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The bridge to possible

Traffic-Engineering with SR and SRv6 Evolution

How SRv6 Simplified Network

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BRKMPL-2119

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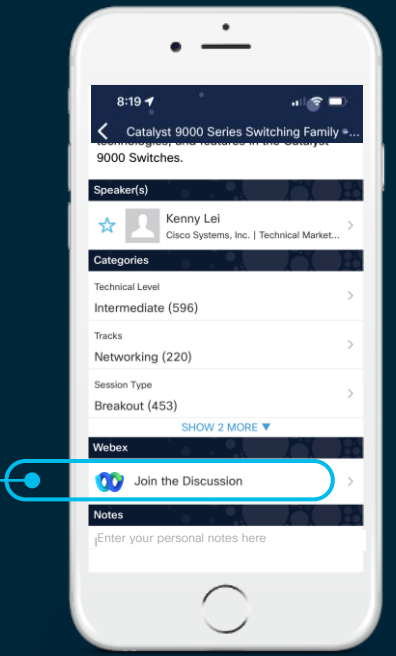

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Agenda

- Introduction
- Traffic-engineering Considerations
- How SRv6 Simplified Network
- SRv6 Scale and Efficiency
- SRv6 Service Examples
- Conclusion

Network requirements for today & beyond

High scale of network
As 5G and cloud develops, IoT and virtual nodes bring in large number of network connections, which require high scale of IP addresses.

High-quality Connections
Low-latency & bandwidth guarantee enhanced user-experience. Such as cloud AR/VR services require low delay, which driving the demand of data path with traffic-engineering.

Network programmable
Smart and automate way to set up connection that allow service provision in hours instead of weeks. Also, easier to locate the faults in minutes instead of days.

Network Scalability and Technology Shifting

IPv4 address space is exhausted

IPv6 is inevitable

IPv6 migration solutions are ready

Dual stack is recommended & widely deployed

IPv6 is growing faster than IPv4

Adopting IPv6 will show technology leadership & enable business innovation

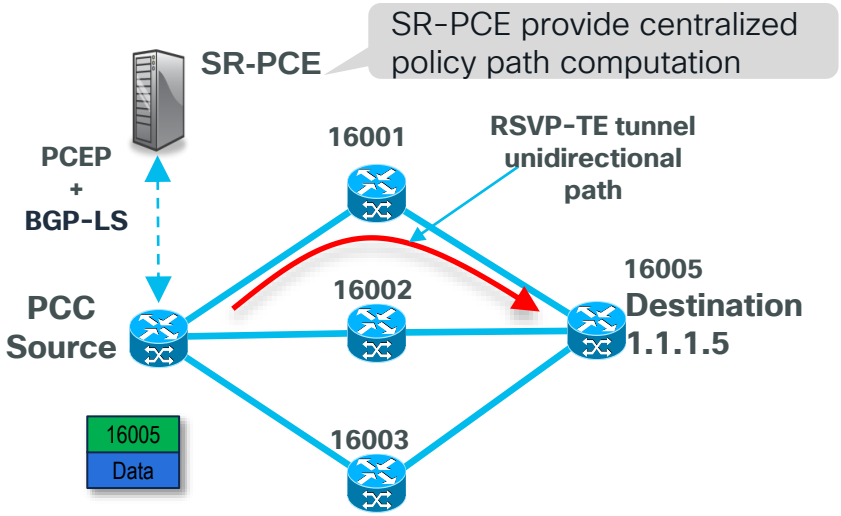
IPv6 enables advanced innovations

SRv6, 5G, Cloud Computing & more futuristic technologies are fueled by IPv6

Stateless SR-TE vs Stateful RSVP-TE

- Source Routing
  - Source chooses a path and encodes it in the packet header as an ordered list of segments
  - The rest of the network nodes execute the SR encoded instructions
- Stateless SR-TE Policy
  - Policy label stack with Node-SID, or Adj-SID
  - Each Policy assigned unique Binding-SID
  - Node-SID ECMP Load-balance by IGP Nature
  - SR-PCE controller-based Inter-domain SR policy path calculation available
- Failure Protection - TiLFA
  - Local reroute comparable to MPLS TE Link / Node without RSVP signaling
  - IGP algorithm, support Microloop avoidance

	SR-TE	RSVP-TE
TE state only at head-end	Yes	No
ECMP-capability for TE	Yes	No
Engineered for SDN	Yes	Yes/No



How SRv6 Simplified Network

Segment Routing over IPv6 Fabric

DATA PLANE

- Native IPv6 (Brown field migration)
- SRv6 (SRv6 extension header)

CONTROL PLANE

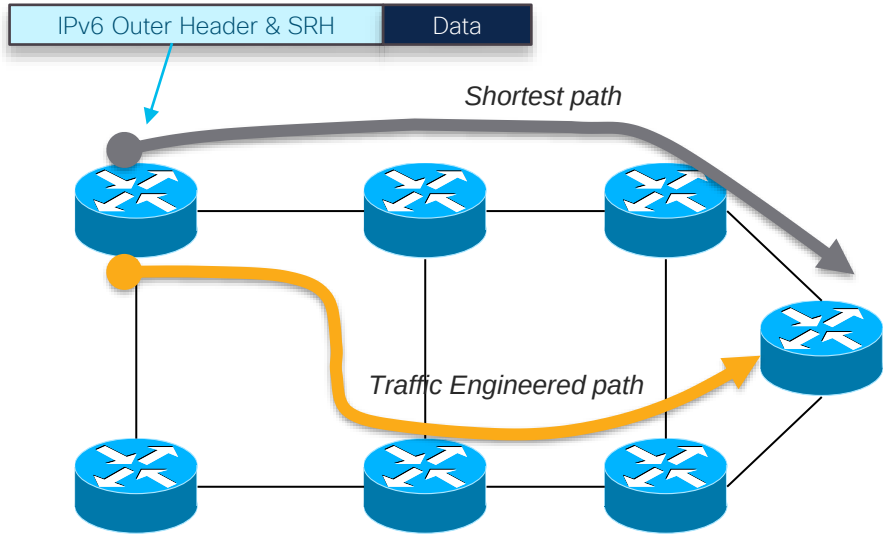
- Routing protocols with extensions (IS-IS, OSPF, BGP)
- SDN controller (BGP, PCEP, NETCONF/YANG)

PATH OPTIONS

- Dynamic (Optimized CSPF computation)
- Explicit (expressed in the packet)

SRv6 Function and Service

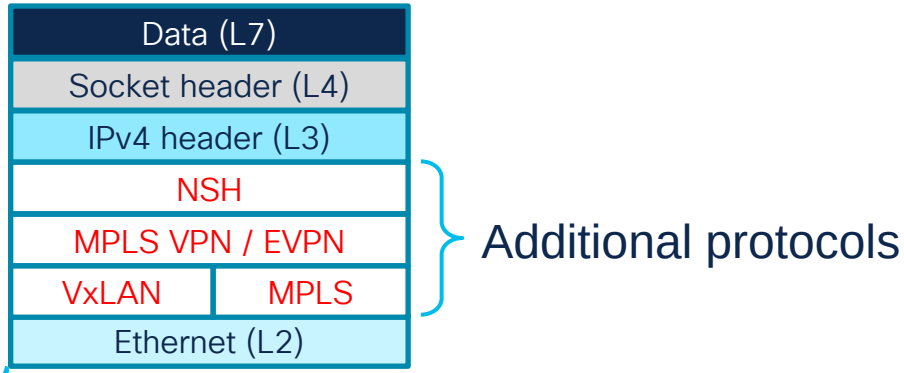
- Over stateless IPv6 fabric
- Path expressed in the packet header
- Enable service without additional protocols!



IPv4 Network Services Buildup

Network Functions	IPv4
Reachability	IPv4 Header
Engineered Load Balancing	MPLS Entropy Label, VxLAN UDP
VPN	MPLS VPN, VxLAN, 6PE/VPE
Traffic Engineering	RSVP-TE, SR-TE MPLS
Source Routing	SR-TE MPLS
Service Chaining	NSH

IPv4 Address space 32-bit
No optional header to support
- VPN
- Traffic Engineering
- Service Chaining
- Engineered Flow optimization
- Source-Routing

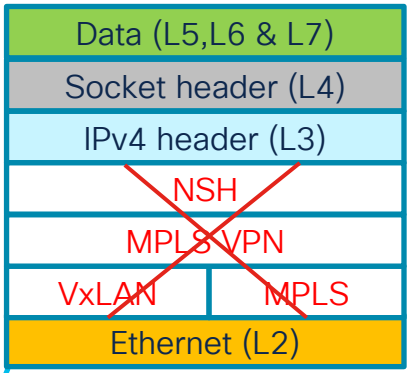


SRv6 Simplified Solution

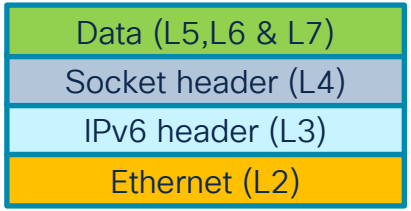
Network Functions	IPv6
Reachability	IPv6 Header
Engineered Load Balancing	IPv6 Header
VPN	IPv6 Header
Traffic Engineering	IPv6 Header
Source Routing	IPv6 Header
Service Chaining	IPv6 Header

IPv6 Address 128bits
IPv6 Flow Header
- Engineered Flow optimization

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



Simplicity
(back to OSI model)



SRv6 unleash IPv6 fabric potentials

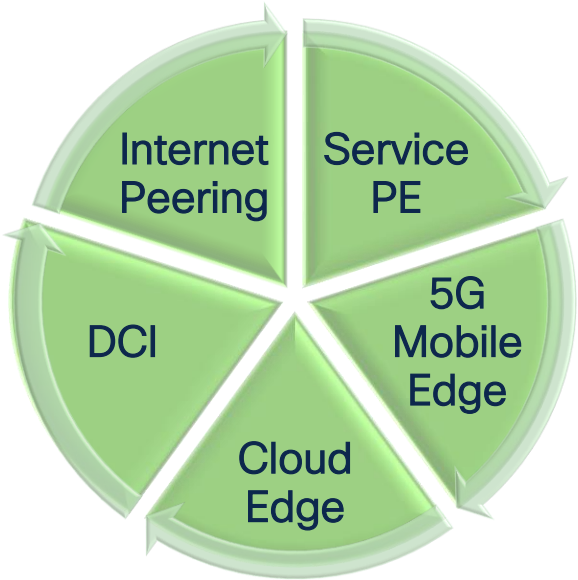
Leverage IPv6 huge address space for end-to-end services

Hyperscale provided by IPv6 Prefix summarization (impossible in MPLS)

Fast convergence enabled by IPv6/SRv6
No need additional MPLS/RSVP protocols

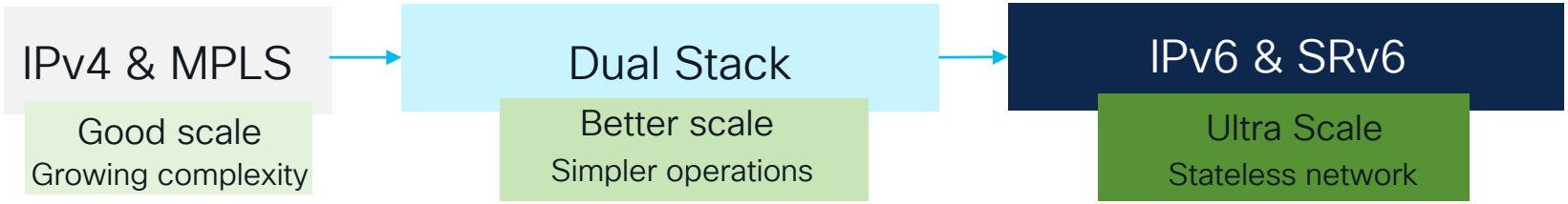
Seamless deployment with classic IPv6 nodes
SRv6-based services only required on edge nodes

IOS-XR IPv6 Forwarding optimization
Improved hashing based IPv6 forwarding



Multiple Market Segments

Network Scalability and Simplification



Hybrid Solutions:

Build IPv6 fabric & ready to upgrade with SRv6 services

- IPv4 & IPv6 protocols run in parallel
- Build IPv6 fabric core networks
- Incremental upgrade to SRv6 on PEs for L2/L3VPN services

IPv6 Overlay:

End-to-end IPv6 with on-demand SRv6 services

- Programmable SRv6 network over stateless IPv6 fabric
- IPv6-everywhere, SRv6 service on-demand

SRv6 Scale & Efficiency

SRv6 Base-format & Operations

SRv6 Optimized for HW processing

Integrate underlay & tenant use-cases

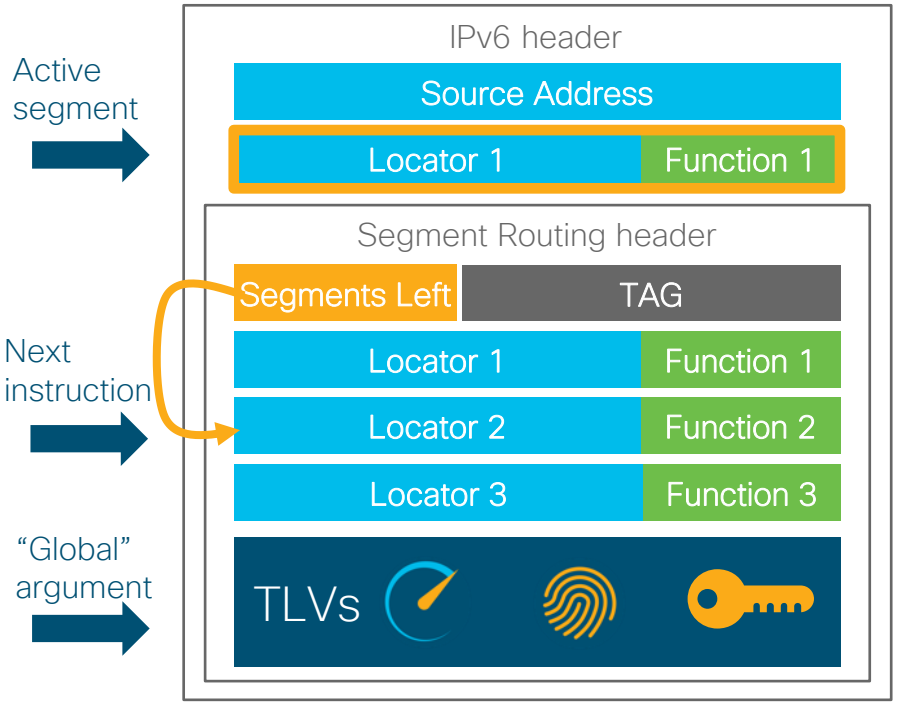
SRv6 provides network intelligence for SW processing

Encoding service as a function of SRv6 SIDs

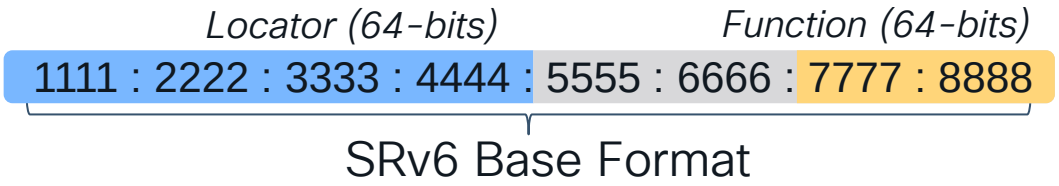
SRv6 allows huge simplification and enables IPv6 to be self-sufficient

Ultra-scale and end-to-end policy

Stateless network programming

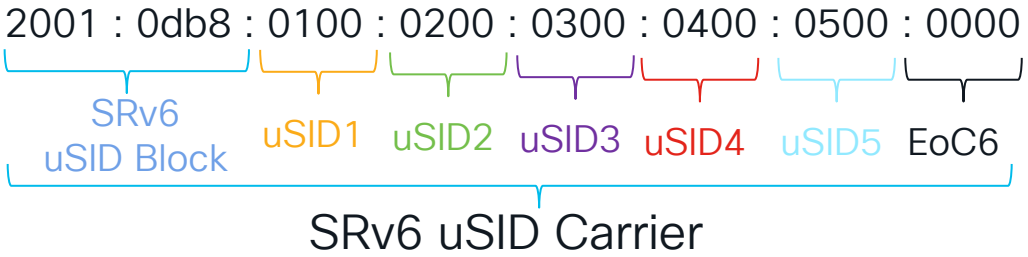


SRv6 Micro-segment vs Base-format



Micro-segment (uSID) F3216 format: (32+16x6=128)

- uSID Block size: 32 bits
- uSID size: 16 bits



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 Multi-carrier & MTU Efficiency

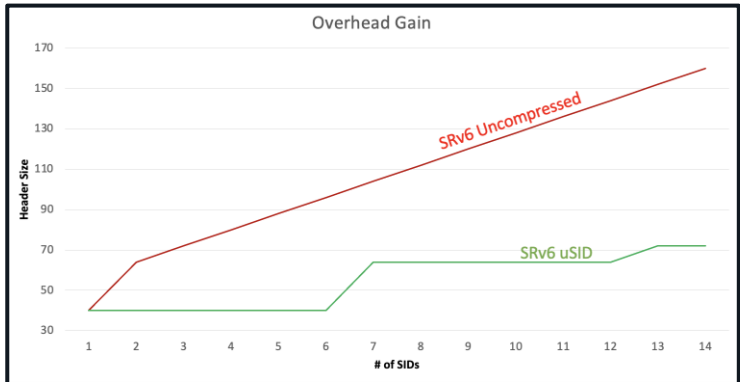
Outer DA: FCBB:BB00:0001:0002:0003:0004:0005:0006

uSID1 uSID2 uSID3 uSID4 uSID5 uSID6

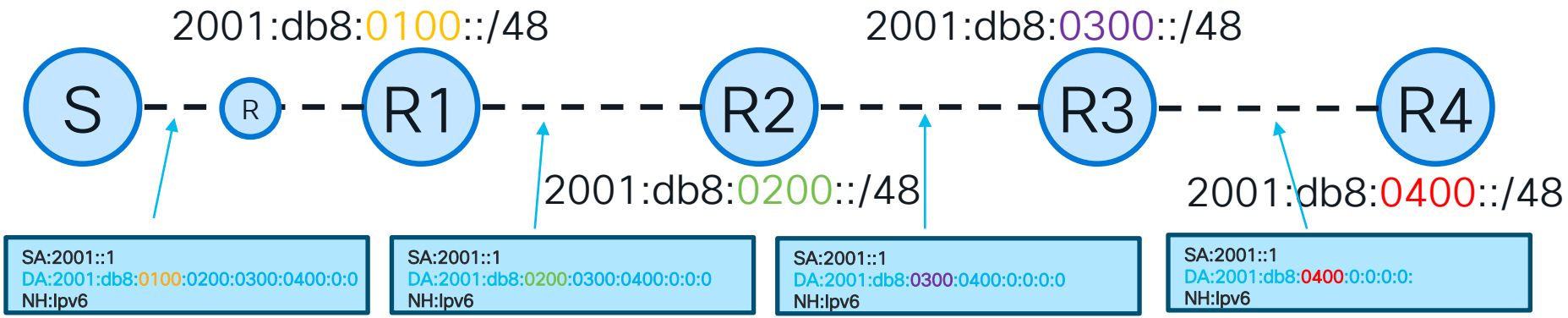
Outer SRH: FCBB:BB00:0007:0008:0009:0010:0011:0012

uSID7 uSID8 uSID9 uSID10 uSID11 uSID12

- SRv6 policy SID-list default support up to 12 uSIDs
  - 6 in the outer DA, 6 in the SRH
  - With solely 24-bytes of MTU overhead



SRv6 uSID Shift & Forward



Shift & Forward

Active uSID | Next uSID | Last uSID

Incoming DA	2001:db8:0100:0200:0300:0400::
Shift	2001:db8:0200:0300:0400::
Forward	Lookup result for 2001:db8:0200::/48

SRv6 Micro-segment (uSID) Advantages

SRv6 uSID Simplified network instructions

Shift & Forward uSID

Control Plane Benefits:

Scale of Multi-domain global unique uSIDs

No new protocol extensions required

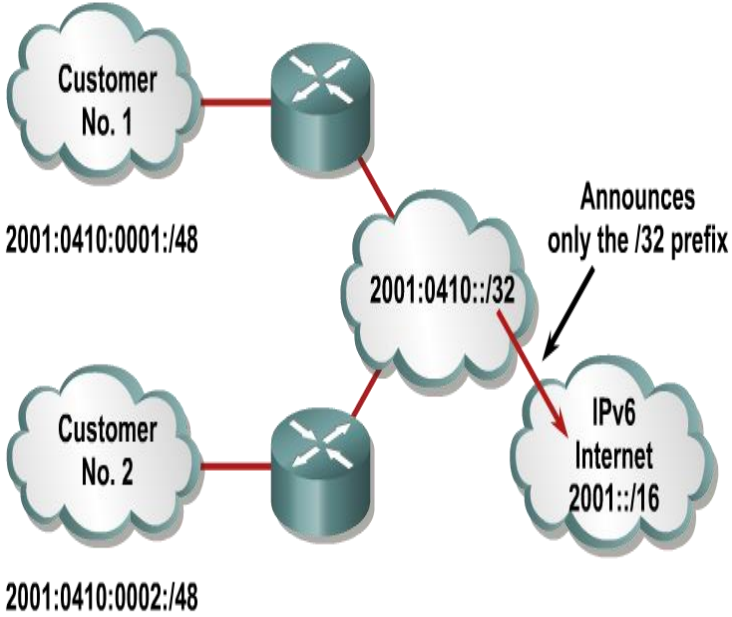
Data Plane Benefits:

IP summarization and hashing is POWERFUL

Lowest MTU efficiency (up to 6 uSIDs without SRH)

SRv6 uSID richness function provide network service and intelligence

VPN services binding with uSID



SRv6 Carry-on the Value of SR-MPLS

New Revenue Services

Real-Time Low Latency Services
Path Disjointness (Network Multi-plane)
Bandwidth Optimization
Point-to-Multipoint with Tree-SID
Inter-domain Egress Peer Engineering (EPE)

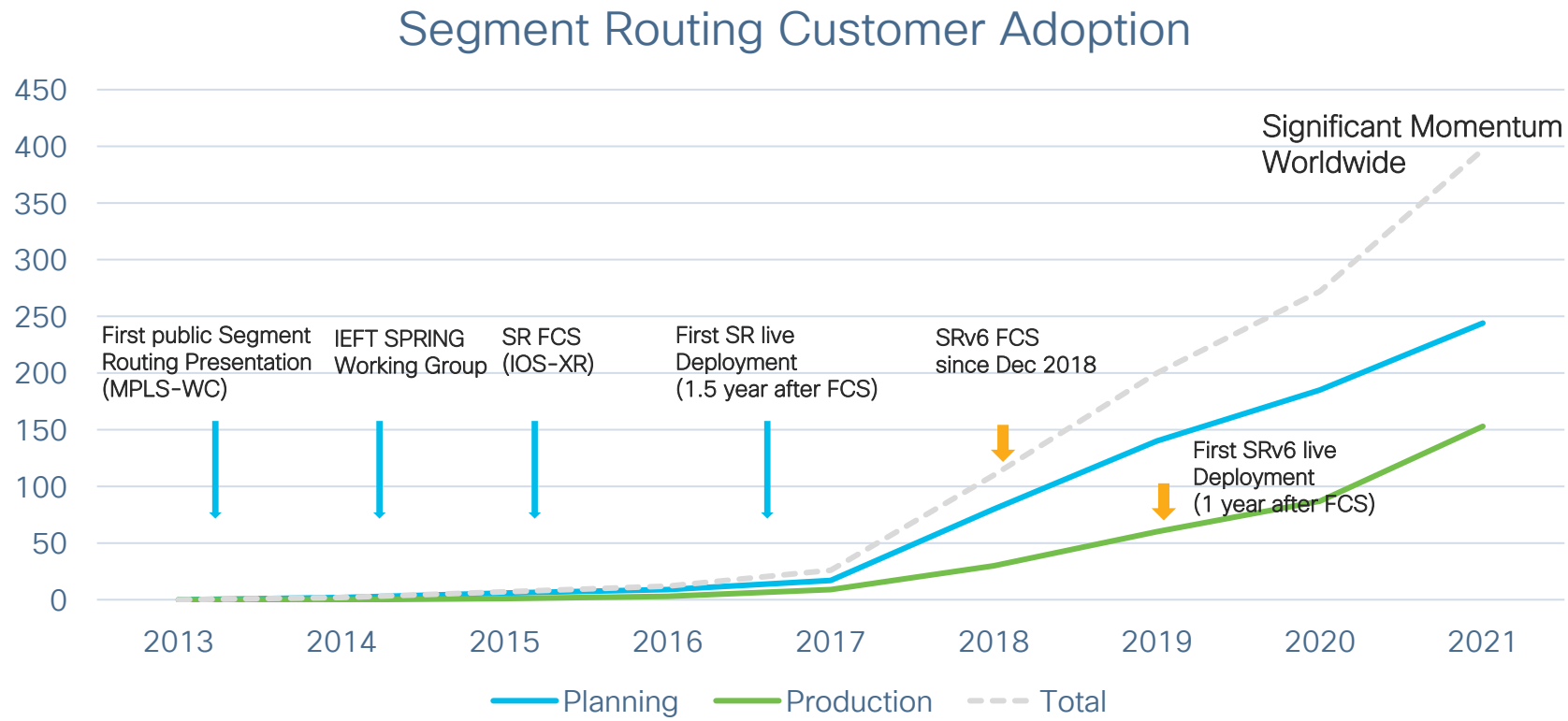
Network Availability

Protect with automatic TI LFA FRR
Stabilize with Microloop avoidance
Operate with Advanced blackhole detection
Monitor with SR Performance Measurement toolkit

Intent-Based Traffic Engineering

Multi-plane Network Slicing using IGP Flex Algorithms
On-Demand Next-Hop (ODN) + Automated steering (AS)
Multi-Domain intent with SR-PCE
Intent-Based Per-Flow Automated Steering

SR/SRv6 Customer Traction

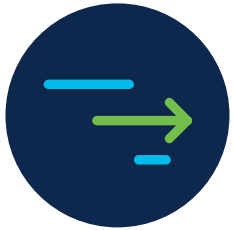


SRv6 Service Examples

SRv6 Service Instruction Bounding to uSID

SRv6 Network Programming

- L2VPN, L3VPN, EPE Peering Optimization
- Network Slicing: Min Cost, Min Delay
- Performance Measurement
- Traffic Engineering
- Disjoint Path
- TI-LFA / uLoop avoidance
- NFV / Service Chaining

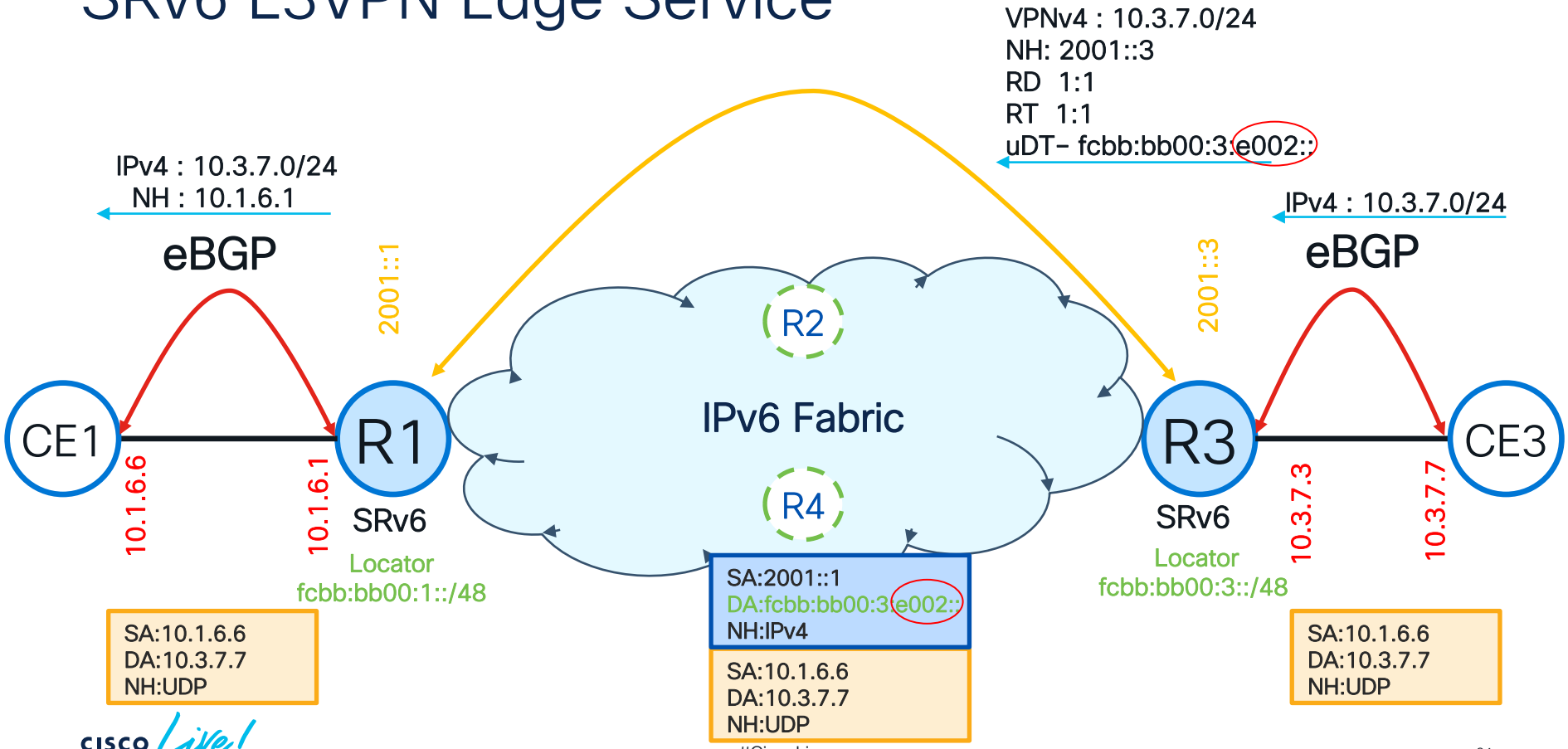


Optimized Transport
MTU Efficiency

VPNs
Mobile, Business

Scalability
V6 Hyperscale

SRv6 L3VPN Edge Service



L3VPN SRv6 uSID Configuration

>>> Egress PE R3 SRv6 uSID Config

```
segment-routing
 srv6
  encapsulation source-address 2001::3
  locators
   locator LATENCY
    micro-segment behavior unode psp-usd
    prefix fcbb:bb01:3::/48
    algorithm 128

router isis 1
 flex-algo 128
  metric-type delay
  advertise-definition
 address-family ipv6 unicast
  segment-routing srv6
   locator LATENCY
```

```
router bgp 1
 neighbor 2001::1
  remote-as 1
  update-source Loopback0
  address-family vpnv4 unicast
 vrf vrf1
  rd 1:1
  address-family ipv4 unicast
   segment-routing srv6
    locator LATENCY
    alloc mode per-vrf
   redistribute connected

performance-measurement
 interface Gig0/0/0/0
  delay-measurement
 interface Gig0/0/0/1
  delay-measurement
```

```
r3# show segment-routing srv6 sid all
*** Locator: 'LATENCY' ***
SID                         Behavior          Context                          Owner               State  RW
--------------------------  ----------------  -------------------------------  ------------------  -----  --
fcbb:bb01:3::               uN (PSP/USD)      'default':3                      sidmgr              InUse  Y
fcbb:bb01:3:e000::          uA (PSP/USD)      [Gi0/0/0/0, Link-Local]:0        isis-1              InUse  Y
fcbb:bb01:3:e001::          uA (PSP/USD)      [Gi0/0/0/1, Link-Local]:0        isis-1              InUse  Y
fcbb:bb01:3:e002::          uDT4              'vrf1'                           bgp-1               InUse  Y
```

SRv6 L3VPN Service Next-hop with uSID Locator

>>> Ingress PE R1 VPNv4 prefix check

```
r1# show bgp vrf vrf1 10.3.7.0/24
BGP routing table entry for 10.3.7.0/24, Route Distinguisher: 1:1
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 22          22
Last Modified: Jan 22 19:07:03.533 for 02:47:29
Paths: (1 available, best #1)
  Advertised to CE peers (in unique update groups):
    10.1.6.6
  Path #1: Received by speaker 0
  Advertised to CE peers (in unique update groups):
    10.1.6.6
  Local
    2001::3 (metric 30) from 2001::3 (3.3.3.3)
      Received Label 0xe0020
      Origin incomplete, metric 0, localpref 100, valid, internal, best, group-best, import-candidate, imported
      Received Path ID 0, Local Path ID 1, version 22
      Extended community: RT:1:1
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:fcbb:bb01:3::, Behavior:63, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
      Source AFI: VPNv4 Unicast, Source VRF: vrf1, Source Route Distinguisher: 1:1
```

SRv6 L3VPN Forwarding with uSID Service

>>> Ingress PE R1 forwarding check

```
r1# show cef vrf vrf1 10.3.7.0/24 detail
10.3.7.0/24, version 18, SRv6 Headend, internal 0x5000001 0x30 (ptr 0xd2e03e8) [1], 0x0
(0xe3658d0), 0x0 (0xf6363c0)
 Updated Jan 22 17:53:05.749
 Prefix Len 24, traffic index 0, precedence n/a, priority 3
   via fcbb:bb00:3::/128, 3 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0xe500ad0 0x0]
    next hop VRF - 'default', table - 0xe0800000
    next hop fcbb:bb01:3::/128 via fcbb:bb00:3::/48
    SRv6 H.Encaps.Red SID-list {fcbb:bb01:3:e002::}

Load distribution: 0 (refcount 1)

    Hash  OK  Interface                 Address
    0     Y   HundredGigE0/0/0/1        remote
```

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