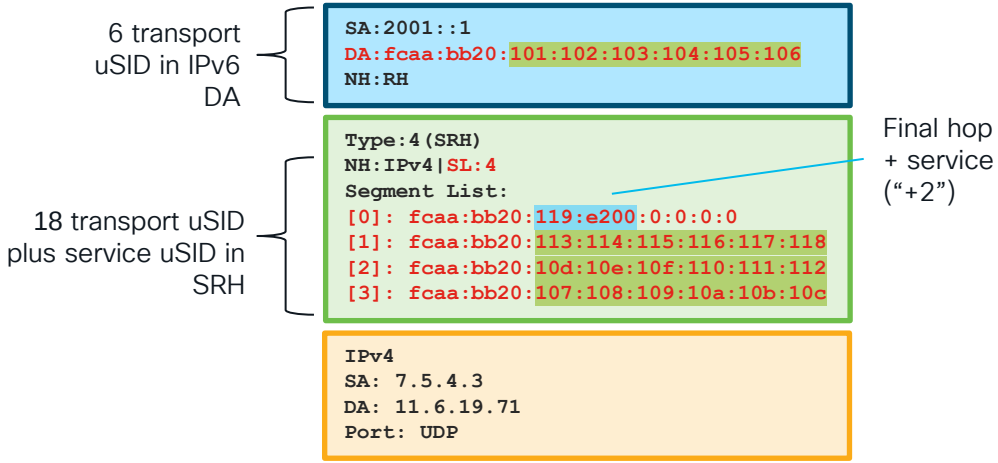
Example MPLS Label Stack with 11 SID Labels + 1 Service Label



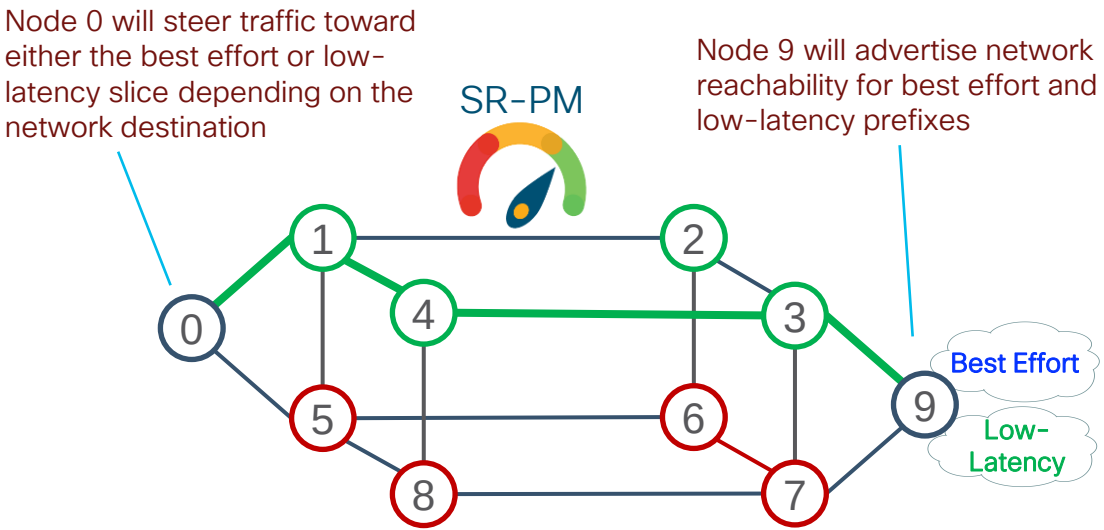
	BRCM Q/J/J+	BRCM Q2/J2	ASR 9k LSP	Cisco 8k Q200
Maximum MPLS Label Imposition	3+3 (9+3)	12	10	8
Maximum SRv6 uSID (Headend Tx)	3+3 (6+3)	24+3	12+3	6+3 (17+3)

Line Rate (With Recirculation)

Example SRv6 with 24+2 uSID



Segment Routing Flexible Algorithm ("Flex Algo") with SR Performance Monitoring

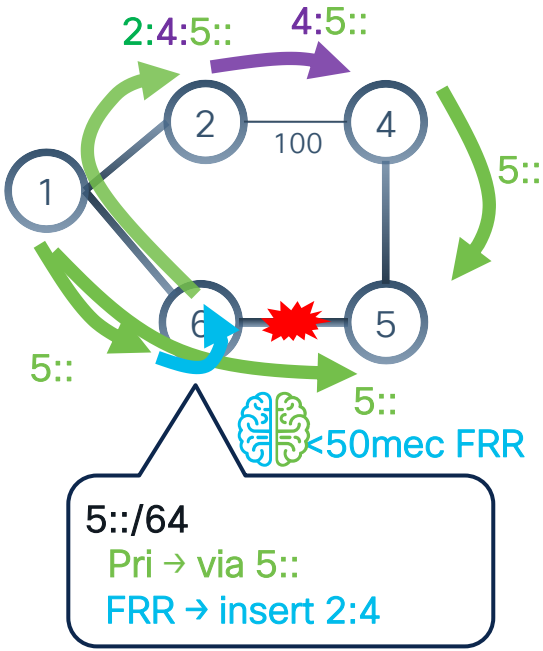


- Leverages IOS-XR initial SR-MPLS Flex Algo implementation
- Now fully supported for SRv6

- SR Performance Monitoring – All nodes actively measure latency (using TWAMP-Lite probes) and report via ISIS link-state updates
- Flexible Algorithm - a numeric identifier in the range 128-255 that is associated via configuration with the Flexible-Algorithm Definition.
  - All nodes have Shortest Path First (SPF) Algo 0 by default
- Low-Latency Flex Algo is defined in order to steer prioritized traffic along lowest latency path

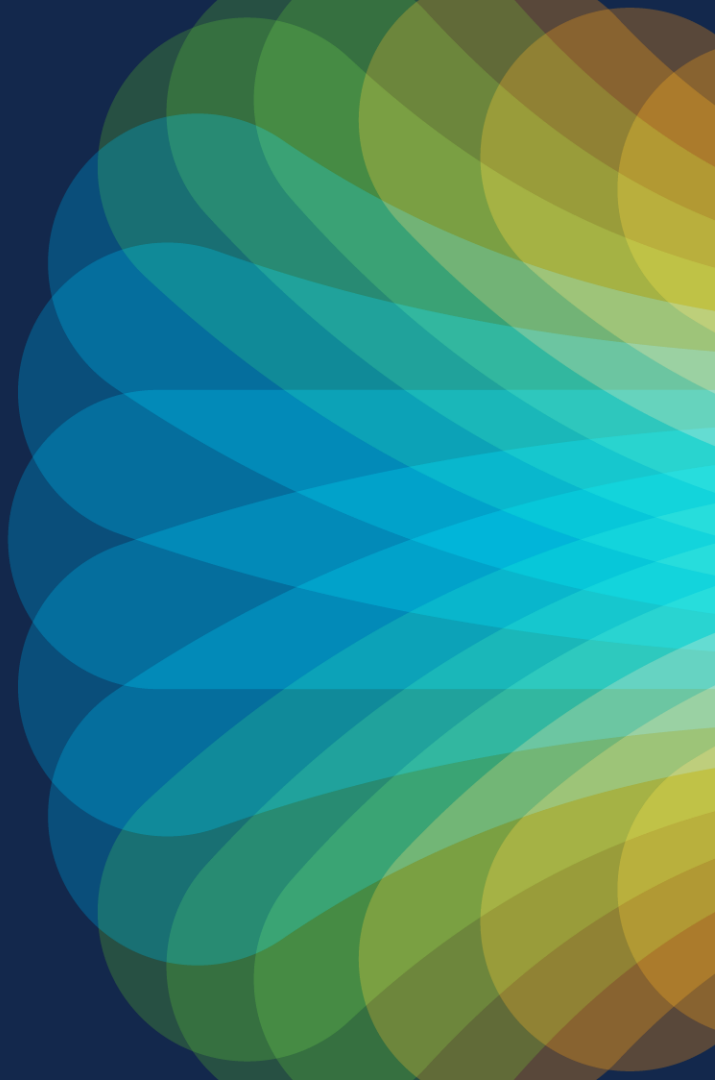
TI-LFA for SRv6

- 50msec Protection upon local link, node or SRLG failure
- Simple to operate and understand
  - automatically computed by the router's IGP process
  - 100% coverage across any topology
  - predictable (backup = postconvergence)
- Optimum backup path
  - leverages the post-convergence path, planned to carry the traffic
  - avoid any intermediate flap via alternate path
- Incremental deployment
- Distributed and Automated Intelligence

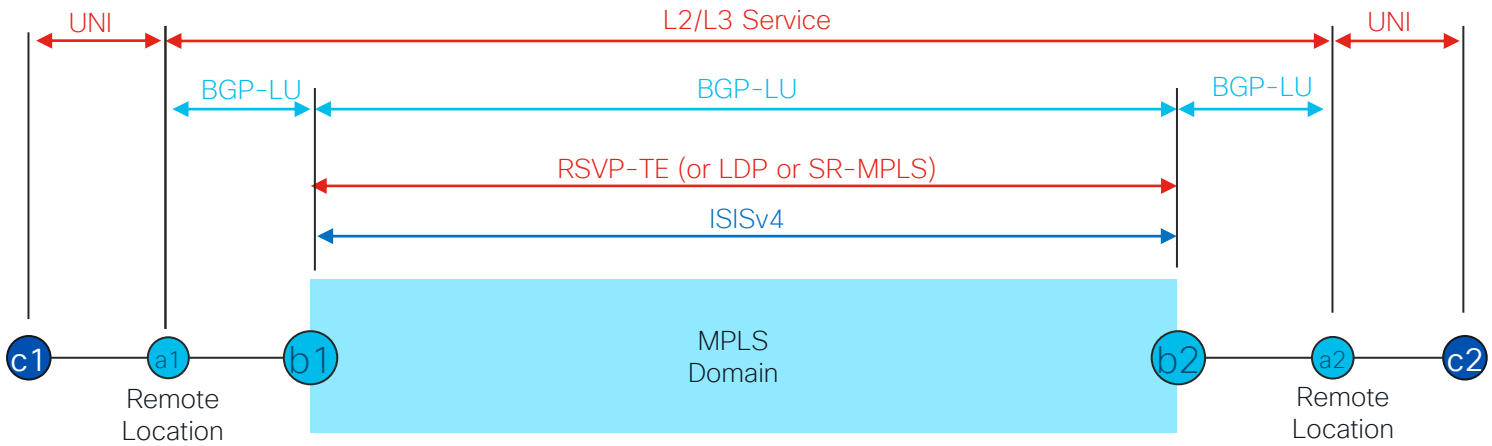


Leveraging the existing TI-LFA SR-MPLS code
- FCS sinced 2014
- Numerous deployments

SRv6 Architecture Advantages



L2/L3 Service over Classic MPLS + BGP-LU

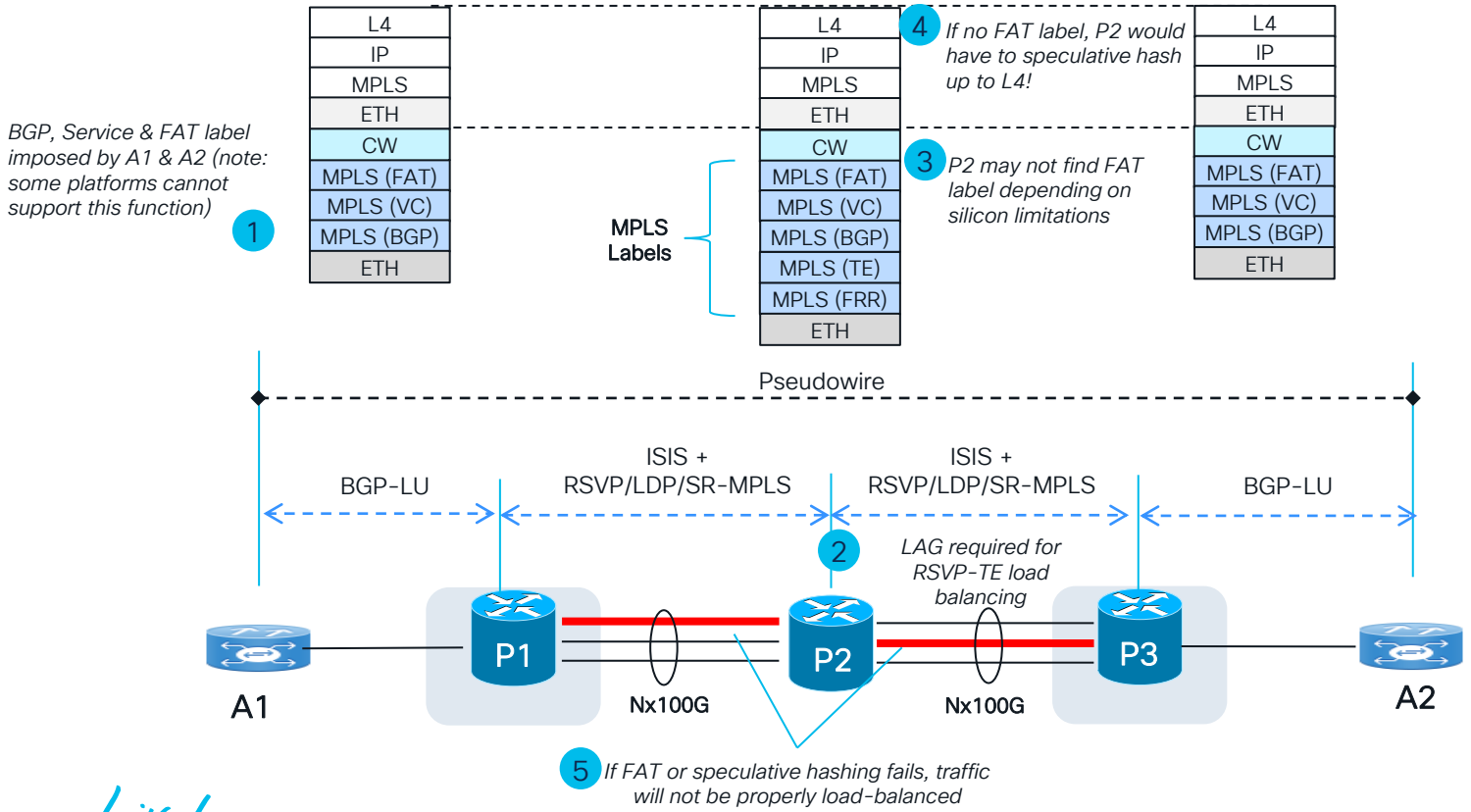


- This common design requires multiple protocols with significant complexity
- BGP-LU is used as a “shim layer” primarily to reduce the size of the IGP domain
- In many cases LDP or SR-MPLS are used instead of RSVP-TE, but overall, the picture doesn’t change

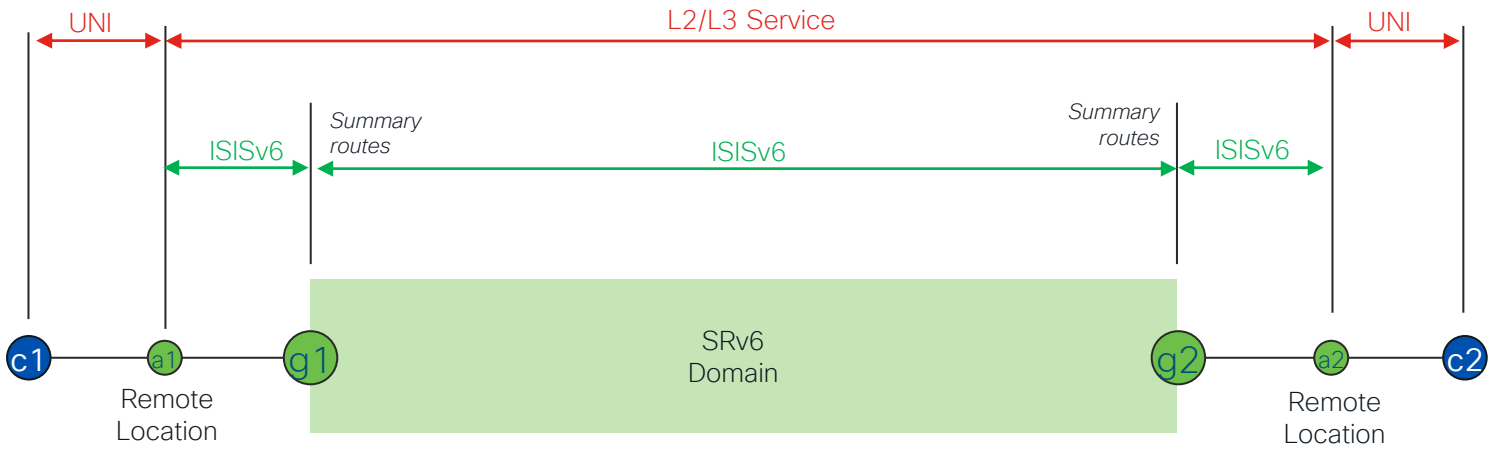
Client device/router

MPLS Node

Load-Balancing Challenges with MPLS



L2/L3 Service over SRv6

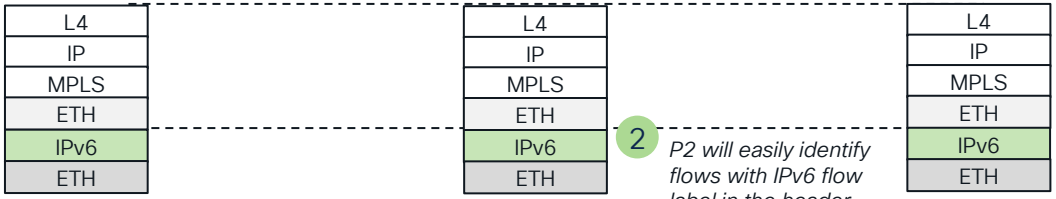


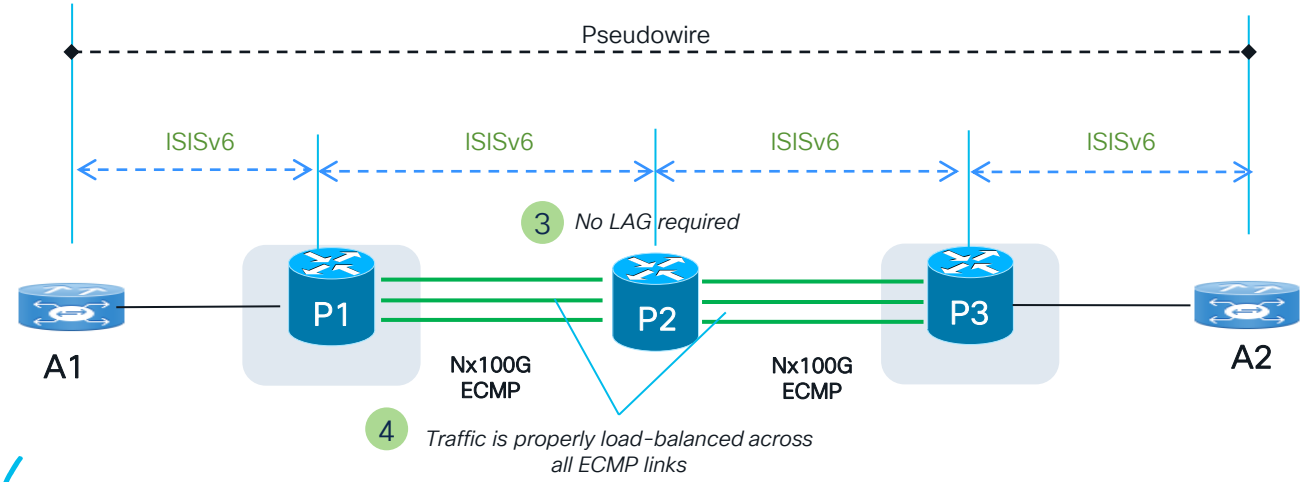
- SRv6 greatly simplifies the design
- Eliminates BGP-LU, RSVP-TE, LDP

Client device/router

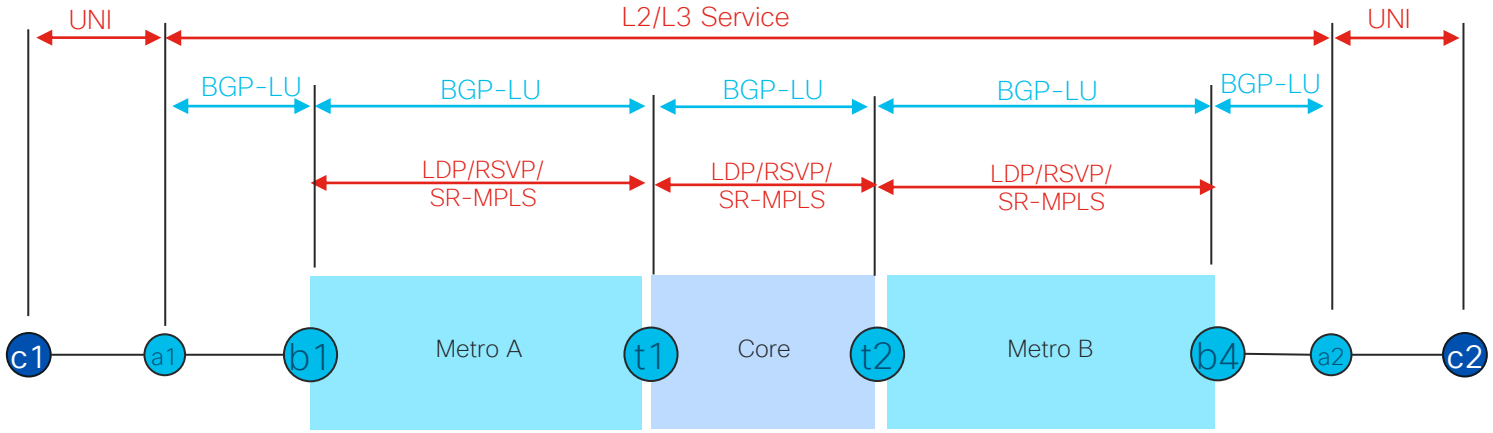
SRv6 Node

Load-Balancing with SRv6





Inter-Domain using BGP-LU

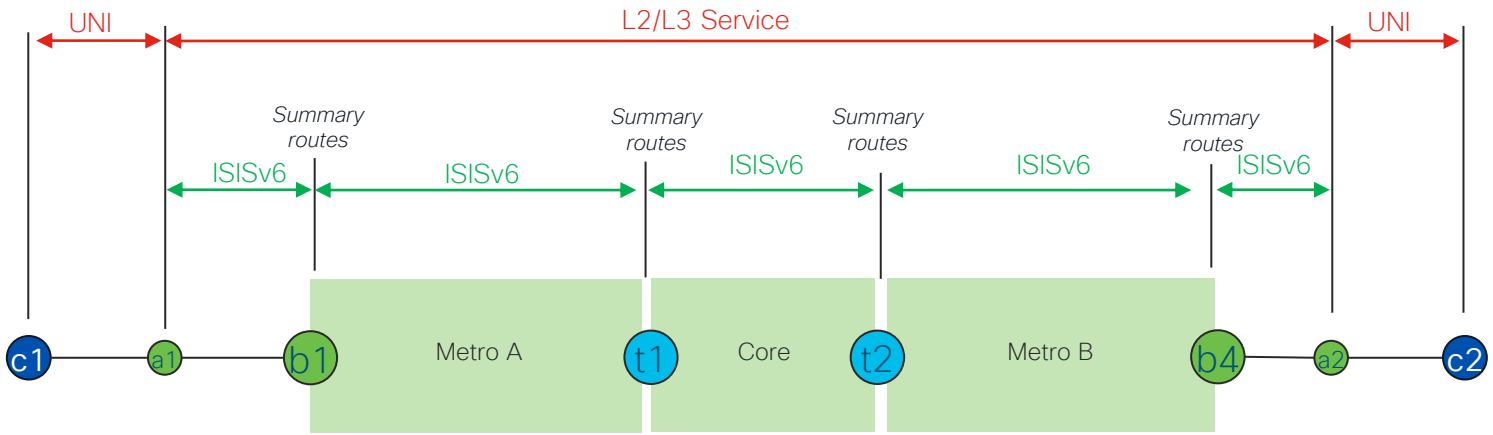


- This common design requires BGP-LU to stitch between domains within the SP
  - Also commonly used to stitch between sub-domains within a domain
- BGP-LU adds a substantial tax of complexity and limits scalability

Client device/router

MPLS Node

Inter-Domain Using SRv6



- SRv6 eliminates the BGP-LU shim layer and significantly improves scalability through summarization

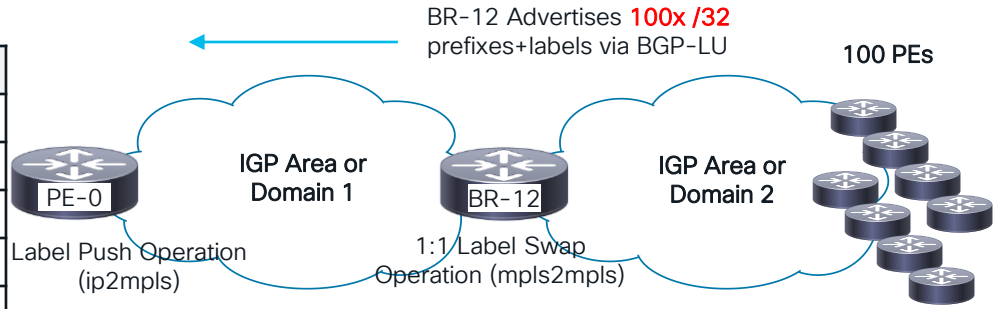
Client device/router

SRv6 Node

MPLS Does not Support Summarization

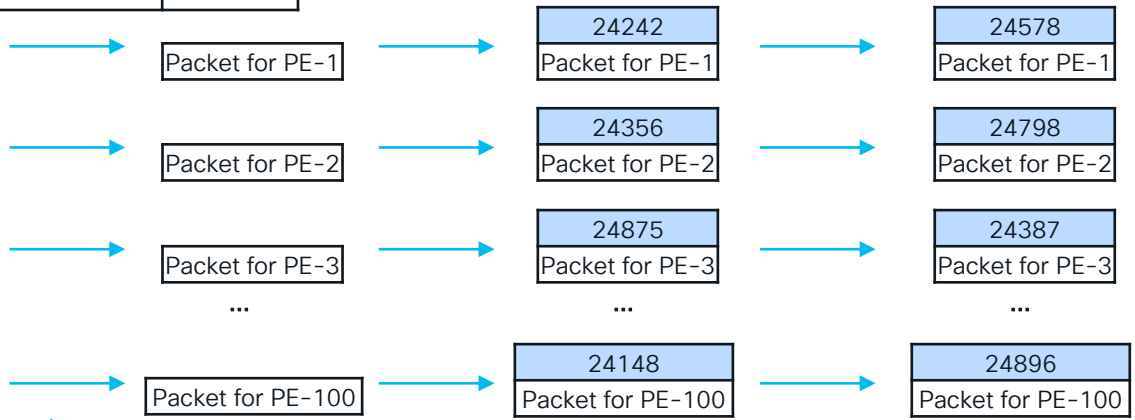
PE-10 Forwarding Table
(100x IPv4 /32 prefixes)

Prefix	Label
20.0.0.1/32 via BR-12	24242
20.0.0.2/32 via BR-12	24356
20.0.0.3/32 via BR-12	24875
…	…
20.0.0.100/32 via BR-12	24148



100x /32 Loopback
IPv4 Prefixes

PE	Loopback
PE-1	20.0.0.1/32
PE-2	20.0.0.2/32
PE-3	20.0.0.3/32
…	…
PE-100	20.0.0.100/32



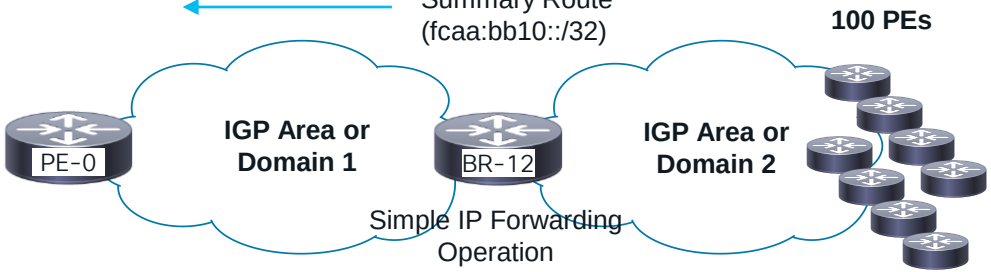
Summarization with SRv6

PE-10 Forwarding Table
(1x IPv6 /32 prefix)

Prefix	Label
fcaa:bb20::/32 via BR-12	N/A

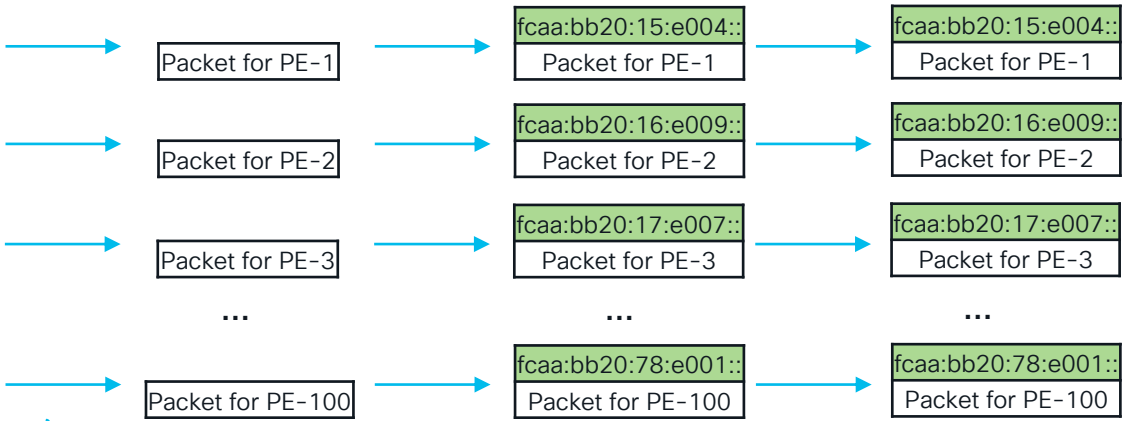
Longest Prefix Match forwards all Domain 2 packets via BR-12

BR-12 Advertises **1x IPv6** Summary Route (fcaa:bb10::/32)

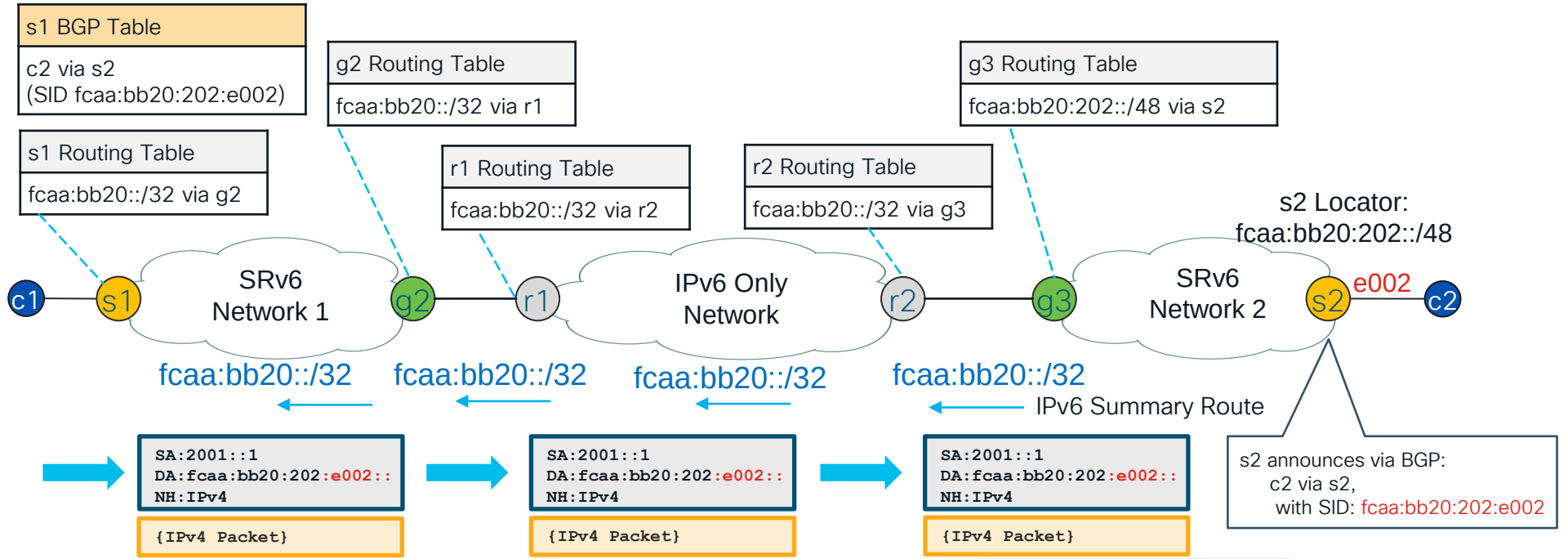


100x /48 Locator IPv6 Prefixes

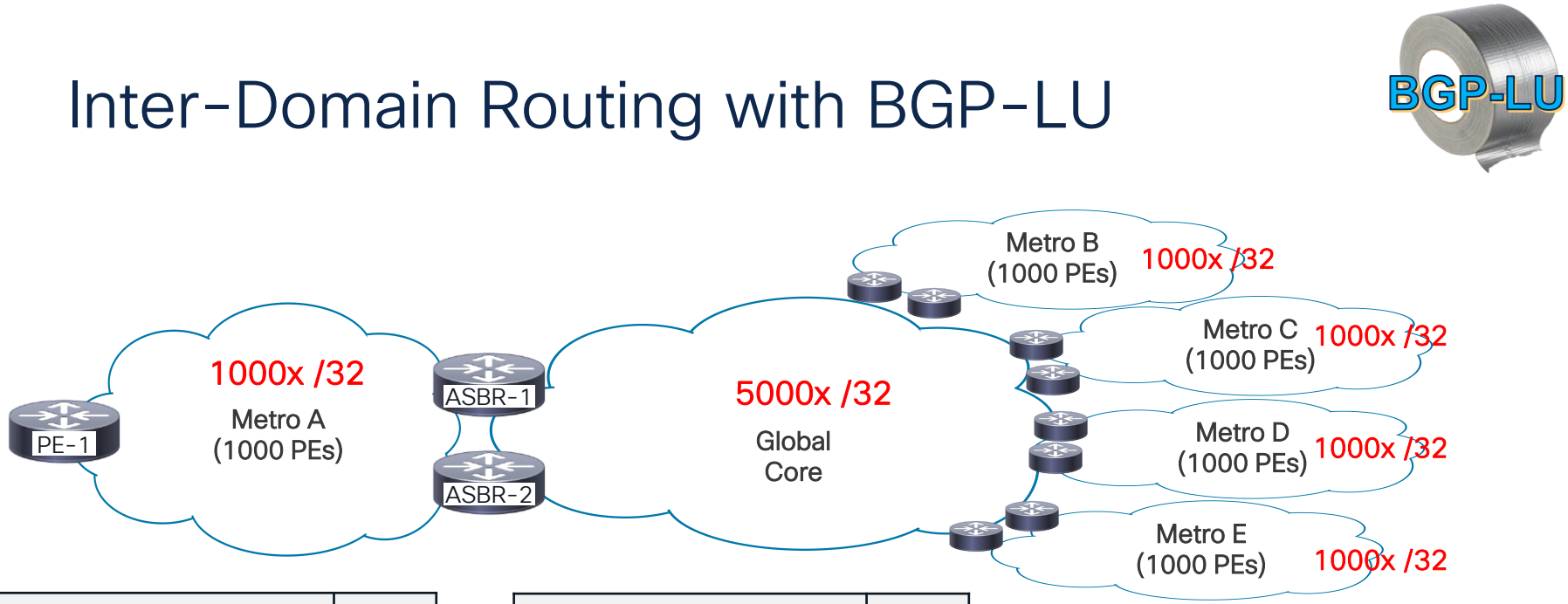
PE	Locator
PE-1	fcaa:bb20:15/48
PE-2	fcaa:bb20:16/48
PE-3	fcaa:bb20:17/48
...	...
PE-100	fcaa:bb20:78/48



SRv6 End-to-End Routing Example



Inter-Domain Routing with BGP-LU



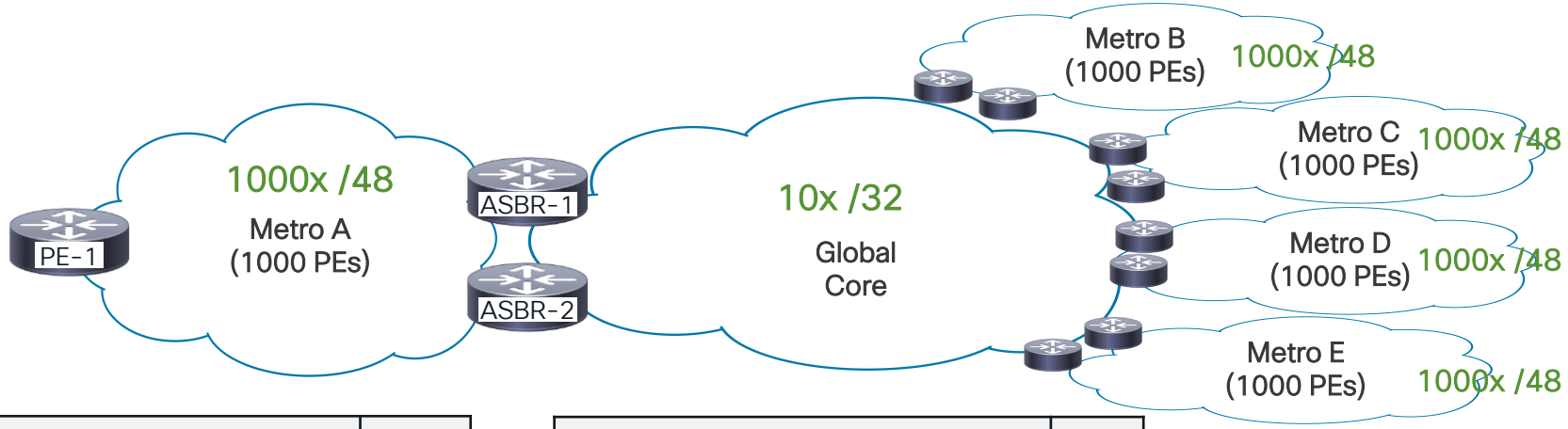
PE-1	QTY
BGP-LU FIB Entries	5000
BGP-LU Backup FIB Entries	4000

9k FIB entries

ASBR-1/ASBR-2	QTY
BGP-LU FIB Entries	5000
BGP-LU Backup FIB Entries	5000

10k FIB entries

Inter-Domain Routing with SRv6 and Summarization



PE-1	QTY
IPv6 inter-domain (via ASBR-1)	4
IPv6 inter-domain (via ASBR-2)	4

ASBR-1/ASBR-2	QTY
IPv6 inter-domain (via each metro ASBR pair)	8

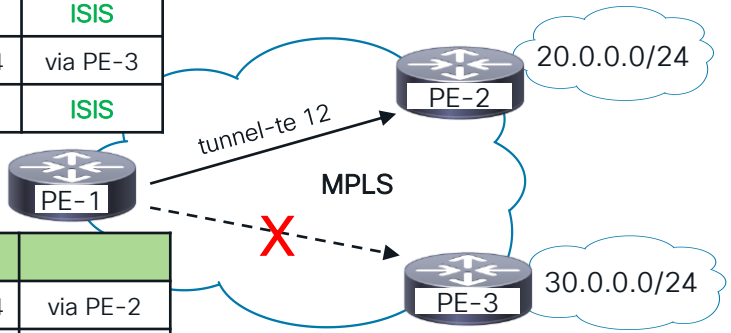
10k FIB entries reduced to 8!

9k FIB entries reduced to 8!

MPLS vs SRv6 Hardware Programming

RIB	
20.0.0.0/24	via PE-2
PE-2	ISIS
30.0.0.0/24	via PE-3
PE-3	ISIS

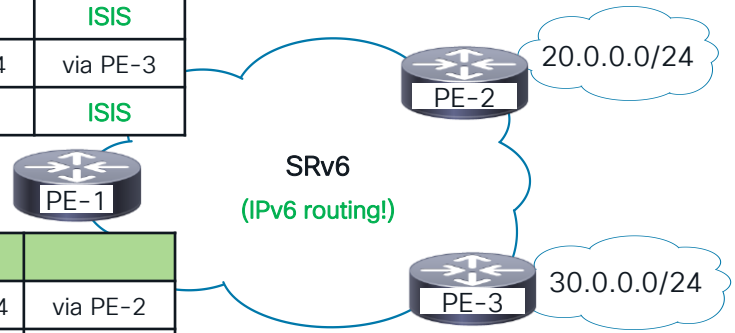
FIB	
20.0.0.0/24	via PE-2
PE-2	LSP12
30.0.0.0/24	via PE-3
PE-3	Unresolved



- MPLS can have IP routing table indicating next-hop reachability, but there is no label switched path (broken LSP)

RIB	
20.0.0.0/24	via PE-2
PE-2	ISIS
30.0.0.0/24	via PE-3
PE-3	ISIS

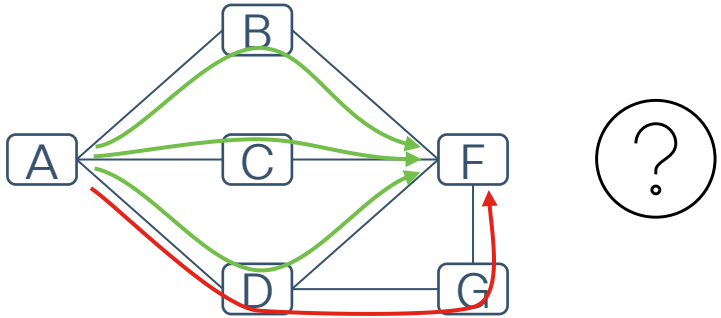
FIB	
20.0.0.0/24	via PE-2
PE-2	IPv6
30.0.0.0/24	via PE-3
PE-3	IPv6



- SRv6 will always have consistency between RIB and FIB since it is forwarding with SRv6 as native IPv6 routing
- Path tracing can identify any issues with forwarding down-stream

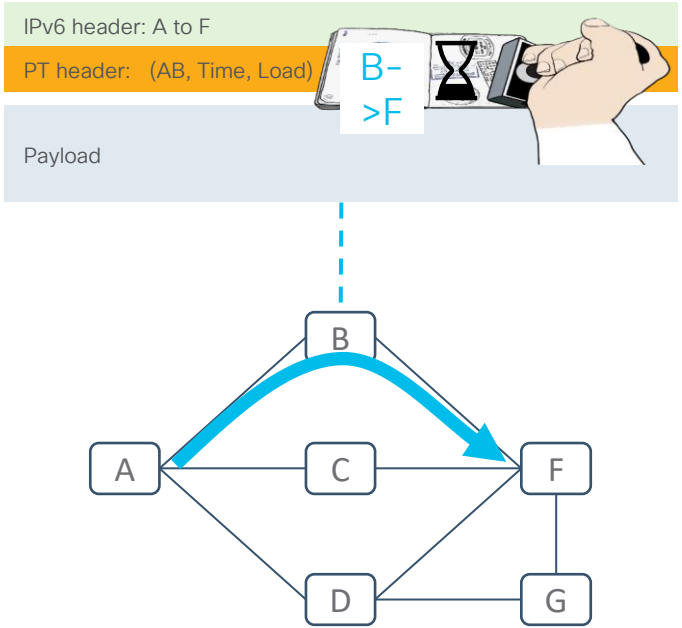
How did the packet arrive from A to F?

- 3 possible “valid” ECMP paths
  - Any drop?
  - End-to-End Latency homogeneity?
- An invalid path is possible
  - Routing or FIB corruptions
- 40-year-old unsolved IP problem

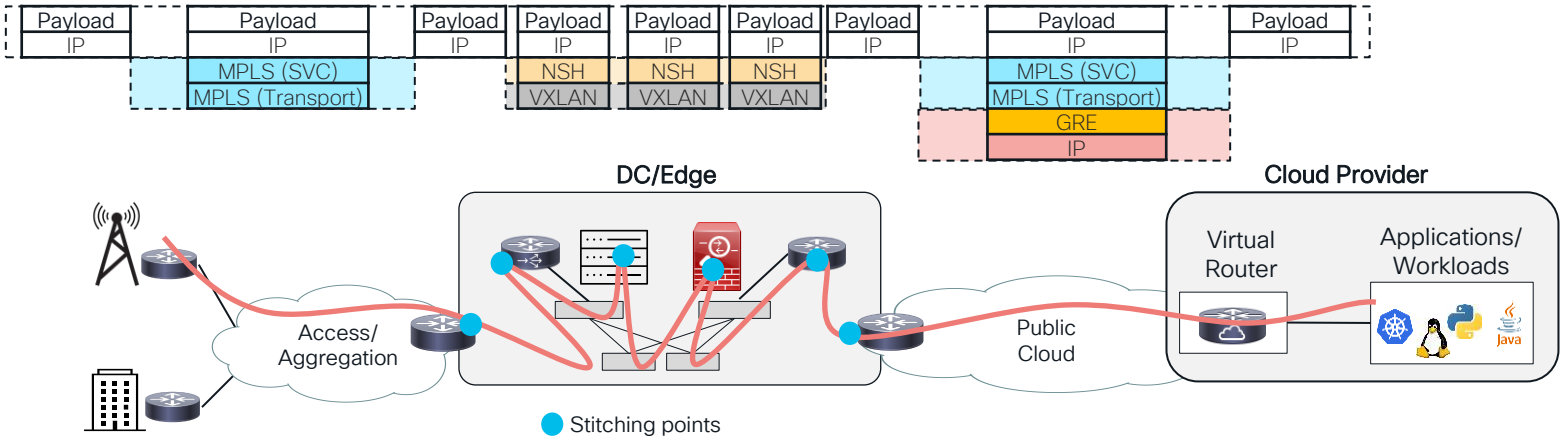


SRv6 Path Tracing

- Each transit router records in PT header:
  - Outgoing interface ID
  - Timestamp (with 60µs accuracy)
  - Egress Queue Load
- Highly compressed for low MTU overhead
  - Only 3 bytes per hop!
- Implemented at linerate: Reports true packet experience
- Native interworking with legacy nodes
  - Seamless deployment
- Hardware/XR feature with analytics app

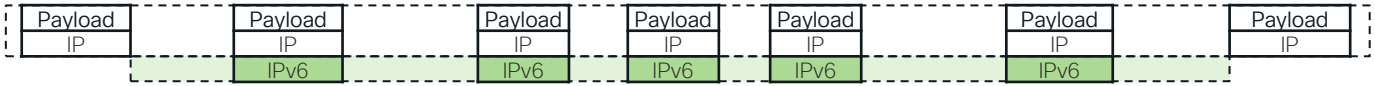


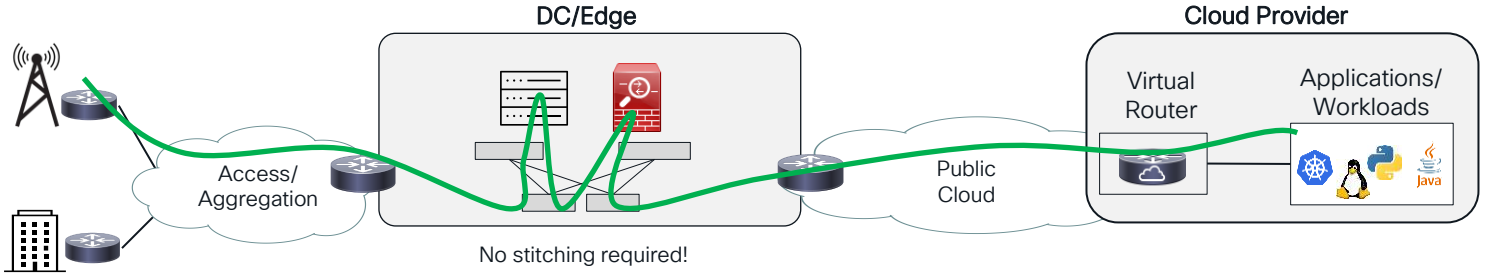
Data Plane & Service Chaining with MPLS



- SP Access/Aggregation utilizes MPLS transport which must be decapsulated at the DC
- Other mechanisms (e.g. VXLAN, NSH) must provide service-chaining and routing/switching through the DC
- Transporting services through the public cloud requires additional tunneling mechanism (e.g. GRE)

Unified IPv6 Dataplane with SRv6

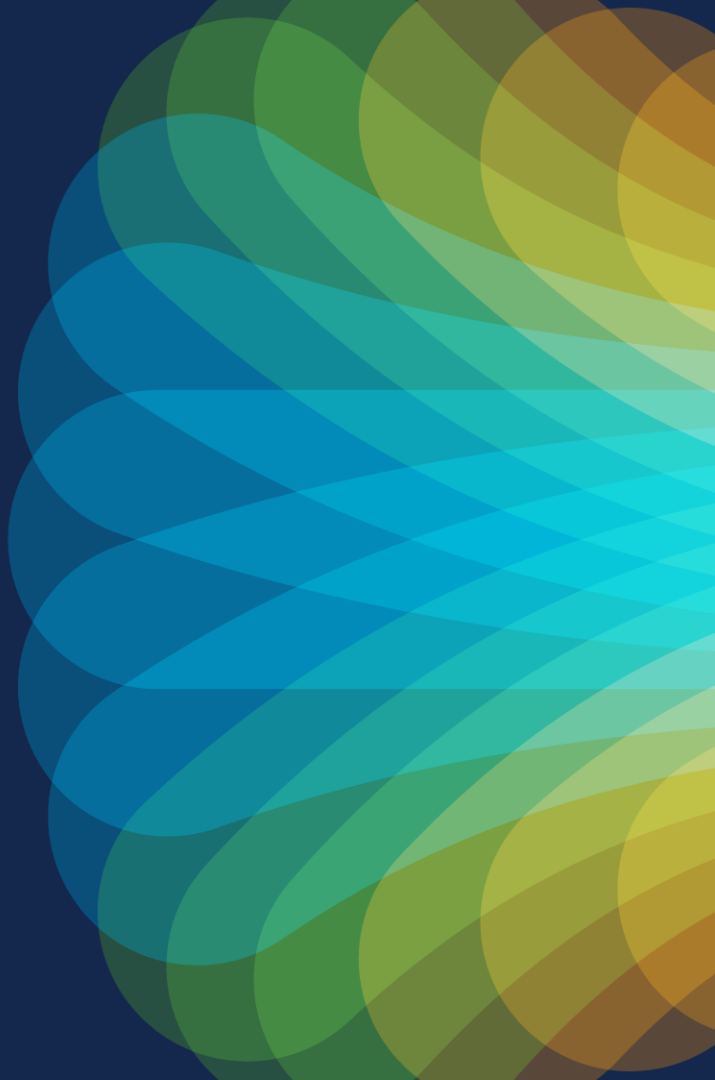




- Enables native routing (IPv6) to cloud/virtual data center providers
  - Unified IPv6 dataplane from socket to Internet peering though DC, Access, Metro, Core
- Can route traffic through devices without SRv6 functionality
- Greatly optimizes and simplifies service-chaining

Path Tracing enables:
- Deterministic confirmation of NFV processing
- Deterministic latency measurement of the NFV processing

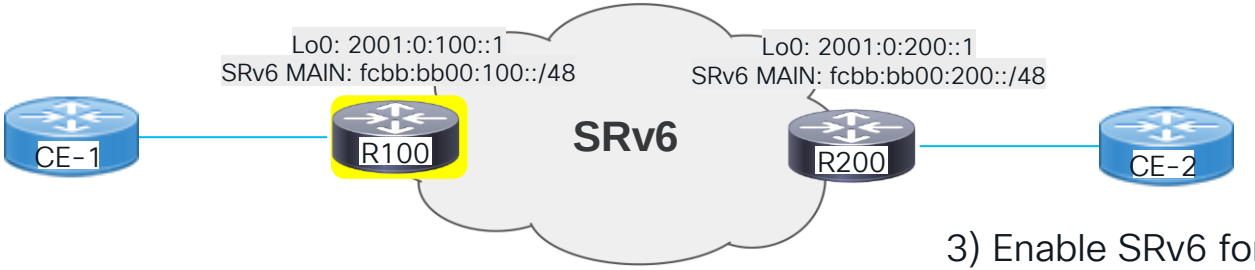
SRv6 Test-Cases



What can I do with SRv6?

- L3VPN
- L2VPN
- BGP Free Core
- Segment Routing Traffic Engineering (SR-TE)
- Network “slicing” with FlexAlgo

SRv6 Common Configuration
R100 Example Configurations



1) Configure SRv6 Locator

```
segment-routing
 srv6
  locators
   locator MAIN
    micro-segment behavior unode psp-usd
    prefix fcbb:bb00:100::/48
```

2) Enable Interfaces for IPv6

```
interface Loopback0
 ipv6 address 2010:0:100::1/128
!
interface HundredGigE0/0/0/2
 ipv6 enable
!
interface HundredGigE0/0/0/3
 ipv6 enable
```

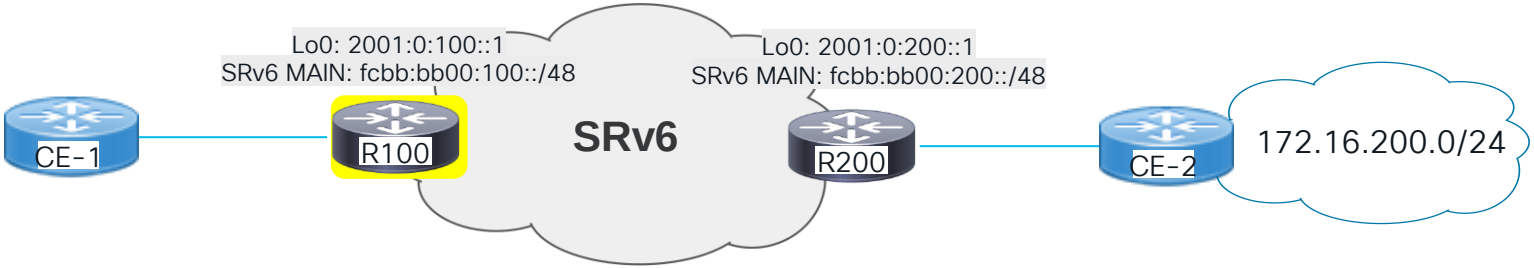
Note:

- No link addressing required (can use IPv6 link local addressing)

3) Enable SRv6 for the IGP

```
router isis 1
 is-type level-2-only
 net 39.0100.0000.0000.0100.00
 address-family ipv6 unicast
  metric-style wide
  router-id Loopback0
  segment-routing srv6
   locator MAIN
!
 interface Loopback0
  passive
  address-family ipv6 unicast
!
 interface GigabitEthernet0/0/0/0
  point-to-point
  address-family ipv6 unicast
!
 interface GigabitEthernet0/0/0/1
  point-to-point
  address-family ipv6 unicast
```

L3VPN Service over SRv6 Example
R100 Example Configurations



1) Define VRF

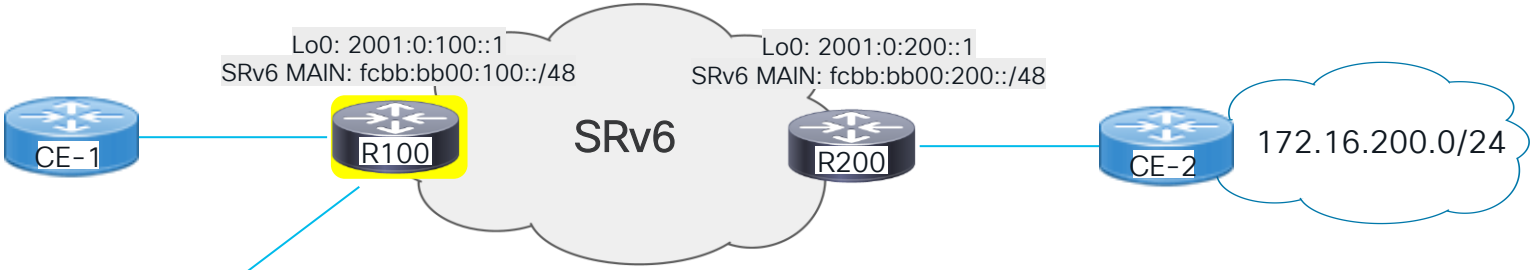
```
vrf BLUE_VRF
 address-family ipv4 unicast
  import route-target
   1:123
  !
  export route-target
   1:123
!
interface Loopback222
 vrf BLUE_VRF
 ipv4 address 172.16.10.100/32
!
interface GigabitEthernet0/0/0/3.231
 vrf BLUE_VRF
 ipv4 address 10.0.231.2/30
 encapsulation dot1q 231
```

2) Configure VRF for SRv6 under BGP

```
router bgp 10
 bgp router-id 100.0.0.100
 address-family vpnv4 unicast
 !
 {configure neighbor for vpnv4 unicast}
 !
 vrf BLUE_VRF
  rd 1:123
  address-family ipv4 unicast
   segment-routing srv6
    locator MAIN
    alloc mode per-vrf
   !
   redistribute connected
```

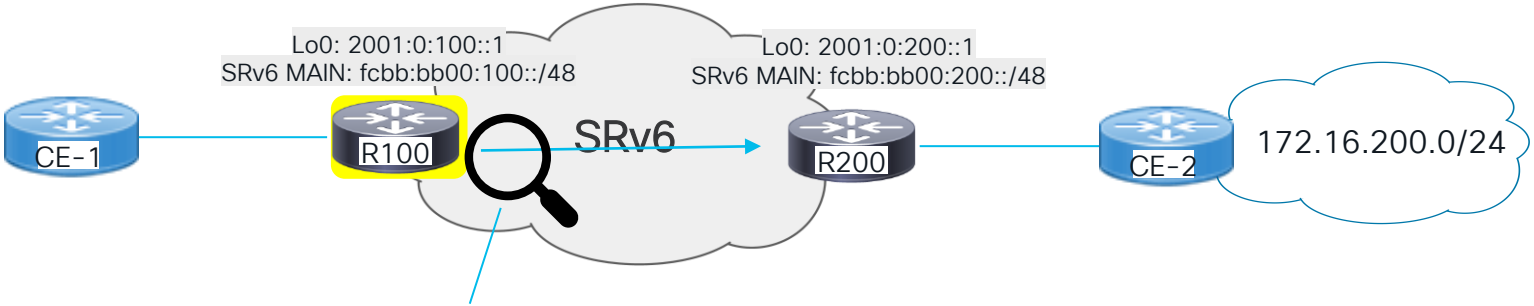
Similar configurations applied to R200

L3VPN Service over SRv6 Example
BGP Update for BLUE_VRF 172.16.200.0/24




```
RP/0/RP0/CPU0:xr9kv-100#show bgp vpnv4 uni vrf BLUE_VRF 172.16.200.0/24
<snip>
BGP routing table entry for 172.16.200.0/24, Route Distinguisher: 1:123
<snip>
Paths: (1 available, best #1)
<snip>
    2001:0:200::1 (metric 30) from 2001:0:30::1 (30.0.0.30)
      Received Label 0xe0050
<snip>
      Extended community: Color:12905 RT:1:123
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:fcbb:bb00:200::, Behavior:63, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
      Source AFI: VPNv4 Unicast, Source VRF: BLUE_VRF, Source Route Distinguisher: 1:123
```

L3VPN Service over SRv6 Example
R100 Packet Capture Towards R200



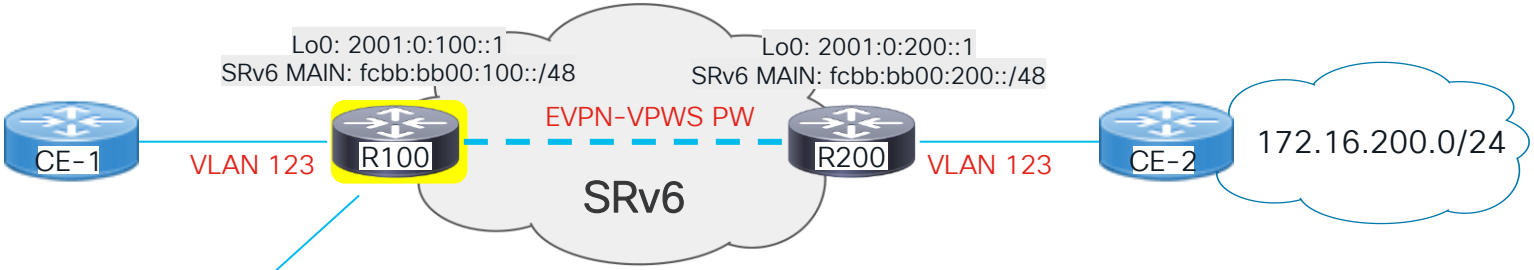

```
> Frame 1: 1232 bytes on wire (9856 bits), 1232 bytes captured (9856 bits)
> Ethernet II, Src: RealtekU_03:0f:1d (52:54:00:03:0f:1d), Dst: RealtekU_02:79:ea (52:54:00:02:79:ea)
v Internet Protocol Version 6, Src: 2001:0:100::1, Dst: fcbb:bb00:200:e005::
    0110 .... = Version: 6
  > .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
    .... 1000 0000 1110 1010 1101 = Flow Label: 0x80ead
    Payload Length: 1178
    Next Header: IPIP (4)
    Hop Limit: 255
    Source Address: 2001:0:100::1
    Destination Address: fcbb:bb00:200:e005::
    [Source Teredo Server IPv4: 1.0.0.0]
    [Source Teredo Port: 65535]
    [Source Teredo Client IPv4: 255.255.255.254]
> Internet Protocol Version 4, Src: 10.0.231.1, Dst: 172.16.200.29
> Transmission Control Protocol, Src Port: 1025, Dst Port: 1025, Seq: 1, Len: 1138
> Data (1138 bytes)
```

SRv6 SID list encoded as uSID in IPv6 DA

Flow label computed

No SRH, next-header IPv4

EVPN-VPWS over SRv6 Service Example
R100 Example Configuration




```
evpn
 segment-routing srv6
  locator MAIN
 !
!
l2vpn
 xconnect group EVPN-VPWS
  p2p EVPN-VPWS-123
   interface GigabitEthernet0/0/0/3.123
   neighbor evpn evi 123 service 12123 segment-routing srv6
```

Similar configurations applied to R200

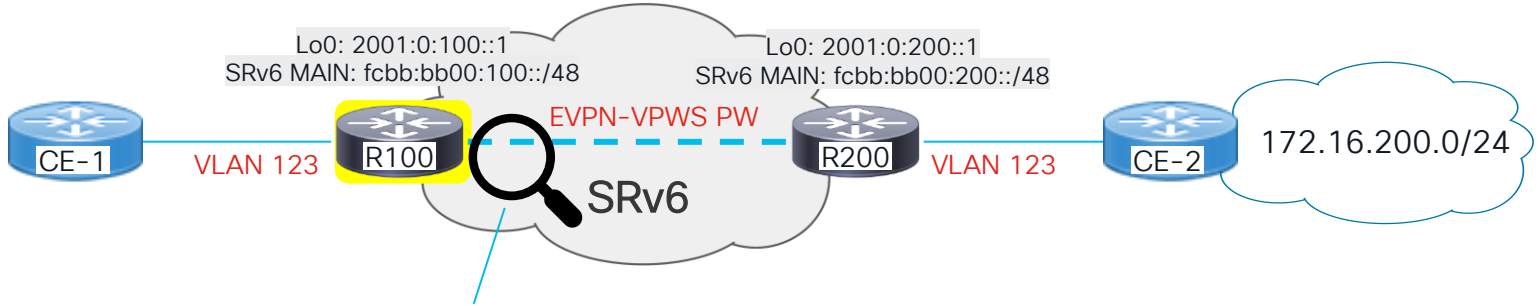
Note: EVPN BGP configurations are not shown but do not require any SRv6 unique configurations

R100 EVPN-VPWS Control Plane State

```
RP/0/RP0/CPU0:xr9kv-100#show l2vpn xconnect detail
<snip>
Group EVPN-VPWS, XC EVPN-VPWS-123, state is up; Interworking none
  AC: GigabitEthernet0/0/0/3.123, state is up
<snip>
    Statistics:
      packets: received 3325526, sent 0
      bytes: received 3977329096, sent 0
      drops: illegal VLAN 0, illegal length 0
  EVPN: neighbor ::ffff:10.0.0.1, PW ID: evi 123, ac-id 12123, state is up ( established )
    XC ID 0xa0000005
    Encapsulation SRv6
    Encap type Ethernet
    Ignore MTU mismatch: Enabled
    Transmit MTU zero: Enabled
    Reachability: Up
    Load Balance Hashing: src-dst-ip

      SRv6              Local                       Remote
      ----------------  --------------------------- --------------------------
      uDX2              fcbb:bb00:100:e008::        fcbb:bb00:200:e008::
      AC ID             12123                       12123
      MTU               1514                        0
      Locator           MAIN                        N/A
      Locator Resolved  Yes                         N/A
      SRv6 Headend      H.Encaps.L2.Red             N/A
```

EVPN-VPWS over SRv6 Service Example
R100 Packet Capture Towards R200



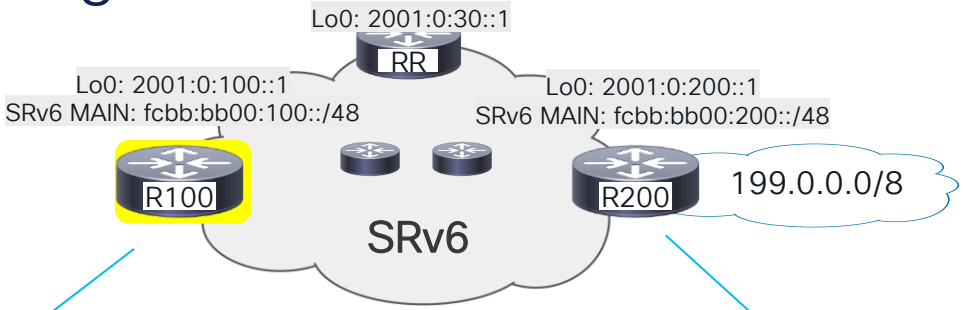

```
Frame 1: 1246 bytes on wire (9968 bits), 1246 bytes captured (9968 bits)
Ethernet II, Src: RealtekU_1c:65:d8 (52:54:00:1c:65:d8), Dst: RealtekU_1d:75:82 (52:54:00:1d:75:82)
Internet Protocol Version 6, Src: 2001:0:100::1, Dst: fcbb:bb00:200:e008::
   0110 .... = Version: 6
   .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
   .... 1010 1000 0011 1101 1010 = Flow Label: 0xa83da
   Payload Length: 1192
   Next Header: Ethernet (143)
   Hop Limit: 255
   Source Address: 2001:0:100::1
   Destination Address: fcbb:bb00:200:e008::
   [Source Teredo Server IPv4: 1.0.0.0]
   [Source Teredo Port: 65535]
   [Source Teredo Client IPv4: 255.255.255.254]
Ethernet II, Src: RealtekU_13:ef:99 (52:54:00:13:ef:99), Dst: RealtekU_09:d4:54 (52:54:00:09:d4:54)
Internet Protocol Version 4, Src: 16.0.0.1, Dst: 48.0.0.27
Transmission Control Protocol, Src Port: 1025, Dst Port: 1025, Seq: 1, Len: 1138
Data (1138 bytes)
```

SRv6 SID list encoded as uSID in IPv6 DA

Flow label computed

No SRH, next-header Ethernet

“BGP Free” Core
Example Configuration




```
router bgp 10
 bgp router-id 100.0.0.100
 address-family ipv4 unicast
  segment-routing srv6
   locator MAIN
 !
 neighbor 2001:0:30::1
  remote-as 10
  update-source Loopback0
  address-family ipv4 unicast
   encapsulation-type srv6
```

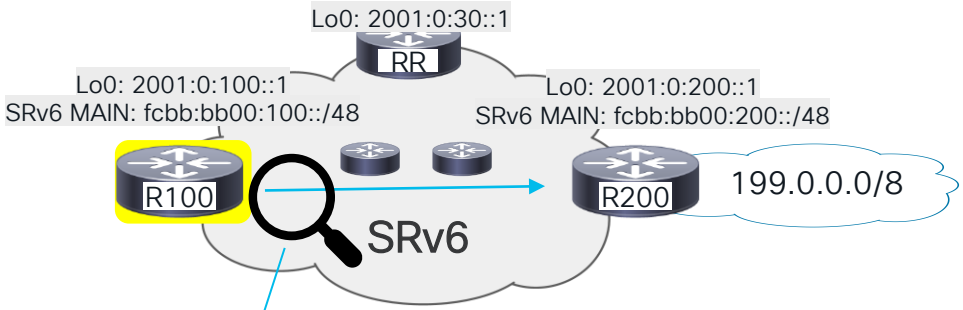
- Configure global IPv4 AF for SRv6 under BGP
- Configure neighbor for SRv6 encapsulation

```
router bgp 10
 bgp router-id 100.0.0.100
 address-family ipv4 unicast
  segment-routing srv6
   locator MAIN
  network 199.0.0.0/8
 !
 neighbor 2001:0:30::1
  remote-as 10
  update-source Loopback0
  address-family ipv4 unicast
   encapsulation-type srv6
```

R100 BGP Entry for 199.0.0.0/8

```
RP/0/RP0/CPU0:xr9kv-100#show bgp ipv4 uni 199.0.0.0/8
Sat Jun  3 19:54:30.283 UTC
BGP routing table entry for 199.0.0.0/8
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                31           31
Last Modified: Jun  3 18:56:26.833 for 00:58:03
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  2
    2001:0:200::1 (metric 30) from 2001:0:30::1 (30.0.0.30)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 1, Local Path ID 1, version 31
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:fcbb:bb00:200:e006::, Behavior:63, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
```

“BGP Free” Core
Packet Capture R100 to R200




```
Frame 1: 1232 bytes on wire (9856 bits), 1232 bytes captured (9856 bits)
Ethernet II, Src: RealtekU_1c:65:d8 (52:54:00:1c:65:d8), Dst: RealtekU_1d:75:82 (52:54:00:1d:75:82)
Internet Protocol Version 6, Src: 2001:0:100::1, Dst: fcbb:bb00:200:e006::
   0110 .... = Version: 6
   .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
   .... 1101 1010 1001 0000 1001 = Flow Label: 0xda909
   Payload Length: 1178
   Next Header: IPIP (4)
   Hop Limit: 255
   Source Address: 2001:0:100::1
   Destination Address: fcbb:bb00:200:e006::
   [Source Teredo Server IPv4: 1.0.0.0]
   [Source Teredo Port: 65535]
   [Source Teredo Client IPv4: 255.255.255.254]
Internet Protocol Version 4, Src: 10.0.231.1, Dst: 199.128.64.5
Transmission Control Protocol, Src Port: 1025, Dst Port: 1025, Seq: 1, Len: 1138
Data (1138 bytes)
```

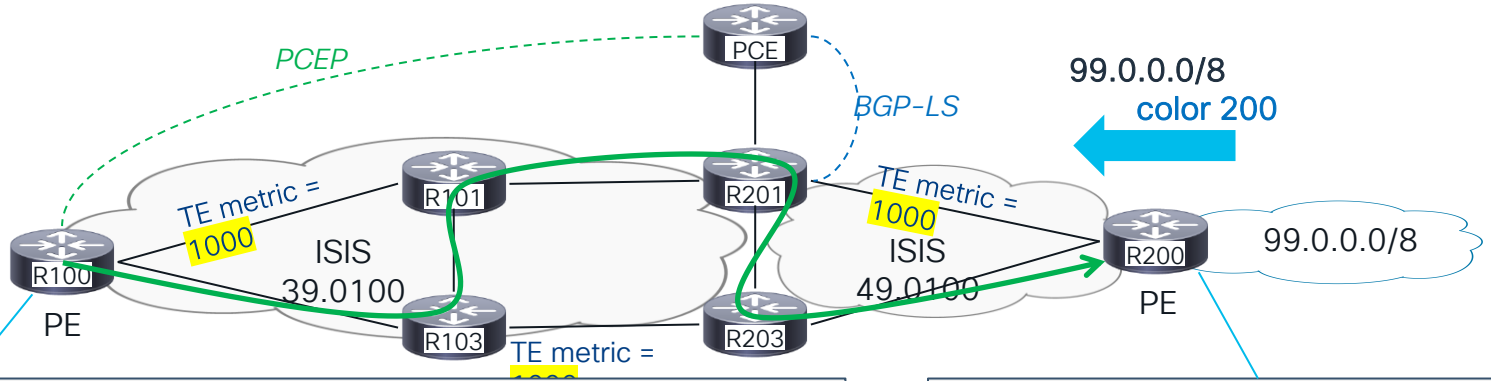
SRv6 SID list encoded as uSID in IPv6 DA

Flow label computed

No SRH, next-header IPv4

- default IGP & TE metric is 10

SRv6 with SR-TE Example



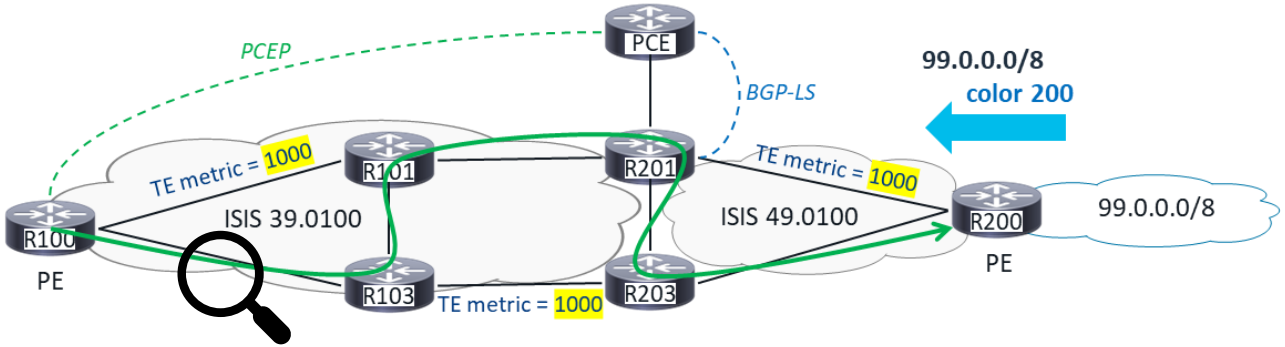

```
segment-routing
 traffic-eng
   on-demand color 200
    srv6
     locator MAIN binding-sid dynamic behavior ub6-insert-reduced
    !
    dynamic
     pcep
     !
     metric
      type te
```

```
extcommunity-set opaque COLOR-200
  200
end-set
!
route-policy SET-COLOR-IPV4-GRT
  if destination in (99.0.0.0/8) then
    set extcommunity color COLOR-200
    pass
  else
    pass
  endif
end-policy
```

R100 SR-TE Policy for Color 200

```
RP/0/RP0/CPU0:xr9kv-100#show segment-routing traffic-eng policy color 200
<snip>
Color: 200, End-point: 2001:0:200::1
  Name: srte_c_200_ep_2001:0:200::1
  Status:
    Admin: up  Operational: up for 01:03:11 (since Jun  3 17:00:18.901)
  Candidate-paths:
<snip>
    Preference: 100 (BGP ODN) (active)
<snip>
      Dynamic (pce 2001:0:30::1) (valid)
        Metric Type: TE,   Path Accumulated Metric: 50
          SID[0]: fcbb:bb00:103::/48 Behavior: uN (PSP/USD) (48)
                  Format: f3216
                  LBL:32 LNL:16 FL:0 AL:0
                  Address: 2001:0:103::1
          SID[1]: fcbb:bb00:201::/48 Behavior: uN (PSP/USD) (48)
                  Format: f3216
                  LBL:32 LNL:16 FL:0 AL:80
                  Address: 2001:0:201::1
          SID[2]: fcbb:bb00:203::/48 Behavior: uN (PSP/USD) (48)
                  Format: f3216
                  LBL:32 LNL:16 FL:0 AL:0
                  Address: 2001:0:203::1
          SID[3]: fcbb:bb00:200::/48 Behavior: uN (PSP/USD) (48)
                  Format: f3216
                  LBL:32 LNL:16 FL:0 AL:80
                  Address: 2001:0:200::1
```

Packet Capture on R100→R103 Link




```
> Frame 1: 1232 bytes on wire (9856 bits), 1232 bytes captured (9856 bits)
> Ethernet II, Src: RealtekU_03:0f:1d (52:54:00:03:0f:1d), Dst: RealtekU_02:79:ea (52:54:00:02:79:ea)
v Internet Protocol Version 6, Src: 2001:0:100::1, Dst: fcbb:bb00:103:201:203:200:e006:0
    0110 .... = Version: 6
  > .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
    .... 1100 1001 0111 1101 0111 = Flow Label: 0xc97d7
    Payload Length: 1178
    Next Header: IPIP (4)
    Hop Limit: 255
    Source Address: 2001:0:100::1
    Destination Address: fcbb:bb00:103:201:203:200:e006:0
    [Source Teredo Server IPv4: 1.0.0.0]
    [Source Teredo Port: 65535]
    [Source Teredo Client IPv4: 255.255.255.254]
> Internet Protocol Version 4, Src: 10.0.231.1, Dst: 99.128.64.16
> Transmission Control Protocol, Src Port: 1025, Dst Port: 1025, Seq: 1, Len: 1138
> Data (1138 bytes)
```

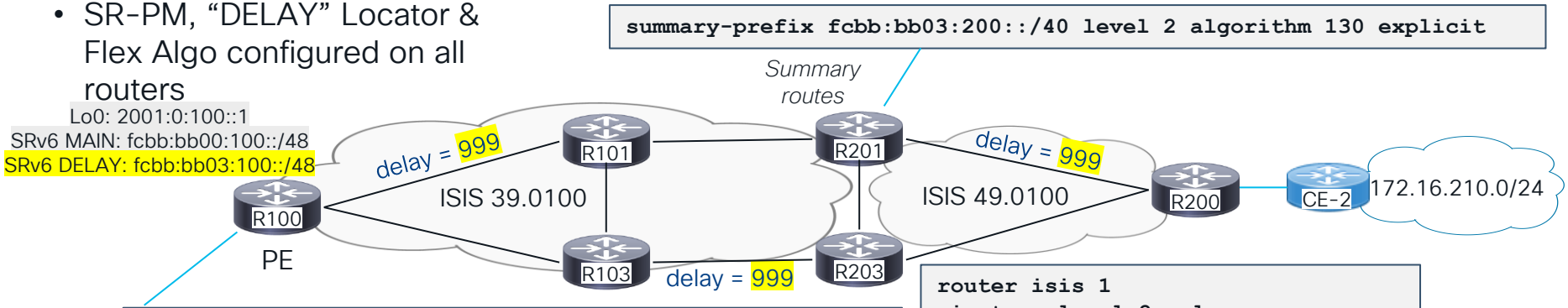
SRv6 SID list encoded as uSID in IPv6 DA

Flow label computed

No SRH, next-header IPv4

Interdomain Network “Slicing” with Flex Algo

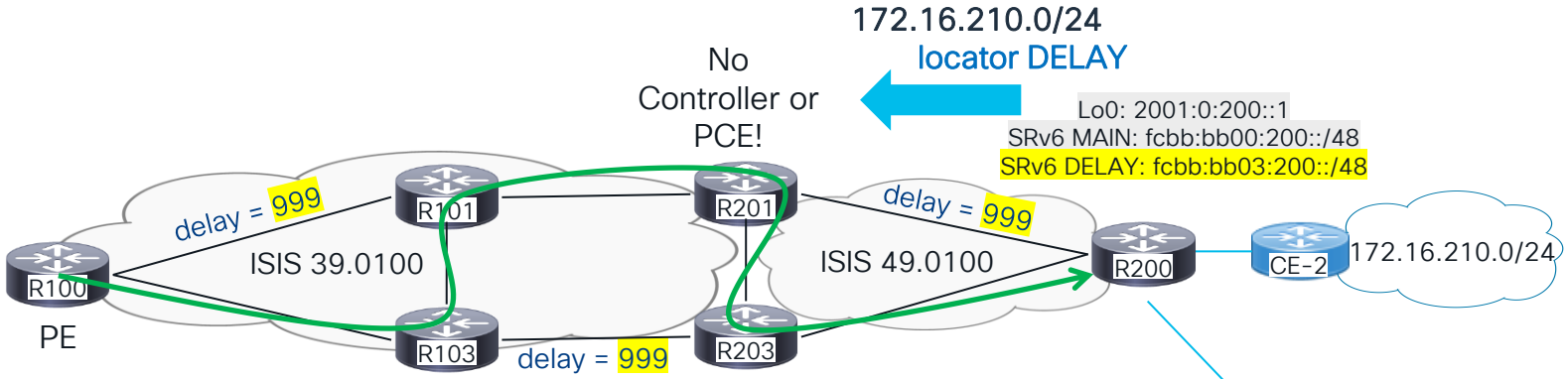
- SR-PM, “DELAY” Locator & Flex Algo configured on all routers




```
segment-routing
 srv6
  locators
   locator MAIN
    micro-segment behavior unode psp-usd
    prefix fcbb:bb00:100::/48
   !
   locator DELAY
    micro-segment behavior unode psp-usd
    prefix fcbb:bb03:100::/48
    algorithm 130
```

```
router isis 1
 is-type level-2-only
 net 39.0100.0000.0000.0100.00
 flex-algo 130
  metric-type delay
  advertise-definition
 !
 address-family ipv6 unicast
  metric-style wide
  router-id Loopback0
  segment-routing srv6
   locator MAIN
  segment-routing srv6
   locator DELAY
```

Interdomain Network “Slicing” with Flex Algo
R200 Example Configurations



- All routers forward packets along lowest delay path according to “DELAY” Flex Algo topology
- No controller or PCE required

```
route-policy SET-ALGO
  if destination in (172.16.210.0/24) then
    set srv6-alloc-mode per-vrf locator DELAY
    pass
  else
    set srv6-alloc-mode per-vrf locator MAIN
    pass
  endif
end-policy
```

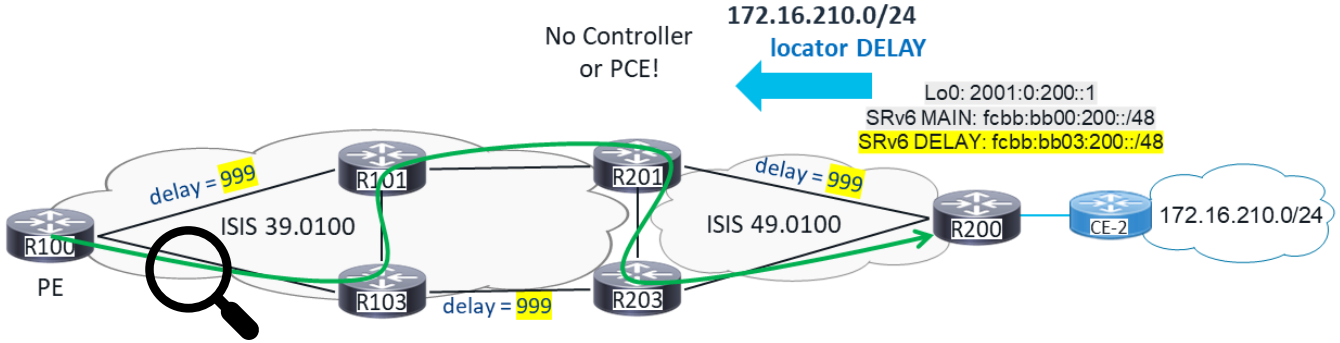
- default delay 100

R100 BGP Entry for 172.16.210.0/24

```
RP/0/RP0/CPU0:xr9kv-100#show bgp vpnv4 uni vrf BLUE_VRF 172.16.210.0/24
<snip>
BGP routing table entry for 172.16.210.0/24, Route Distinguisher: 1:123
<snip>
Paths: (1 available, best #1)
<snip>
    2001:0:200::1 (metric 30) from 2001:0:30::1 (30.0.0.30)
      Received Label 0xe0040
<snip>
      Extended community: RT:1:123
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:fcbb:bb03:200::, Behavior:63, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
      Source AFI: VPNv4 Unicast, Source VRF: BLUE_VRF, Source Route Distinguisher: 1:123
```

```
RP/0/RP0/CPU0:xr9kv-100#show isis database xr9kv-201.00-00 detail
<snip>
IS-IS 1 (Level-2) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL
xr9kv-201.00-00       0x00000066   0xdb76        785  /1200         0/0/0
  Area Address:   39.0100
<snip>
  SRv6 Locator:   MT (IPv6 Unicast) fcbb:bb00:200::/40 D:0 Metric: 11 Algorithm: 0
  SRv6 Locator:   MT (IPv6 Unicast) fcbb:bb03:200::/40 D:0 Metric: 201 Algorithm: 130
```

Interdomain Network “Slicing” with Flex Algo
Packet Capture R100→R200 (DELAY FA)




```
Frame 1: 1232 bytes on wire (9856 bits), 1232 bytes captured (9856 bits)
Ethernet II, Src: RealtekU_03:0f:1d (52:54:00:03:0f:1d), Dst: RealtekU_02:79:ea (52:54:00:02:79:ea)
Internet Protocol Version 6, Src: 2001:0:100::1, Dst: fcbb:bb03:200:e004::
    0110 .... = Version: 6
  > .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00 (DSCP: CS0, ECN: Not-ECT)
    .... 1011 1000 1010 1001 1101 = Flow Label: 0xb8a9d
    Payload Length: 1178
    Next Header: IPIP (4)
    Hop Limit: 255
    Source Address: 2001:0:100::1
    Destination Address: fcbb:bb03:200:e004::
    [Source Teredo Server IPv4: 1.0.0.0]
    [Source Teredo Port: 65535]
    [Source Teredo Client IPv4: 255.255.255.254]
Internet Protocol Version 4, Src: 10.0.231.1, Dst: 172.16.210.5
Transmission Control Protocol, Src Port: 1025, Dst Port: 1025, Seq: 1, Len: 1138
Data (1138 bytes)
```

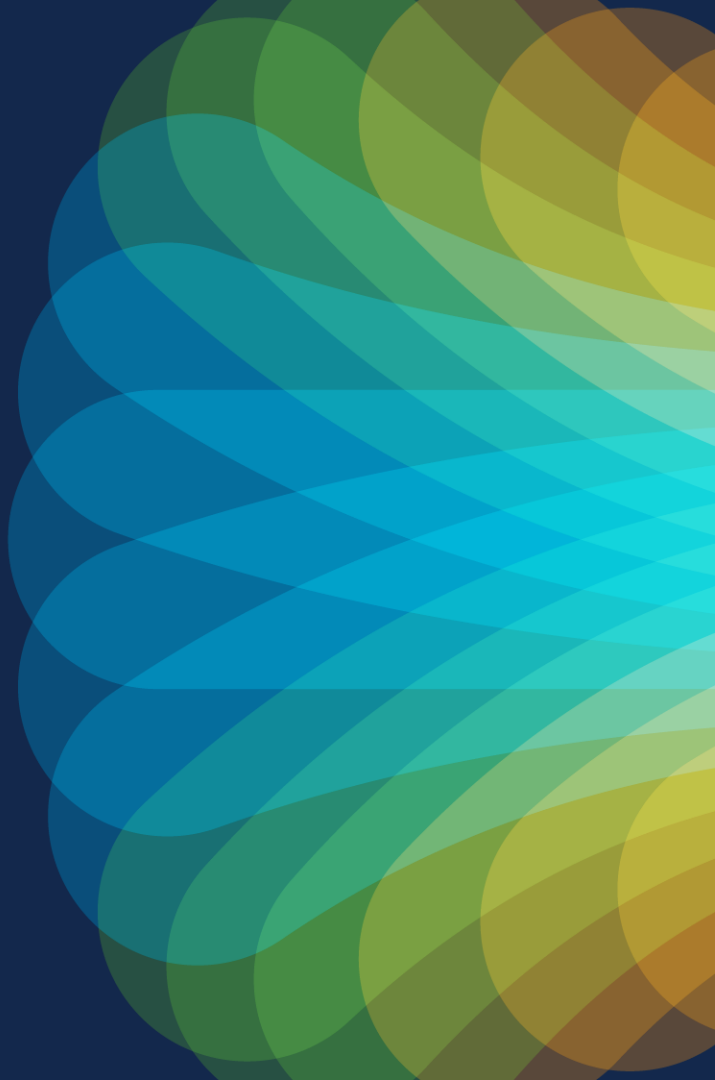
SRv6 SID list encoded as uSID in IPv6 DA

Flow label computed

No SRH, next-header IPv4

- default delay 100

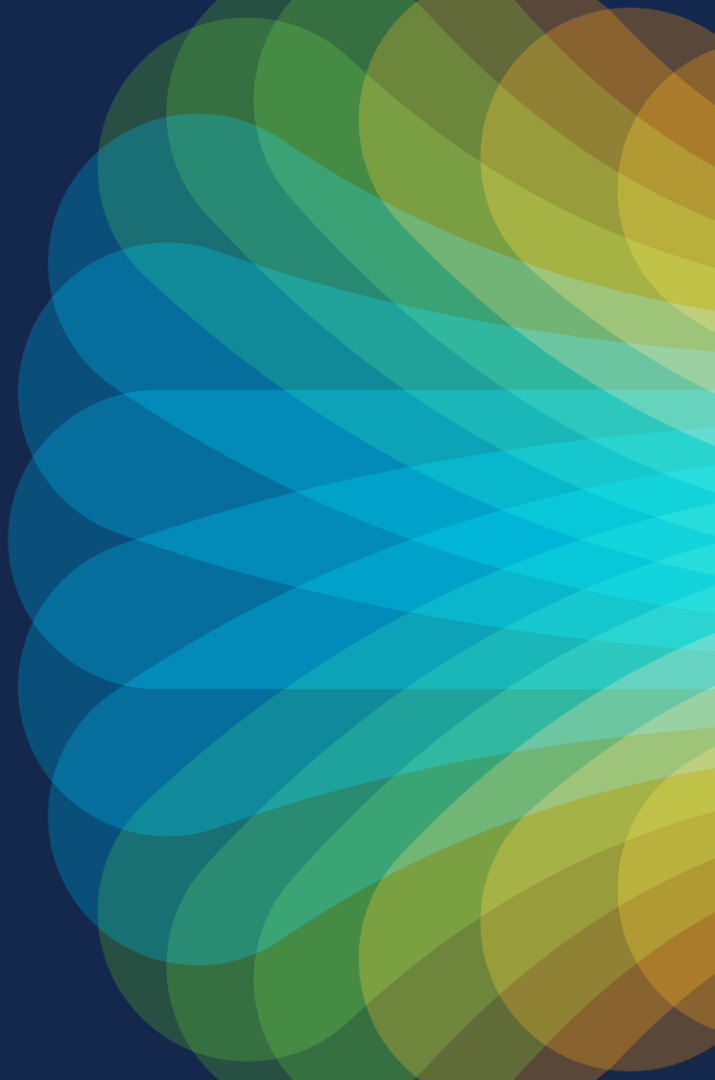
Cisco Platform Support for SRv6



SRv6 Feature Support for Cisco IOS-XR Platforms

Feature name	NCS 5500 NCS 540	NCS 560	NCS 5700 NCS540-Q2A	ASR9K (LSP)	8000 (Q200)
LSR: ISIS (incl. Ti-LFA / uLoop / Flex-Algo)	Supported				
OAM (Ping, Traceroute, SID Verification)	Supported				
SRv6 PM (Delay, Loss, Liveness)	Supported				
Seamless Migration (F1 -> uSID + Dual-mode)	Supported				
L3 Services: VPNv4 / VPNv6	Supported				
L3 Services: IPv4 / IPv6 Internet (GRT)	Supported				
L2 Services: EVPN-VPWS (ELINE P2P)	Supported				Not supported
L2 Services: EVPN (ELAN BD)	Supported		Roadmap	Supported	Not supported
SRv6TE: SRv6 PCE (ODN)	Supported				
SRv6TE: Headend w/ Explicit Path	Supported				
Path Tracing	Not supported		Supported		

Conclusion



Key Takeaways

- SRv6 is gaining significant traction with network operators globally
- SRv6 is fully standardized and ready for deployment
- Services delivered today with MPLS can be delivered with SRv6 with greater simplicity and scalability
- Cisco is making significant investments in SRv6 across our portfolio

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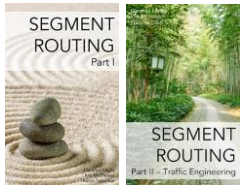

Segment Routing, Part I / II Textbooks

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More SRv6 @ Cisco Live Las Vegas 2023

Session	Title	Time & Location
BRKSPG-2039	Architecting Modern Broadband Networks	Monday, Jun 5 3:00 PM - 4:30 PM PDT Level 2, Mandalay Bay L
BRKSPG-2043	Simplify your journey to SR and SRv6 with Crosswork Automation	Monday, Jun 5 4:00 PM - 5:00 PM PDT Level 2, Oceanside F
BRKMPL-2203	SRv6 Fundamentals	Tuesday, Jun 6 3:00 PM - 4:30 PM PDT Level 3, South Seas B
BRKMPL-2117	SRv6 based IP Transport – Design, Deployment Best Practices & Challenges	On-Demand Video
LABMPL-1201	SRv6 Basics	Walk-in Lab
LABSP-3393	Implementing Segment Routing v6 (SRv6) Transport on NCS 55xx/5xx platforms	Walk-in Lab

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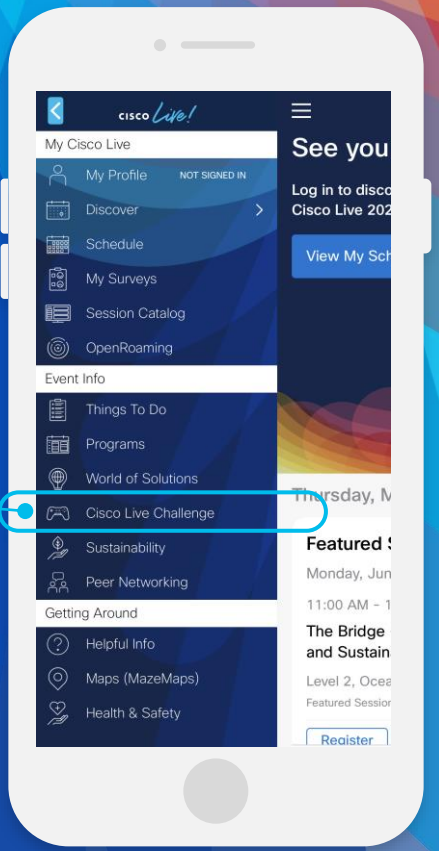


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