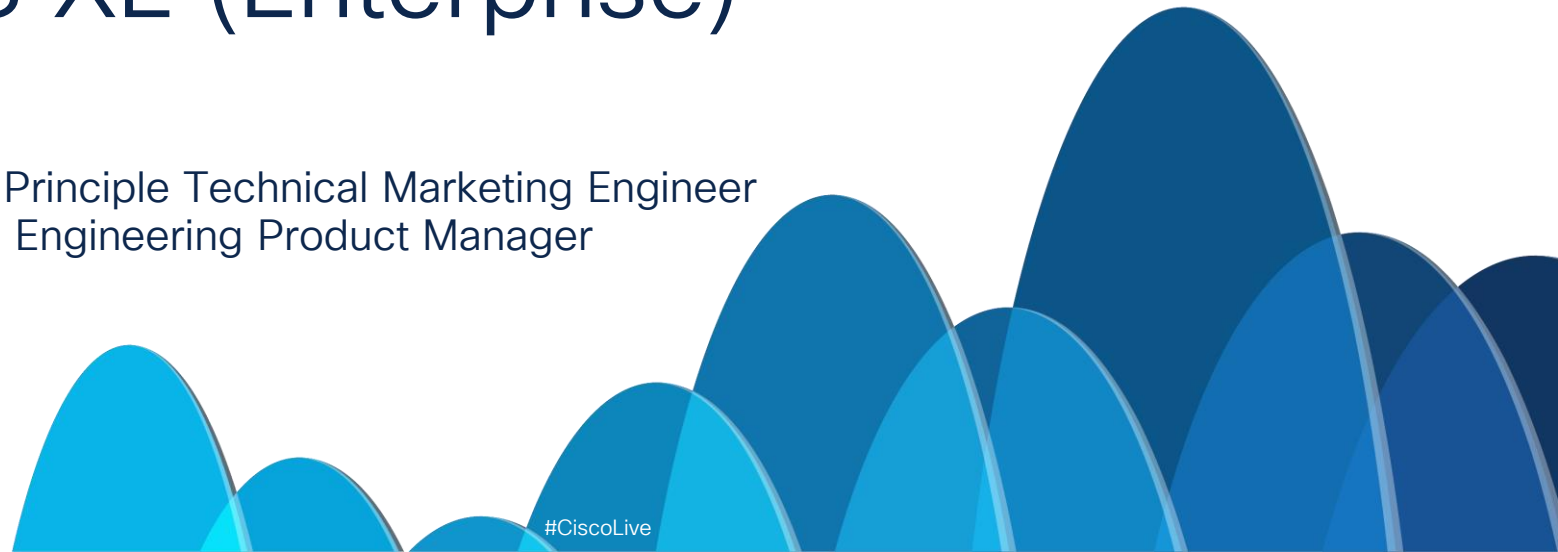
The bridge to possible

Segment Routing Innovations in IOS XE (Enterprise)

Jason Yang, Principle Technical Marketing Engineer
Sumant Mali, Engineering Product Manager

BRKENT-1520



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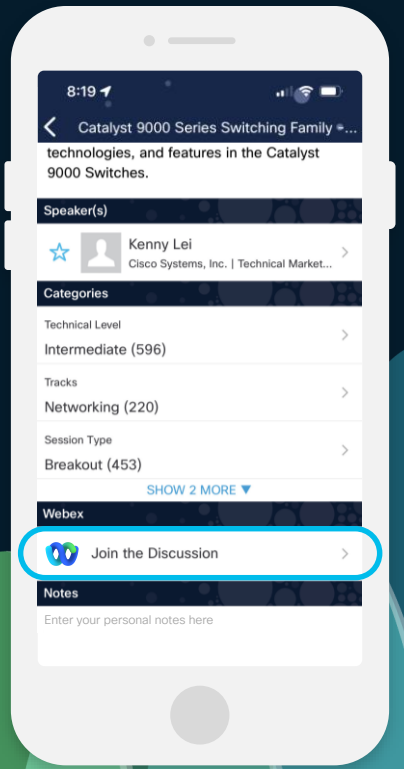
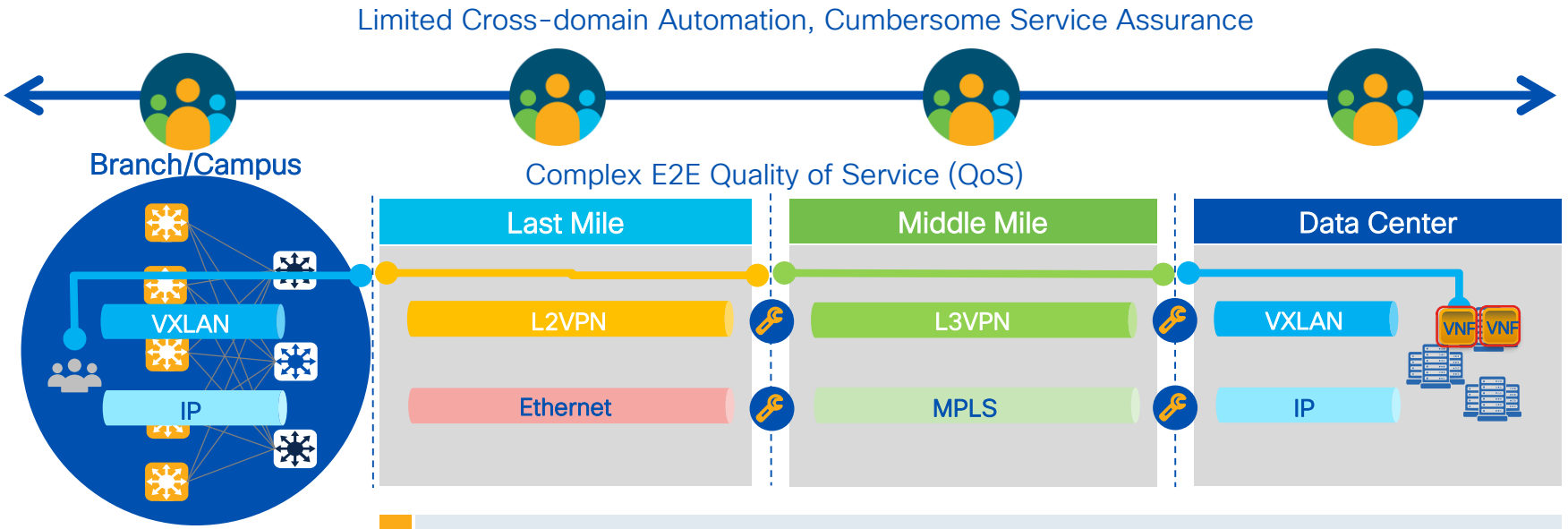


Agenda

- Why SRv6 in Enterprise
- SRv6 Use Cases in EN
- SRv6 Introduction

The Legacy Service Creation

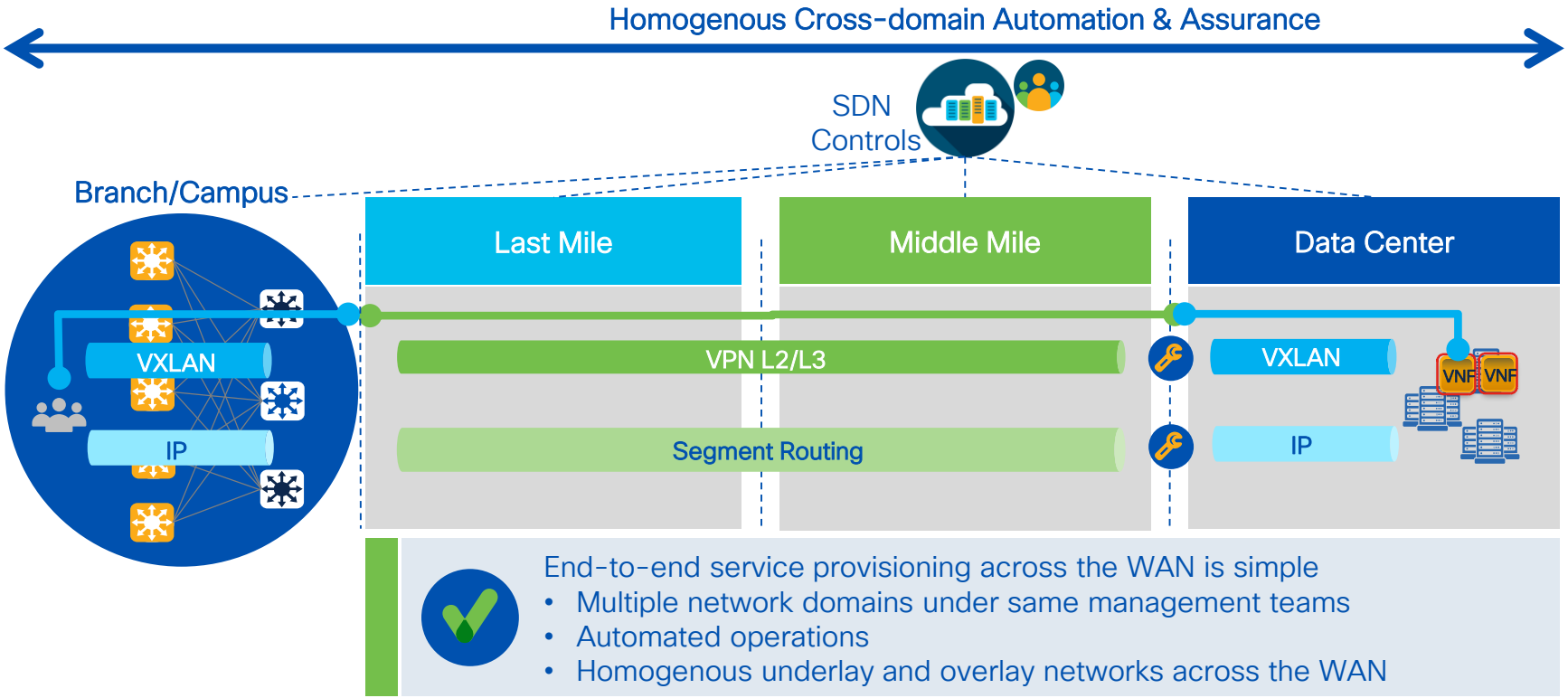


End-to-end service provisioning is lengthy and complex

- Multiple network domains under different management teams
- Manual operations
- Boundary Gateways requiring DPI / Protocol Conversion
- Heterogeneous underlay and overlay networks
  - Consequence: Low Scale, High Cost, Low Reliability

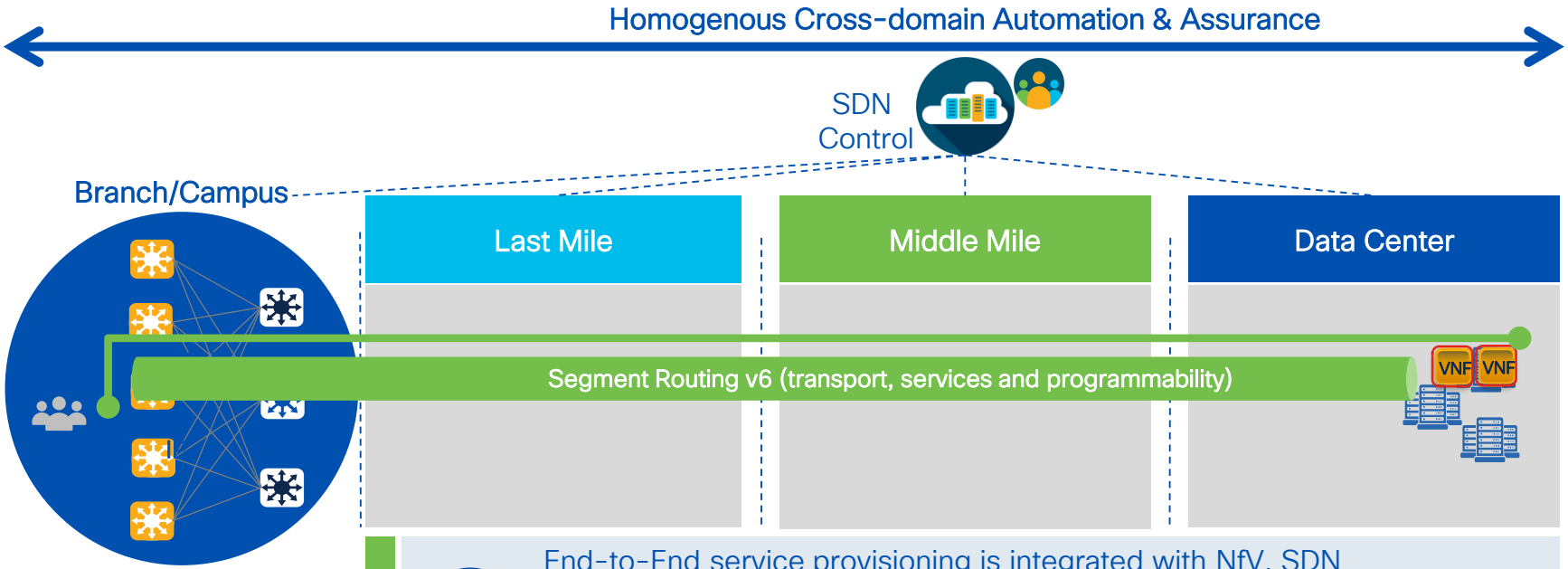
Today “Network as a Fabric” for Service Creation

SR-MPLS



Future “Network as an API” for Service Creation

SRv6



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

- Multiple network domains under same management teams
- Automated operations
- Integrated underlay and overlay networks
- Network as API – programmable end to end user to app solution
- Hyper Scale

SRv6 Use Cases in Enterprise

SRv6 Use Cases in Enterprise

Segments

- National Critical Infra
- Energy Services
- Military Protected Core
- Large Enterprise

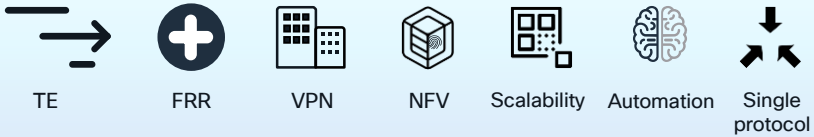
They all have their own private WAN, w/ public networks as add-on

Needs

- Reliable and resilient network second to none
- Network makes their own routing decision, no dependency on controller.
- Security domain compliance in each country

Solution – SRv6

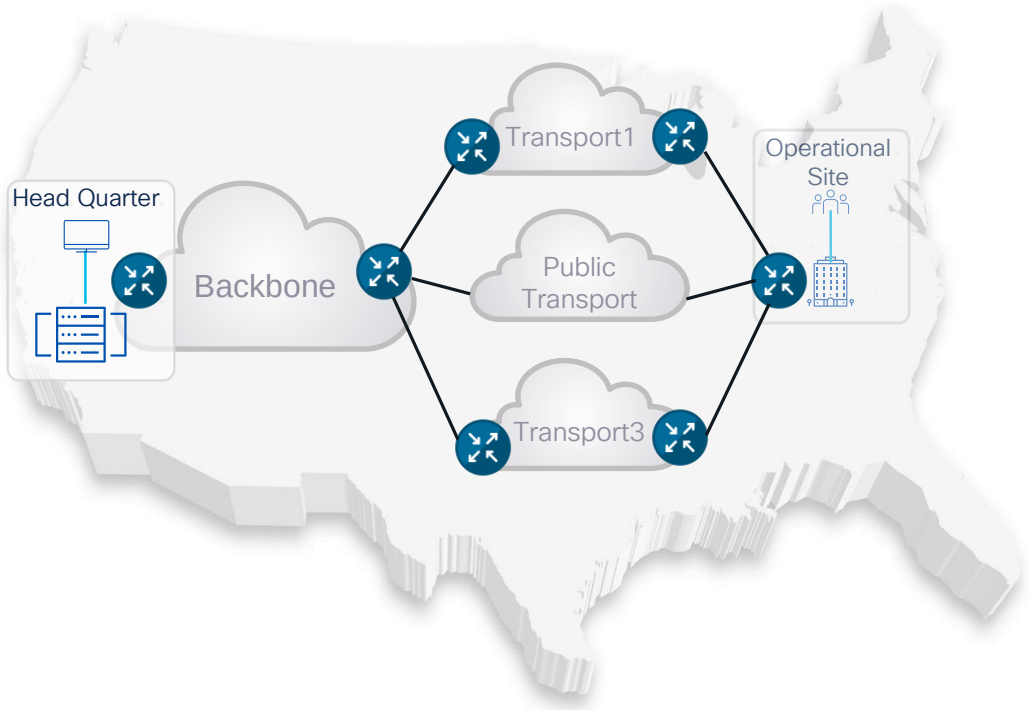
- Simplify network stack – no legacy protocol encap
- Universality: WAN, xHaul, DC, Metro, IoT, Host, etc.
- Enables tight application interaction w/ network i.e. application-driven network programmability
- Seamless brownfield deployment with classic IPv6



Case Study 1 – National Critical Infra

Customer Requirements:

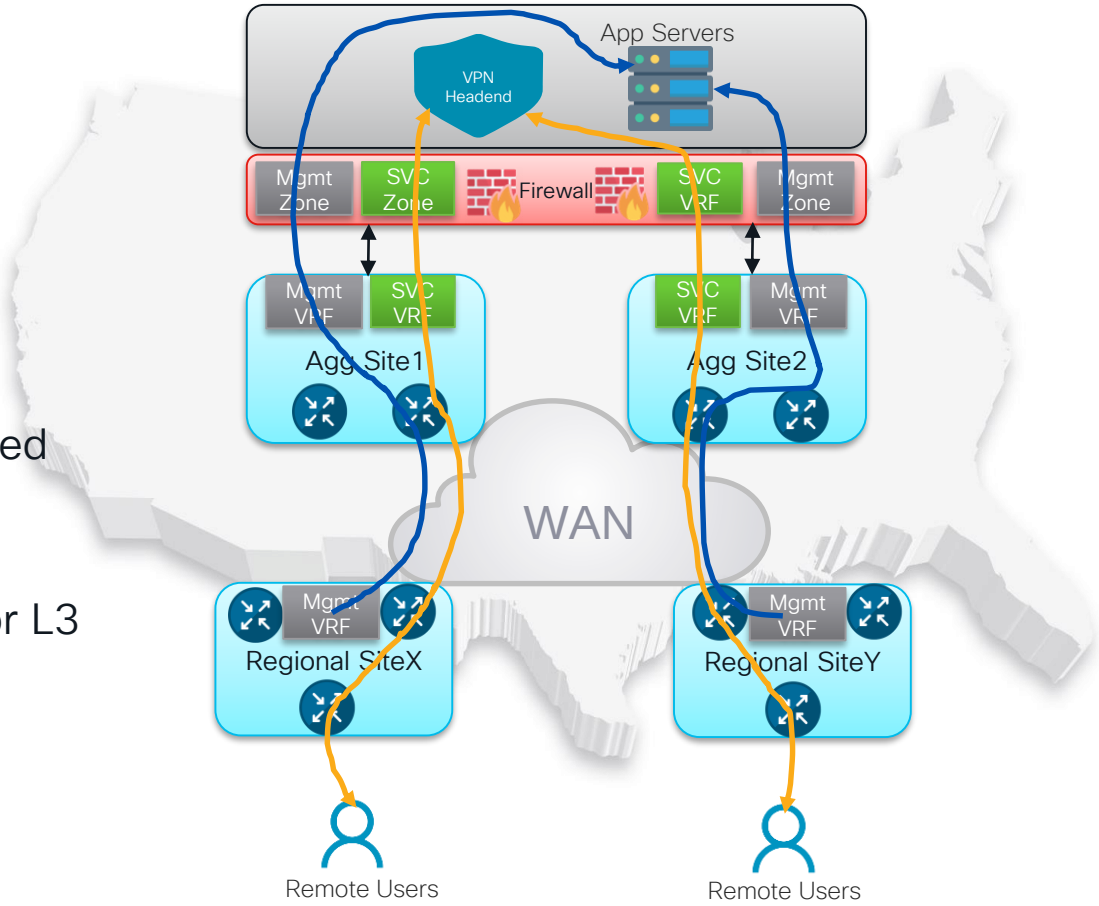
- IPv6 over multiple transports
- L3 Segmentation
- Voice & Video needs to be routed to low latency path
- M365 needs to be routed to high BW path
- Business critical app needs to be routed over Transport1, if unreachable find the best alternative SLA path
- If primary path fail, then traffic needs to be re-routed to alternative path within few seconds



Case Study 2 - Manufacturing Network

Customer Requirements:

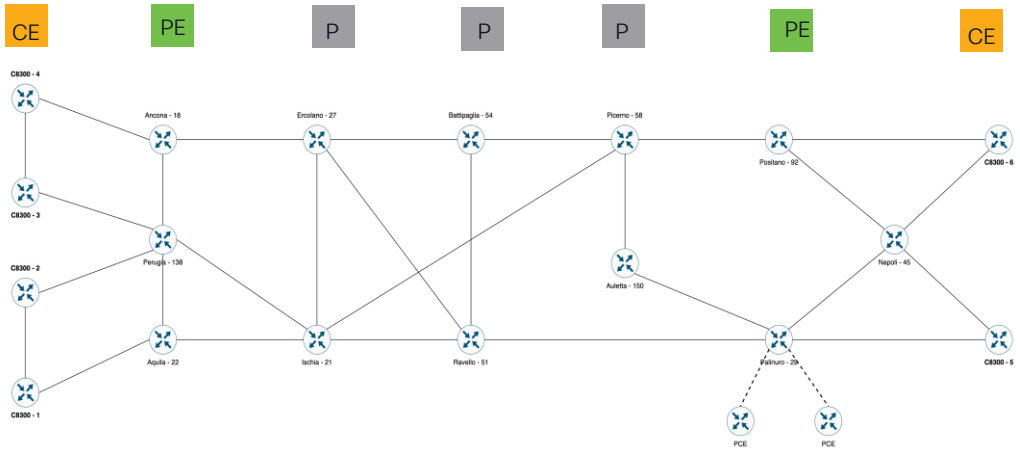
- IPv6 native to SRv6 migration
- Multi-sites connected via private WAN
- App(IPv6), VPN(IPv4) and traffic segmentation
- Remote VPN can not be terminated in regional sites but in DC VPN headend
- Bridge-domain for L2 with BDI for L3
- Fast Reroute for link/node failure
- WAN MACsec



Case Study 3 – Transportation Requirement

Customer Requirements

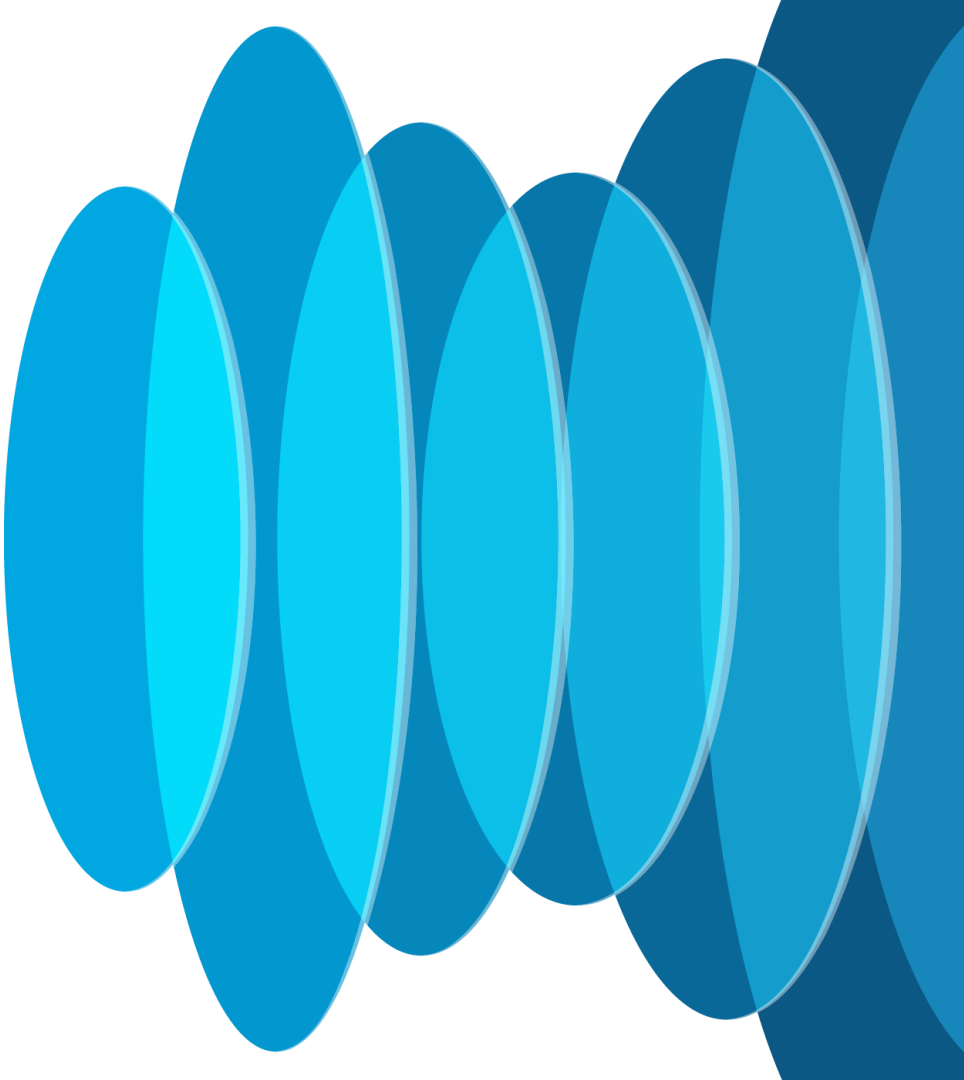
- MPLS to SRv6 migration
- Turn CE into CPEs to have end to end SRv6 uSID and only one touchpoint to provision new services to the “object” directly on the cPE.
- “Always-on / never out” network



Existing network problems:

- MPLS VPN with VRF lite to CE and a lot of touchpoint to provision services,
- slow convergence and
- complex redundancy

SRv6 Introduction



SRv6

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

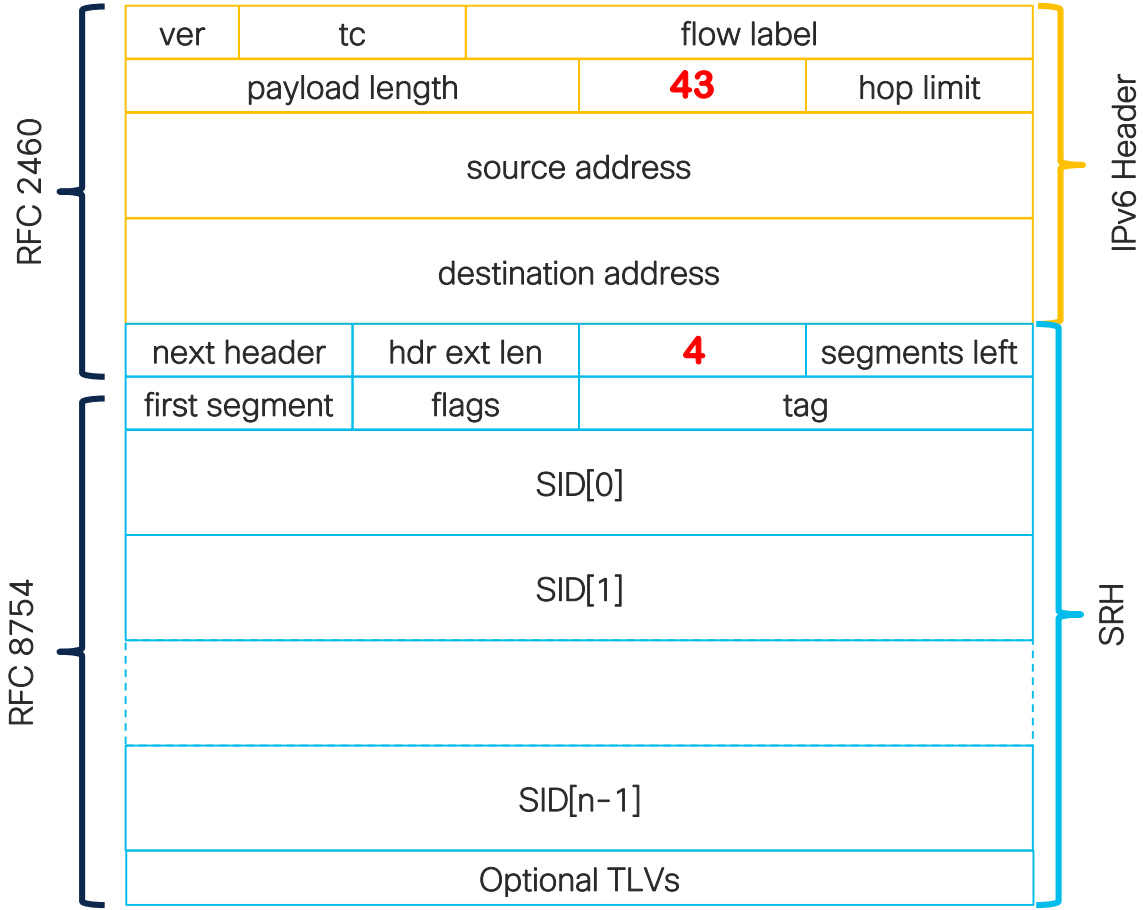
0 Source Route (deprecated)

1 Nimrod (deprecated)

2 Type 2 (RFC 6275)

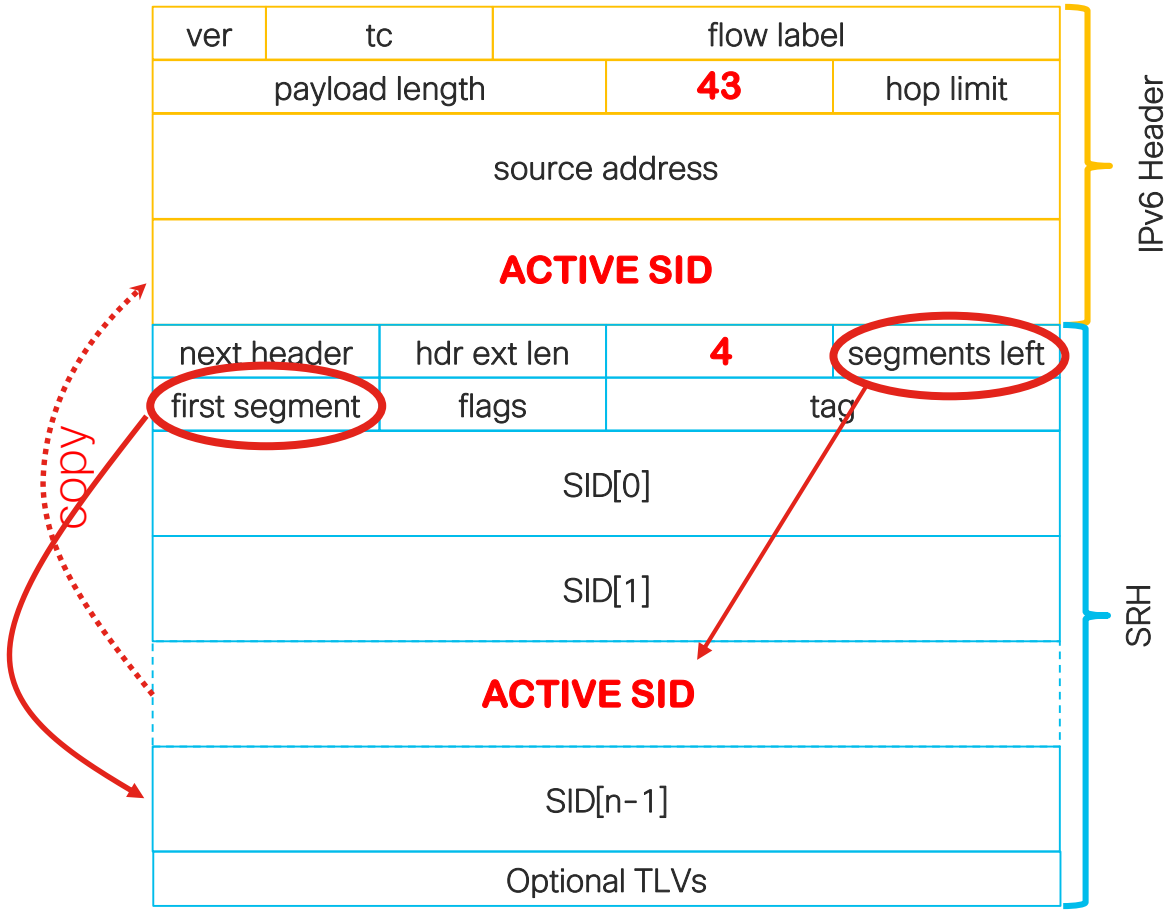
3 RPL (RFC 6554)

4 SRH (RFC 8754)

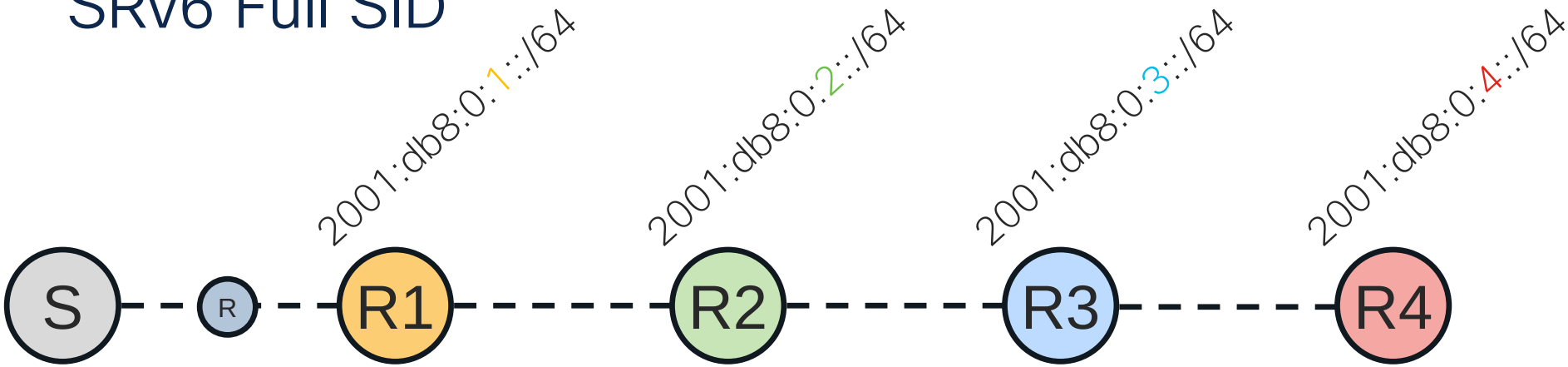


SRH

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



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::
```

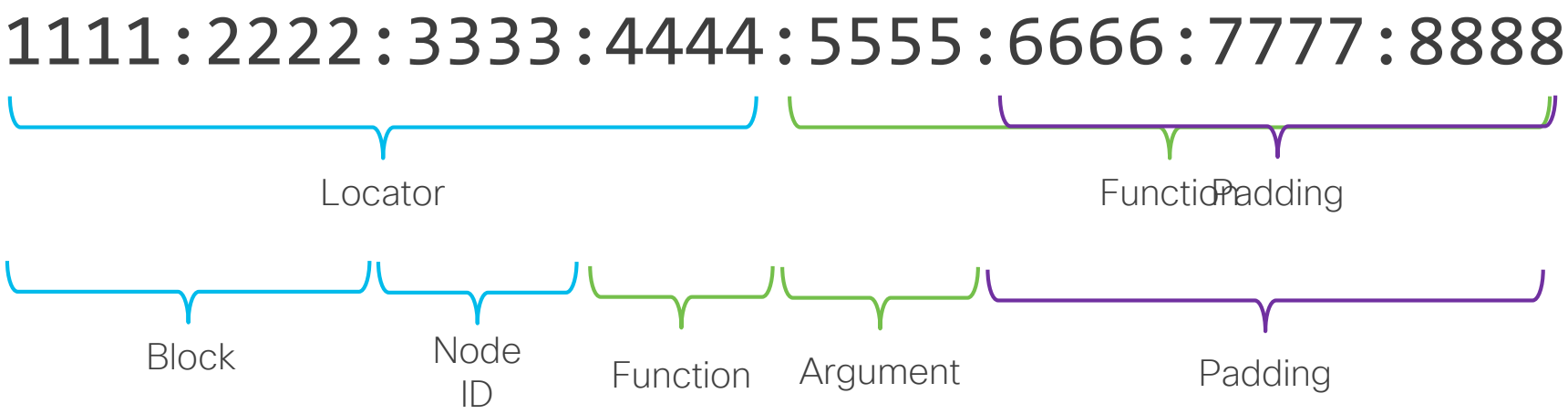
```
SA:2001::1
DA:2001:db8:0:2:1::
NH:RH
Type:4(SRH)
NH:IPv4|SL:2
Segment List:
[0]:2001:db8:0:4:eeee::
[1]:2001:db8:0:3:48::
[2]:2001:db8:0:2:1::
[3]:2001:db8:0:1:1::
```

```
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:IPv4
```

SID Structure

128 Bits Like IPv6 address but different semantics

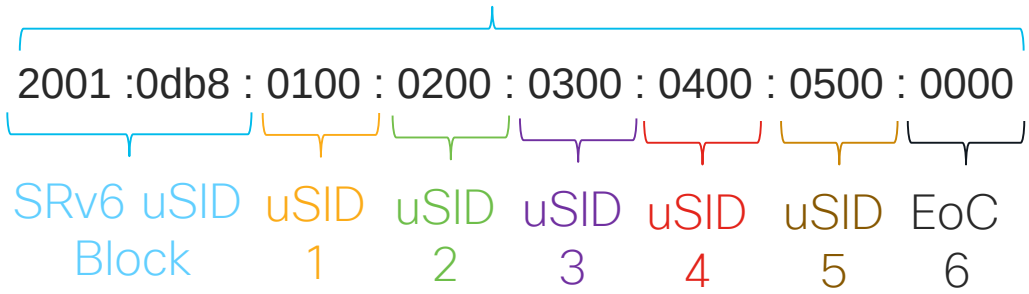


Why SRv6 uSID

: 0100 : =SRV6 uSID

16 bits here, but can be anything

SRV6 uSID Container



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
```

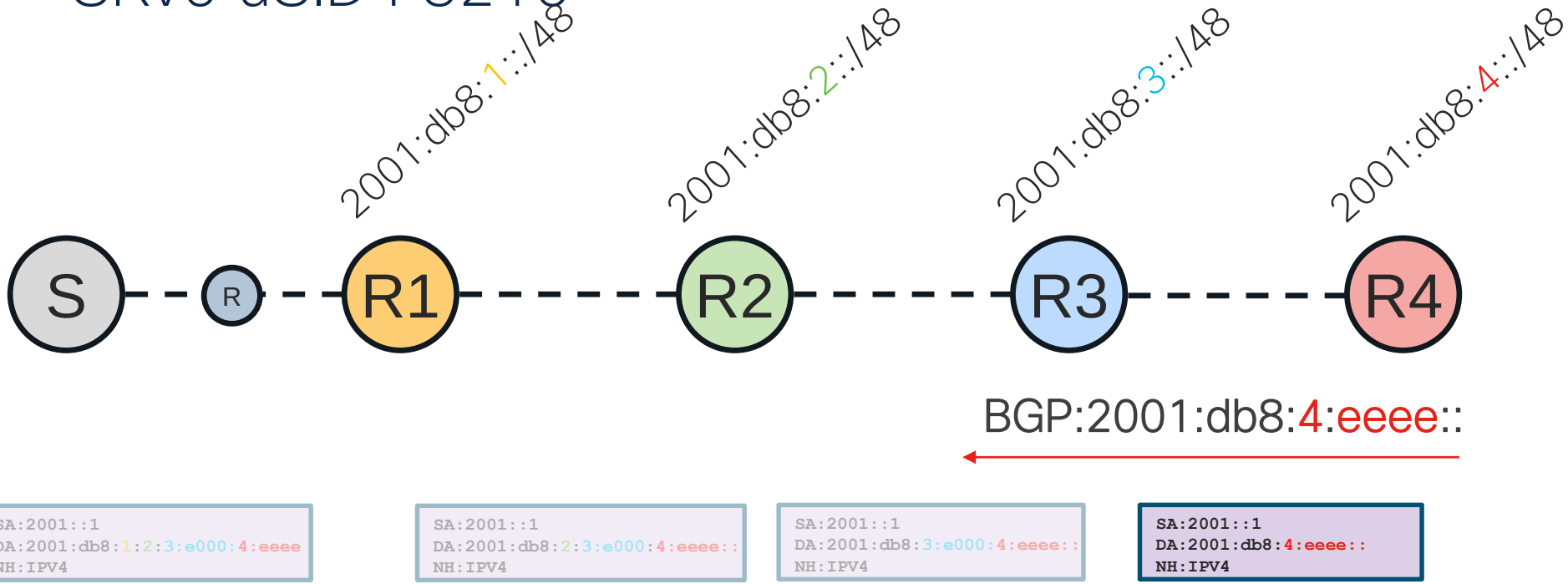
SRV6 uSID Encapsulation

```
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 functions: Network Programming and Services

What is supported in IOS XE

Codename		Behavior	
End	uN	END with Next – Default endpoint	[Node SID]
End.X	uA	Endpoint with Layer-3 cross-connect	[Adj SID]
End.DT6	uDT6	Endpoint with decapsulation and specific IPv6 table lookup	[L3VPN IPv6 Per-VRF]
End.DT4	uDT4	Endpoint with decapsulation and specific IPv4 table lookup	[L3VPN IPv4 Per-VRF]
End.DT46	uDT46	Endpoint with decapsulation and lookup IPv4 and IPv6 in same VRF	[L3VPN single SID for both IPv4 and IPv6]

IS-IS for SRv6

LSP (Link State Packet):

TLVs:

Hostname: r2

Interfaces: Ten0/0/0 uA:fcbb:0:2:e001::

Structure: BL=32;NL=16;FL=16;AL=0

Te0/0/1 uA:fcbb:0:2:e002::

Structure: BL=32;NL=16;FL=16;AL=0

Lo0

Neighbors: r1

r3

IP addresses: fcbb:0:2::1/128

2001:12::2/64

Locator: fcbb:0:2::/48

uN:fcbb:0:2::

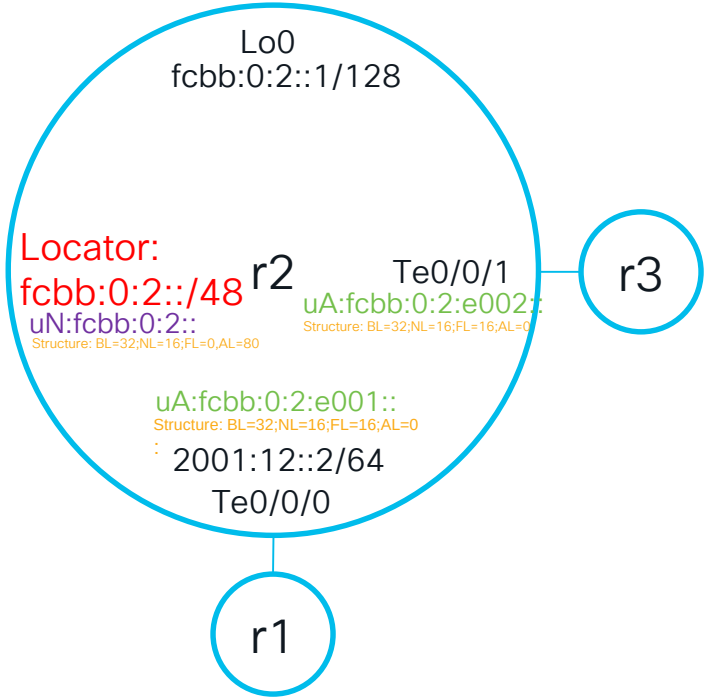
Structure: BL=32;NL=16;FL=0,AL=80

Capabilities: Algorithms .....

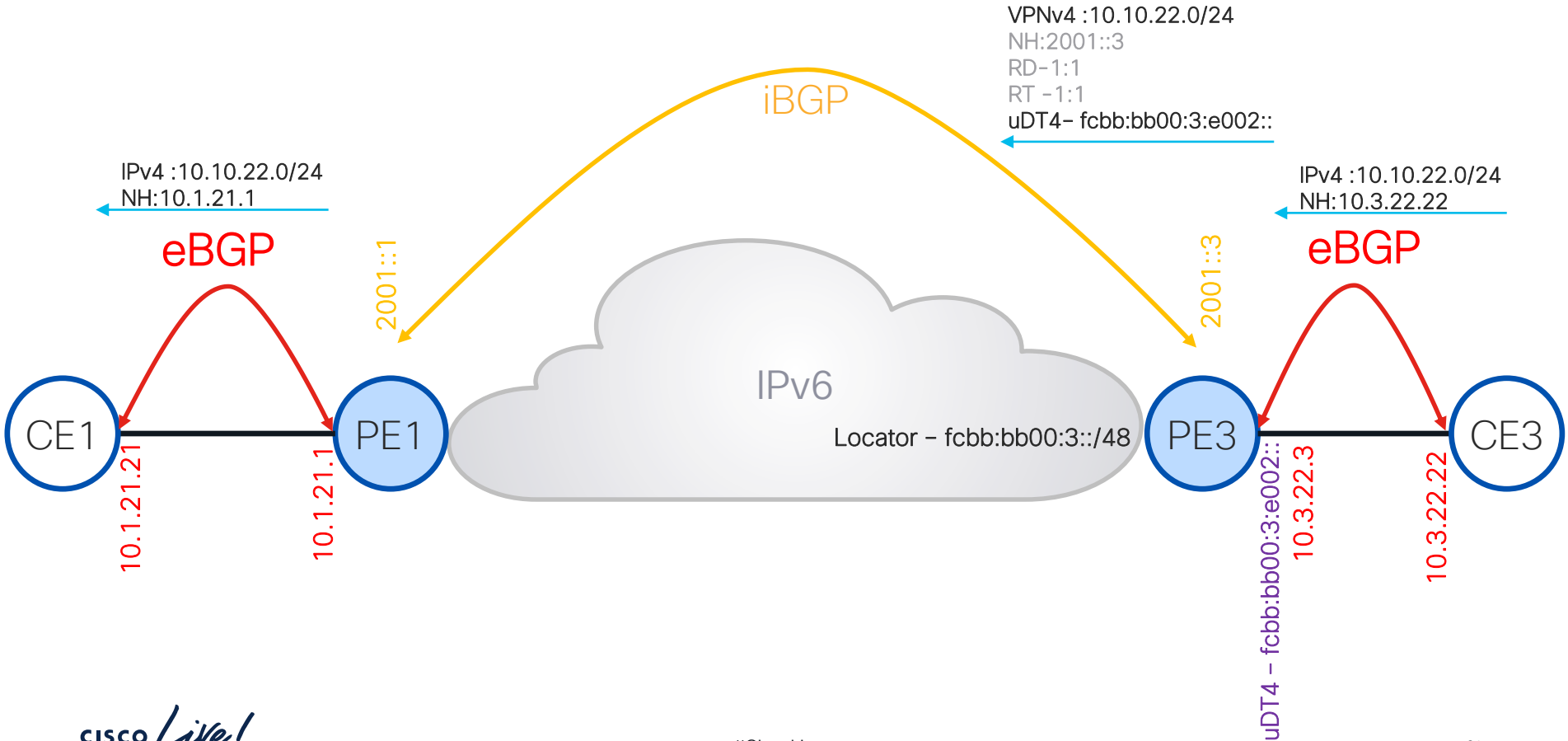
SIDs can insert

SIDs can decap

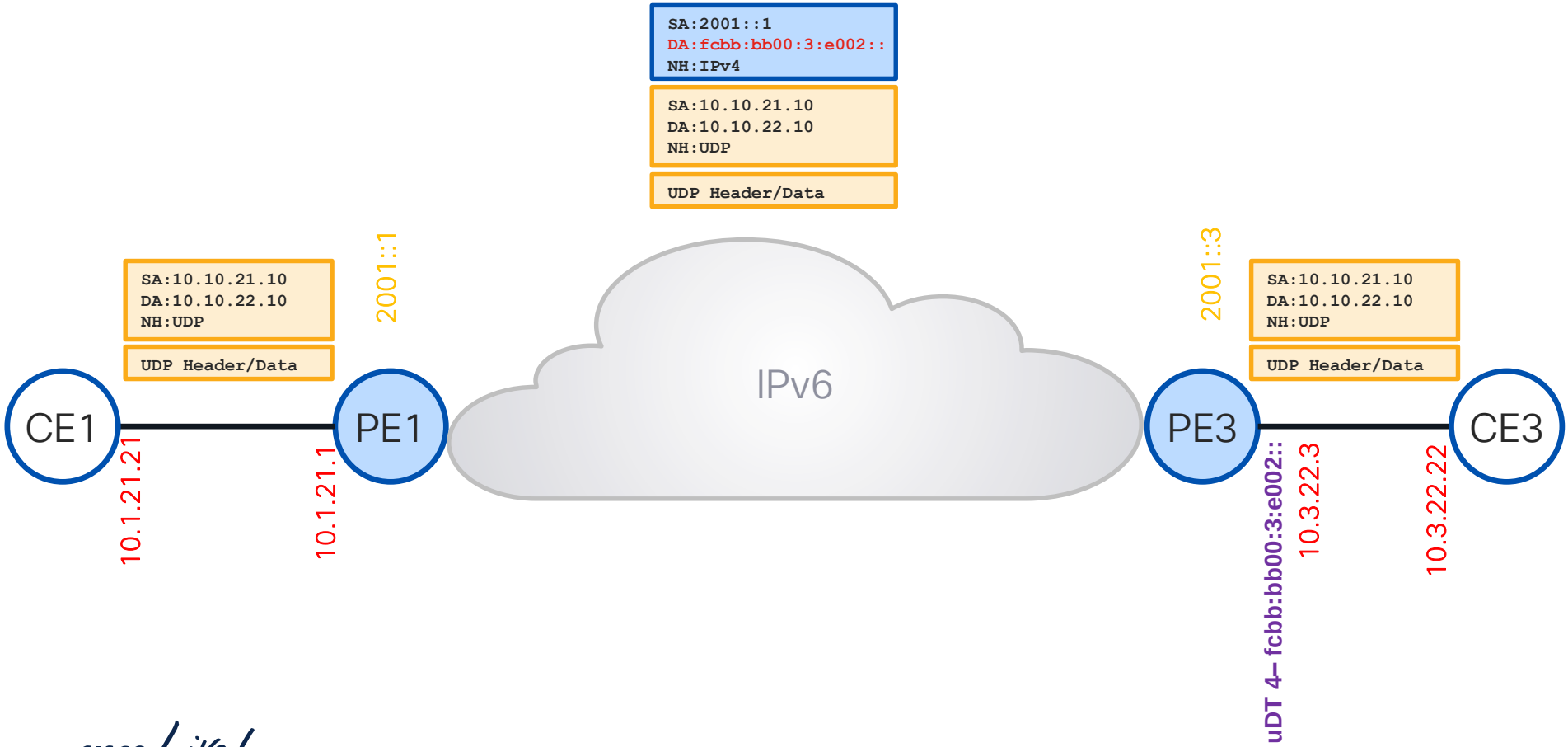
.....



BGP for SRv6



L3 VPN Forwarding



SRv6 Policy

Per-Destination Policy (PDP)

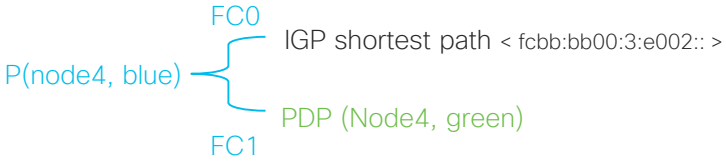
- The policy determines which candidate path to use based on the candidate path's preference and state
- A candidate path is either dynamic or explicit

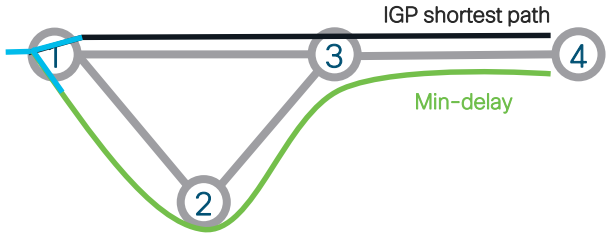
Per-Flow Policy (PFP)

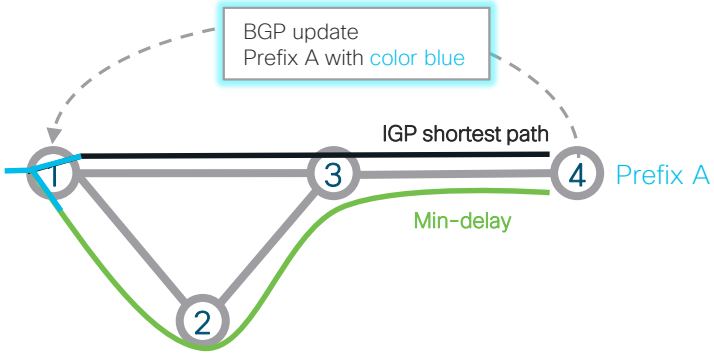
- A PFP is identified by <color, endpoint>. It is configured with a per-flow forwarding class (FC) table with up to 8 entries, with each entry indexed by an FC and pointing to a PDP

Per-Flow Policy w/ ODN/AS

- The egress node advertise BGP route for a prefix A to the ingress node with SLA hint "color-blue" encoded with an ext. BGP color community.
- BGP dynamically instantiate SRv6 policies to steer traffic onto on-demand next-hop (ODN)
- An ePBR policy is applied to the ingress interface to classify traffic and associated with the FC.

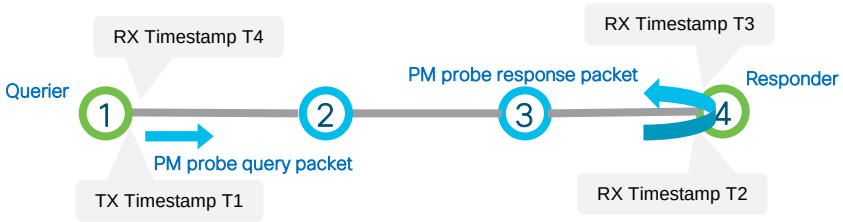






Performance Measurement for SRv6

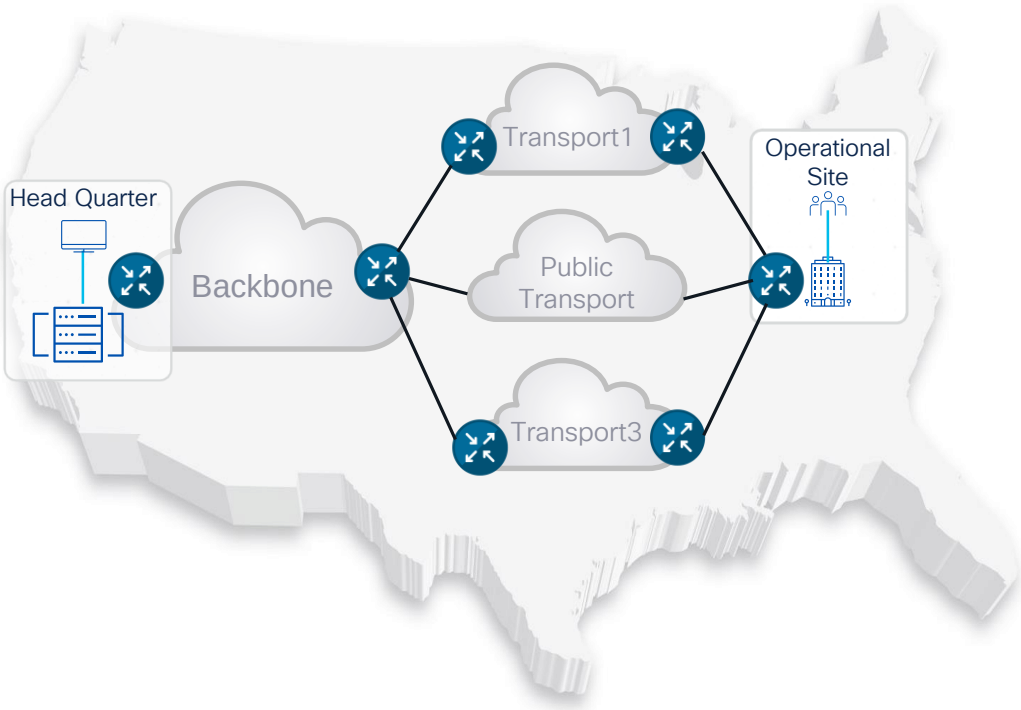
- PM Liveness Detection
  - PM probes all the segment lists of every candidate paths
  - Probes are sent every 3 seconds
  - Option to configure the path programmed in HW only after it was validated with PM probes
  - Reoptimize to a different candidate path if PM probes failed
  - Or bring the policy down if no other paths available
- PM delay measurement



  - 1-way mode delay measurement E2E =(T2-T1)
  - 2-way mode delay measurement E2E =(T4-T1)-(T3-T2)

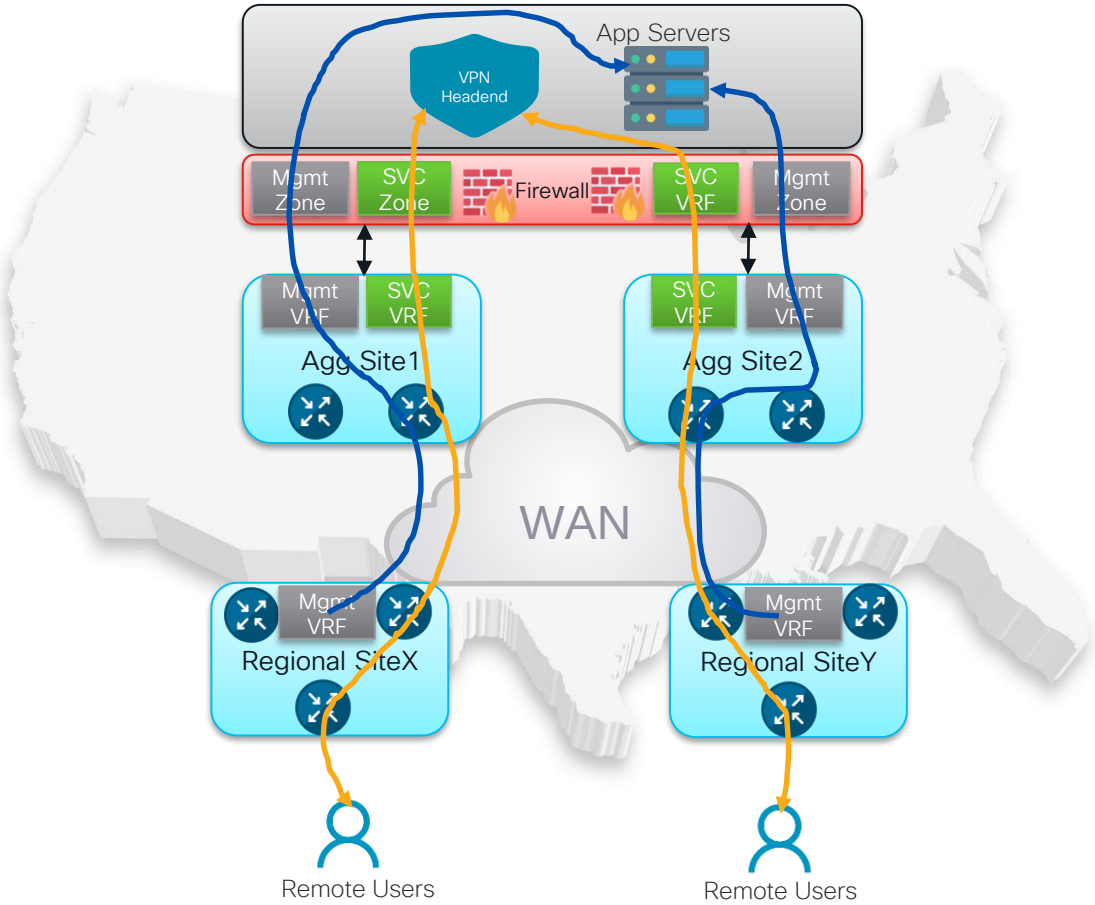
Case Study 1 Solution – National Critical Infra

- IS-IS w/ SRv6 extension as transport
- SRv6 over GRE with Tunnel Protection for public transport
- SRv6 over MACsec for private transport
- SRv6 BGP L3VPN ODN/AS
- SRv6 PDP/PFP policy to route the right app to the right path
- PM for policy liveness detection and latency measurement



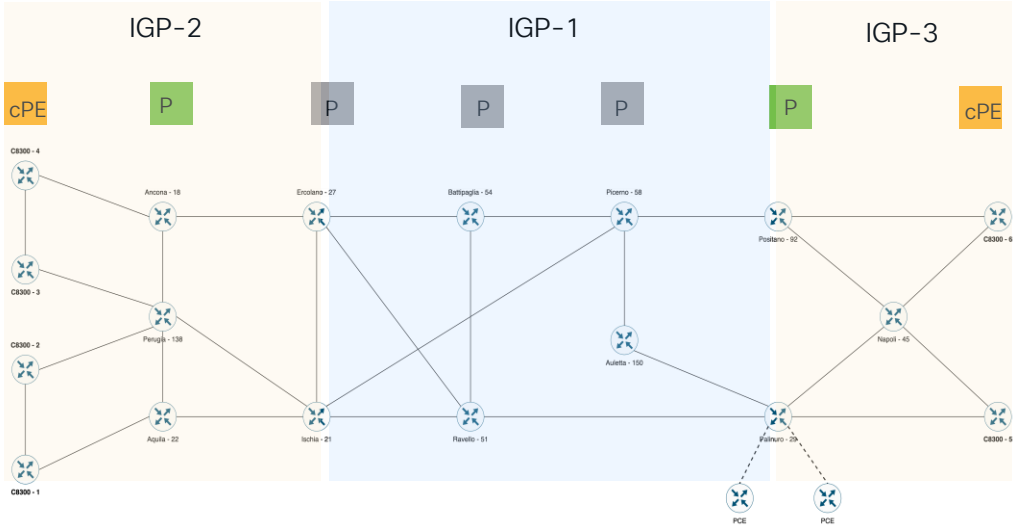
Case Study 2 Solution – Manufacturing Network

- IS-IS w/ SRv6 extension as transport
- SRv6 over MACsec
- SRv6 BGP as service for L3VPN
- SRv6 TI-LFA



Case Study 3 Solution – Transportation Network

- IS-IS w/ SRv6 extension
- 3 different IGP domains
- PCE for inter-domain reachability
- SRv6 BGP for L3VPN service
- SRv6 TI-LFA
- SRv6 Policy with Flex Algo



SRv6 Capabilities in EN Routing

IOS XE 17.12

Reference slide

- IS-IS SRv6 extension
- BGP L3VPN (v4/v6) for SRv6
- SRv6 policy select egress interface on ingress PE via PFP
- Static route for IPv6 and IPv4
- SRv6 over IPv6 GRE with Tunnel Protection
- SRv6 path failure detection and reroute

IOS XE 17.12 – cont'd

Reference slide

- SRv6 OAM (ping/traceroute)
  1. IPv6 ping/traceroute CE-CE
  2. IPv4 ping/traceroute CE-CE
  3. IPv6 ping/traceroute PE-CE
  4. IPv4 ping/traceroute PE-CE
  5. IPv6 SID ping/traceroute PE-PE
  6. IPv6 VRF ping/traceroute PE-CE using custom SRv6 SID list

IOS XE 17.12 – cont'd

Reference slide

- SRv6 Performance Measurement (PM)
  1. PM liveness for path-proofing and re-optimization
  2. PM over IPv6 links for delay metric
  3. End-to-end delay measurement

IOS XE 17.13

Reference slide

- BGP L3VPN On-Demand Next-hop (ODN) and auto steering (AS)

IOS XE SRv6 uSID and Behaviors

Reference slide

- Supports uSID (F3216), consistent with customer deployment blueprint
- Support End-behaviors*:
  - uN (PSP/USD)
  - uA (PSP/USD)
  - uDT6
  - uDT4
  - uDT46
- Support Policy Headend behaviors*:
  - H.Encaps.Red

*Behaviors reference: rfc8986

Scale

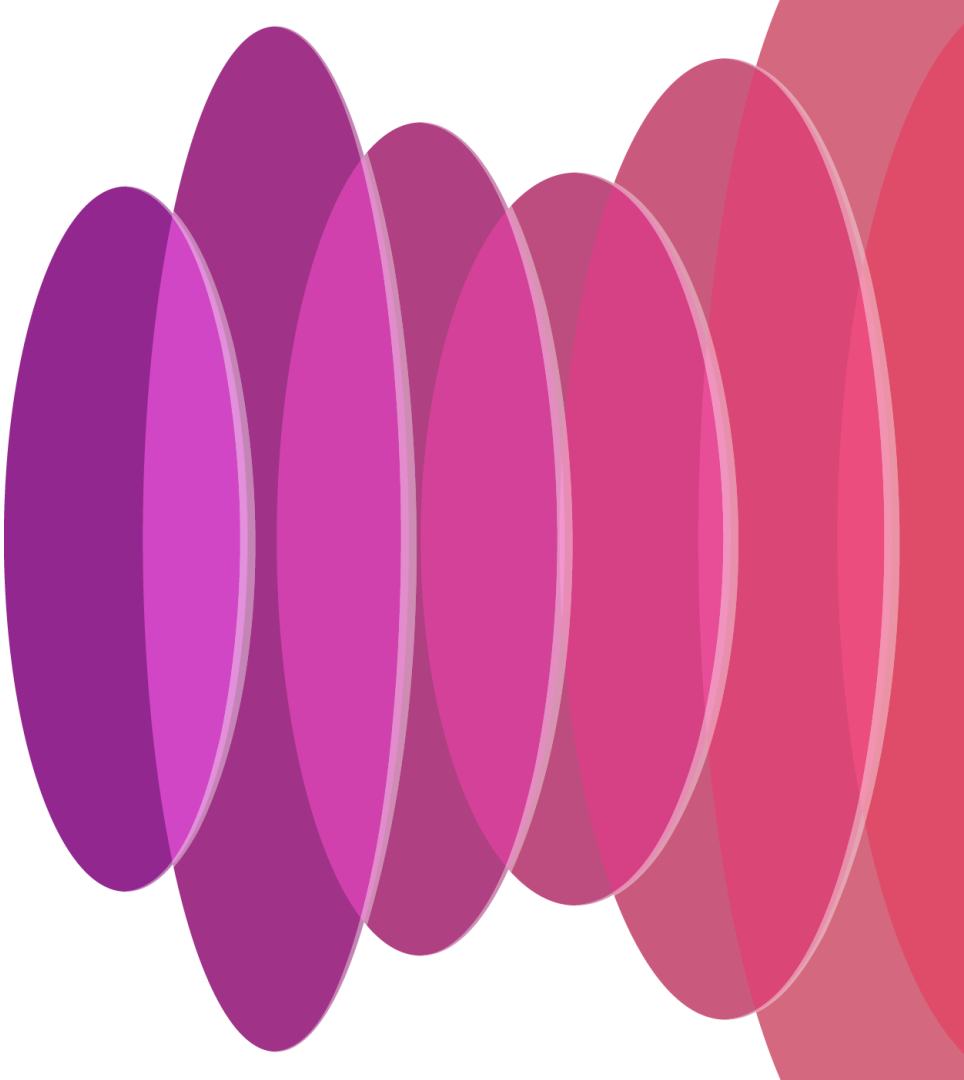
Reference slide

- Support up to 16 segments in the forwarding list
- 200 PFP
- 1000 PDP
- 2000 Candidate Paths (2 per PDP)
- Max 2 ECMP paths per Candidate Path
- 1000 PDPs * 2 Candidate Paths/PDP * 2 ECMP Paths/Candidate path = 4000 PM Sessions

Platforms

- Catalyst 8500/8500L
- Catalyst 8300
- Catalyst 8200
- Catalyst 8000V
- ASR1002-HX
- ASR1001-HX
- ASR1000-RP3/ESP100-X

SRv6 Journey



SRv6 - the journey

Reference slide

17.15

- SRv6 TI-LFA
- SRv6 OAM TE
- SRv6 Micro Loop (uLoop) Avoidance
- SRv6 Path MTU

Radar

- Flex Algo
- Flex Algo with TI-LFA
- Oper models
- DX2
- DT2U
- DT2M

Reference slide

SR Learning Path

Session ID	Title	Session Type	Speakers	Schedule and location
TECSPG-1000	Segment Routing Masterclass	Technical Seminar	Jose Liste | Jakub Horn	Jun 2 | 9:00 am - 1:00 pm L2, Breakers BH
BRKMPL-2203	Introduction to SRv6 uSID Technology	Breakout	Jakub Horn	Jun 3 | 10:30 am - 12:00 pm L3, South Seas B
BRKMPL-2135	Preparing for a Successful Segment Routing Deployment -	Breakout	Jose Liste	Jun 3 |10:30 am - 12:00 pm L2, Surf EF
BRKENT-1520	Segment Routing Innovations in IOS XE	Breakout	Jason Yang | Sumant Mali	Jun 3 | 9:30 am - 10:30 am L3, Palm D
BRKMPL-2131	Deploying VPNs over Segment Routed Networks Made Easy	Breakout	Krishnan Thirukonda	Jun 3 | 01:00 PM / LL, Tradewinds DEF
BRKMPL-2177	Empower Your Network with Segment Routing and MPLS Network Migration	Breakout	Thomas Wang	Jun 3 | 9:30 am - 10:30 am LL, Tradewinds DEF
BRKMPL-2043	Simplify Your Journey to SR and SRv6 with Cisco Crosswork Automation	Breakout	Sujay Murthy | Eric Ortheau	Jun 4 | 04:00 PM / LL, Tradewinds ABC

SR Learning Path

Reference slide

Session ID	Title	Session Type	Speakers	Schedule and location
BRKSPG-2474	Reduced Resolution Time with Svc-centric Approach to Troubleshooting	Breakout	Paola Arosia	
LTRSPG-2006	Explore the Power of SRv6: Unleashing the Potential of Next-Generation Networking -	Instructor-led Lab	Jakub Horn | Marius Stoica | Alex Kiritchenko	Jun 5 | 8:00 am - 12:00 pm Luxor - L1, Lotus 3
BRKMPL-2133	Circuit-Style Segment Routing and Service Emulation -	Breakout	Thomas Wang	Jun 5 | 4:00 pm - 5:00 pm L2, Surf CD
BRKSPG-2263	Design, Deploy and Manage Transport Slices using SDN Controller and Assurance	Breakout	Sujay Murthy	Jun 6 | 09:30 AM / LL, Tradewinds ABC
BRKSPG-2870	Automate Transport Service Provisioning, Optimization, and Assurance with SDN Controller	Breakout	Deepak Bhargava	Jun 6 | 01:00 PM / L3, South Seas J
LABMPL-1201	SRv6 Basics	Walk-in Lab	Luc De Ghein	
LABSP-3393	Implementing Segment Routing v6 (SRv6) Transport on NCS 55xx/5xx and Cisco 8000: Advanced -	Walk-in Lab	Paban Sarma | Gautam Renjen | Alexey Babaytsev	
LABSPG-3000	Configure and Implement BGP-EVPN with Segment Routing using NCS 55xx/5xx Platforms	Walk-in Lab	Tejas Lad | Paban Sarma	

Call to Action

Explore how SRv6 can help to solve problems in your network and develop your own use case

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Contact me at: jayang@cisco.com

Thank you