Design Experience of an SRv6 uSID Data Center

SRv6 uSID DC Landscape

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Demo Time 2 of 9

verizon

Demo time!

All Demo's @ YouTube Channel SRv6 uSID DC:
https://youtube.com/@SRv6_uSID_DC
https://github.com/segmentrouting/srv6-labs **Directory:"**3-srv6-dc-case-studies"

- ❑ Host-to-Host multi-pod across the metro
- ❑ Policy programmed from Linux Kernel & VPP host

MPLS WC 2024
SRv6 uSID DC Series

Use-case 1: SRv6 uSID BGP-Only DC & Single AS DC

- IPv6 DC ⇔ *SRv6 uSID Core* ⇔IPv6 DC (1a) ⇔ **YouTube Video #1 (1 of 9) Host Networking**
- *SRv6 uSID DC* ⇔ IPv6 Core ⇔ *SRv6 uSID DC (1b)* ⇔ **YouTube Video #2 (2 of 9) Migration**
- SRv6 uSID uSID End-to-End (1c) ⇔ **YouTube Video #3 (3 of 9) uSID E2E**

Use-case 2: SRv6 uSID w/ Multi POD Fabrics

- IPv6 DC ⇔ *SRv6 uSID Core* ⇔IPv6 DC (2a) ⇔ **YouTube Video #4 (4 of 9) Host Networking**
- *SRv6 uSID DC* ⇔ IPv6 Core ⇔ *SRv6 uSID DC (2b)* ⇔ **YouTube Video #5 (5of 9) Migration**
- SRv6 uSID End-to-End (2c) ⇔ **YouTube Video #6 (6 of 9) uSID E2E**

Use-case 3: SRv6 uSID w/ Multi POD/Domain Fabrics

- IPv6 DC ⇔ *SRv6 uSID Core* ⇔IPv6 DC (3a) ⇔ **YouTube Video #7 (7 of 9) Host Networking**
- *SRv6 uSID DC* ⇔ IPv6 Core ⇔ *SRv6 uSID DC (3b)* ⇔ **YouTube Video #8 (8of 9) Migration**
- SRv6 uSID End-to-End (3c) ⇔ **YouTube Video #9 (9 of 9) uSID E2E**

Demo time!

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Use-case 1: SRv6 uSID BGP-Only DC & Single AS DC

This Deck will be posted to GitHub: Directory:"3-srv6-dc-case-studies"

- ❑ Host-to-Host multi-pod across the metro
- ❑ Policy programmed from Linux Kernel & VPP host
- ❑ Policy programmed from Router-In-Container (XRD)

Real World Use-Cases

#2 Dual Plane MPLS / IPv6 Core Migration

#2 Dual Plane MPLS / IPv6 Core Migration

- **Traffic Engineering & Carrier Grade** features are a requirement ONLY in the Data Center.
- **Traffic Engineering capabilities** in the Data Center, and the intermediate domains follow IGP shortest path **blindly forwarding** the SRv6 uSID packets. **Massive scale & resiliency** with full carrier grade features in the Data Center.
- **Steering** is initiated from the DC host attachment and follows IGP shortest path along the intermediate domains to the egress DC or Domain.

SILOED Networking ⇔ Complexity Tax

Each siloed network Domain has its own Hardware, Software, SDN Stack, Operations & Automation Ecosystem

IPv4 Transport

OVERLAY/SEGMENTATION

PRIVATE IP SCALE

TRAFFIC ENGINEERING

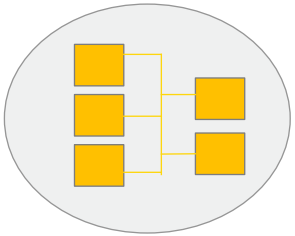
MPLS Transport

NOT WIDELY ADOPTED IN DATA CENTER

LABEL SUMMARIZATION

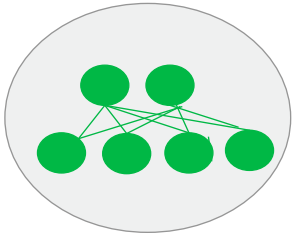
TRAFFIC ENGINEERING

VXLAN / GENEVE



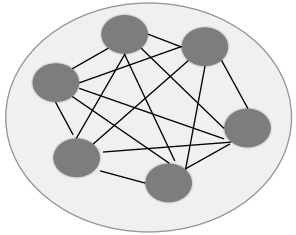
DC OVERLAYS

IPv4



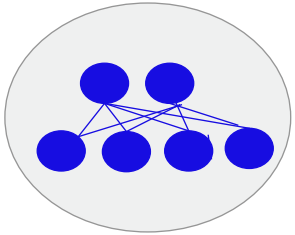
DC FABRICS (UNDERLAY)

MPLS



METRO WAN FABRICS

IPv4, IPv6



EDGE PEERING FABRICS

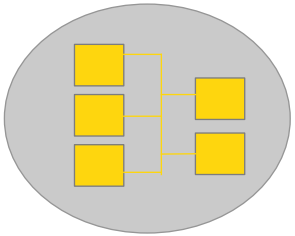
SRv6 uSID ⇔ Simplicity, Functionality, Ultra Scale

A Common End-to-End Forwarding Architecture Enables Common HW, SW, SDN, Ops ⇔ **Massive Scale**

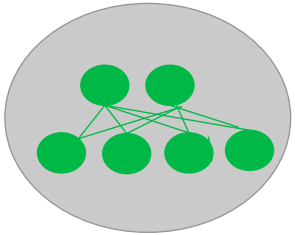
SRv6 uSID

- OVERLAY/SEGMENTATION
- IPv6 UNDERLAY SCALE
- TRAFFIC ENGINEERING
- COMPATIBILITY WITH BROWN FIELD FABRICS
- SERVICE INSERTION / CHAINING
- COMMON HARDWARE, SOFTWARE, SDN, Ops

SRv6 uSID ⇔ Translates into Ultra Massive Scale

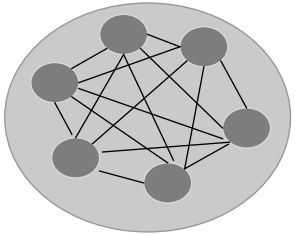


DC OVERLAYS

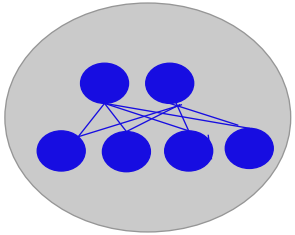


UNDERLAY
DC FABRICS

“End-to-End Inter-Domain Routing via SRv6 uSID”

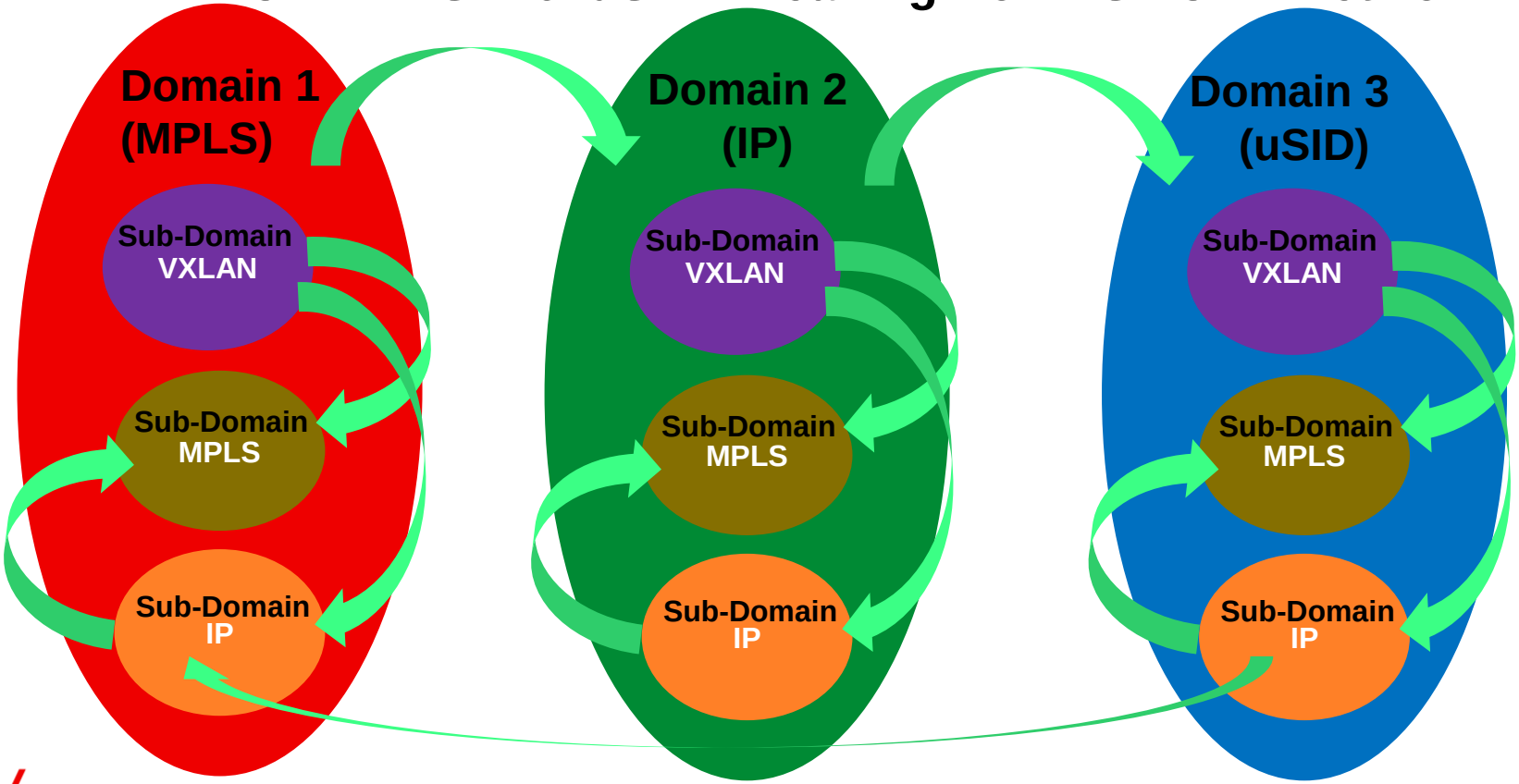


METRO
WAN FABRICS

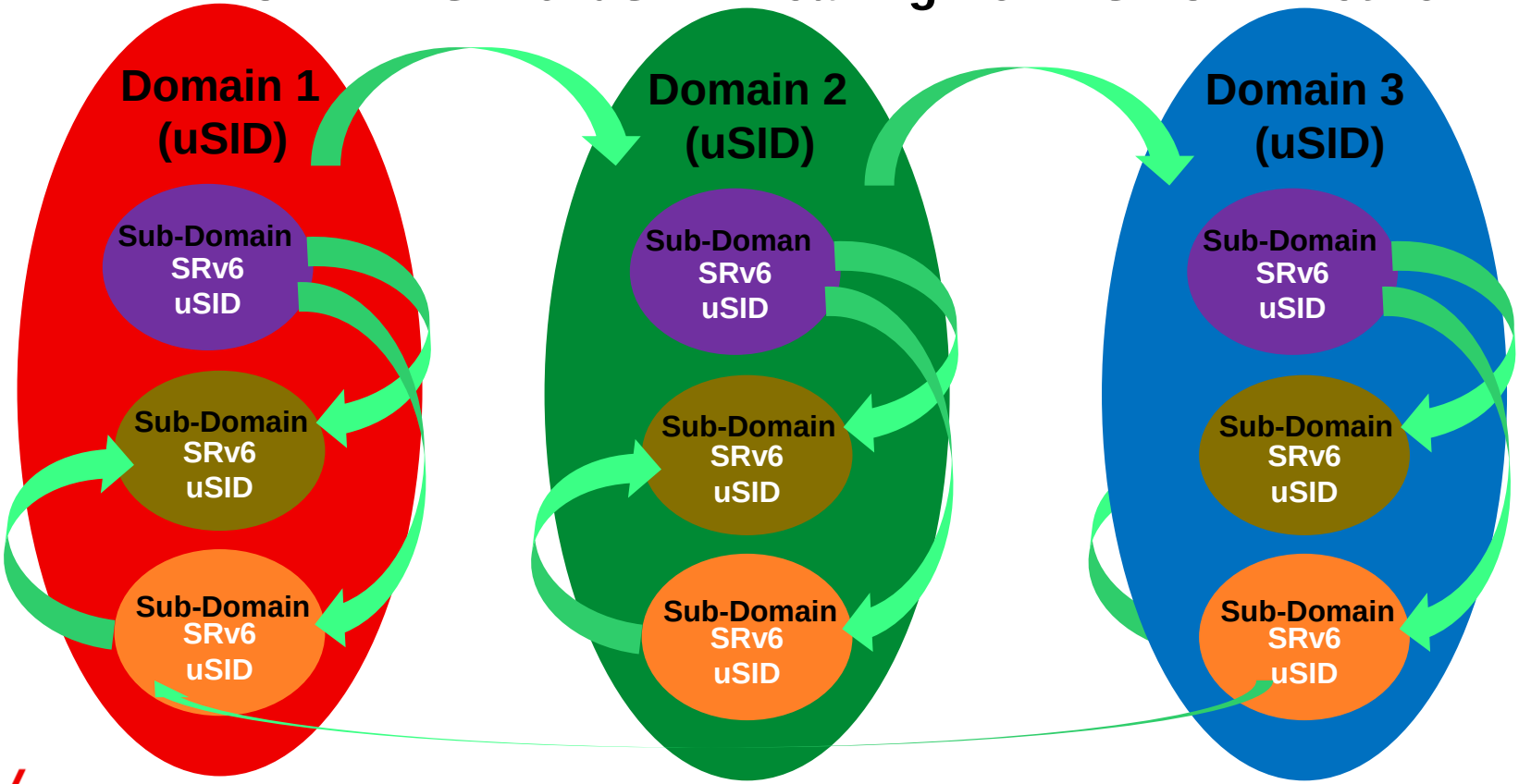


EDGE PEERING
FABRICS

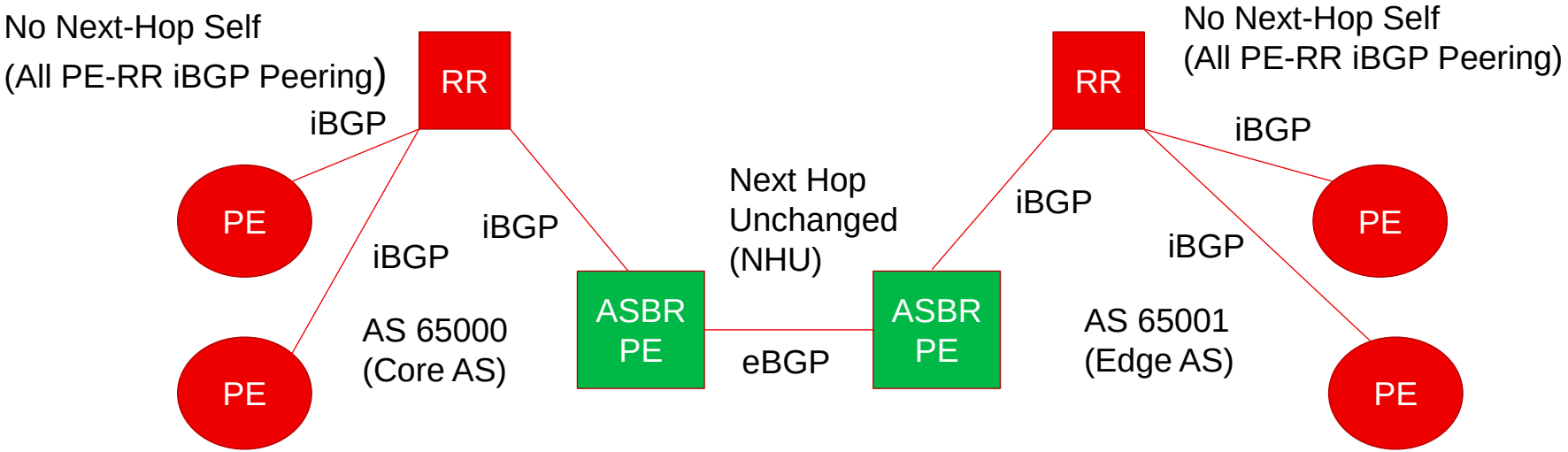
INTER DOMAIN SRv6 uSID Breaking Down SILOED Networking



INTER DOMAIN SRv6 uSID Breaking Down SILOED Networking



INTER DOMAIN SRv6 uSID

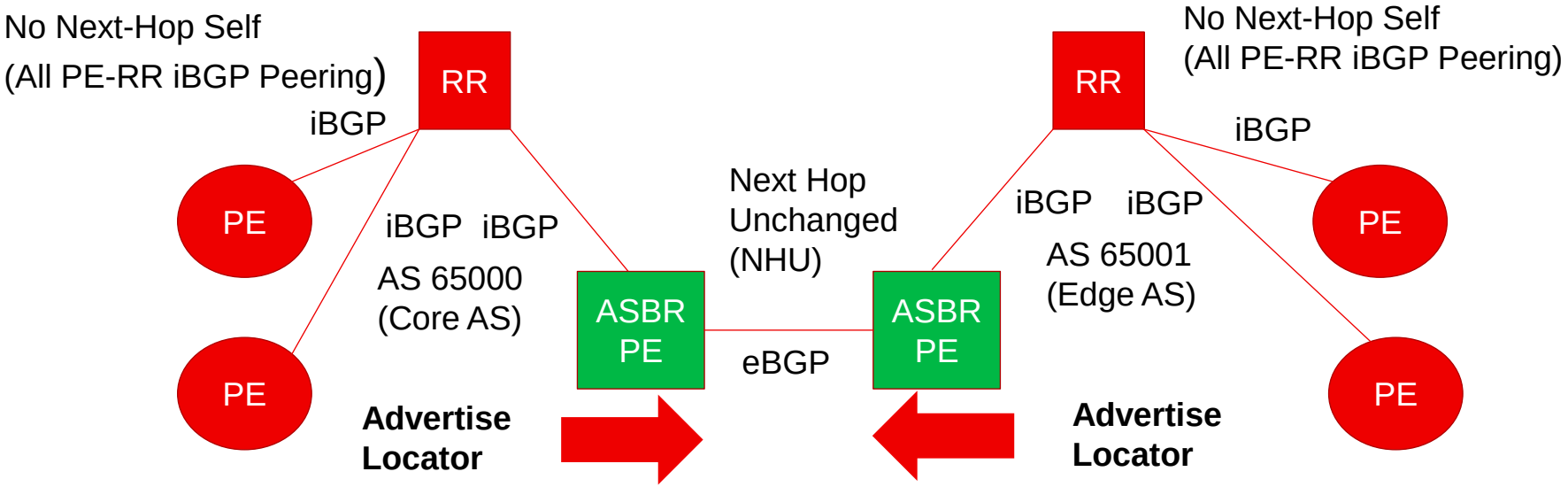


Rule for Inter Domain Peering

- iBGP -No Next-Hop Self
- eBGP –Next Hop Unchanged

(Requirement to Preserve L2 VPN & L3 VPN Service SID across INTER-AS Boundary)

INTER DOMAIN SRv6 uSID ROUTING SIMPLICITY



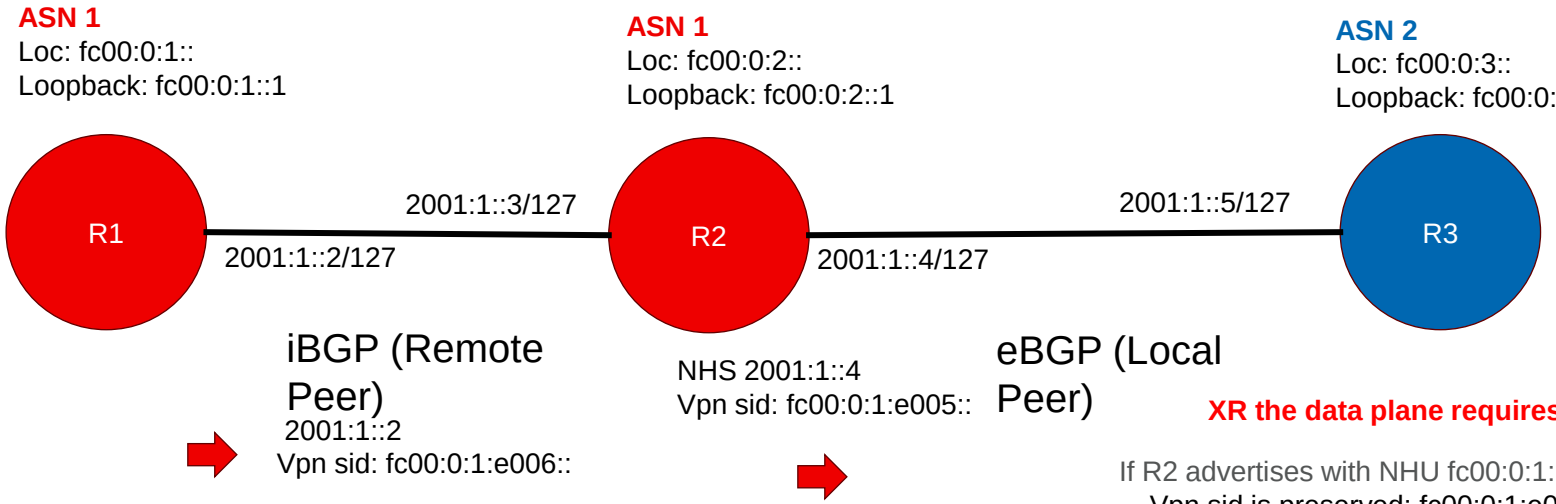
Rule for Inter Domain Peering

- Locator Reachability (That's it!!)

This allows host endpoints to provide static steering capabilities without PCE across any SR Algo cross domain

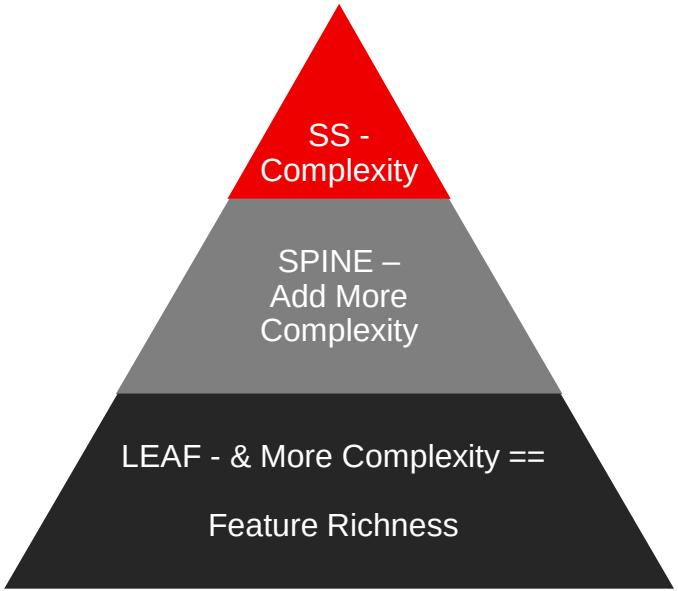
INTER DOMAIN SRv6 uSID

eBGP direct peering (NHU) – (Remote PE)



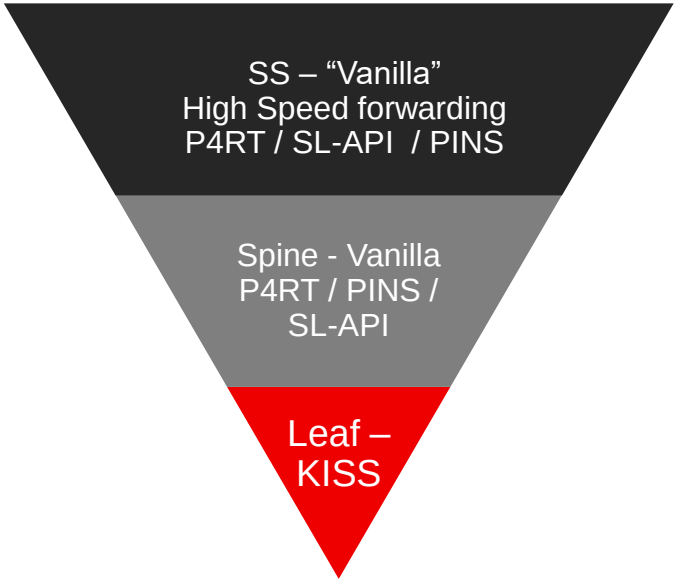
SRv6 uSID Design ⇔ “Top ⇔ Down” & “Bottom ⇔ Up” Approach

Top ⇔ Down



Traditional mindset has been for feature richness & complexity across the Data Center Fabric

Bottom ⇔ UP



SRv6 KISS ⇔ “Keep it Simple & Strategic” approach ⇔ Focus on High speed forwarding plane packet pushing throughput

SRv6 uSID Host Based Networking Traffic Engineering

Options for Host Based Networking

- eBPF/Cilium (Cilium BGP control plane) CNI or Standalone (Option-1)
- Native Linux Kernel (FRR BGP control plane) –Host Routing with Native Kernel (Option-2)
- FD.io VPP (FRR BGP control plane) -Host Routing via VPP (Option-3)
- Router-in-container (Control Plane & Data Plane) (xRD, SONiC, Nokia, Juniper cRPD) CNF (Option-4)

- Options are listed in order of desirability by operators
- Next few slides we will go into each option in detail

Option #1 eBPF/Cilium & SRv6 uSID TE Capabilities

- ❑ CNI Connects to global table ⇔ linkage of host fabric to DC fabric
- ❑ CNI TE is Manual/Static today ⇔ Future Roadmap for Dynamic
- ❑ CNI Provides VPN overlay - Workload Container, VM, CNF, VNF

Details

- ❑ Data plane programming
- ❑ Cilium used for BGP control plane advertisement
- ❑ Cilium is one of the most popular CNI's to date and eBPF with its origins in the Linux kernel with its rich policy features & programmability provides seamless integration to compute nodes making it a powerful win-win for developers
- ❑ eBPF bypasses Linux kernel for policy processing & has direct access to NIC ✓

Option #2 Native Linux Kernel & SRv6 uSID TE Capabilities

- ❑ Connects to global table ⇔ linkage of host fabric to DC fabric
- ❑ TE Capabilities via Linux “iproute 2” support for SRv6 uSID
- ❑ Host VPN overlay - Workload Container, VM, CNF, VNF for VRF attached workload

Details

- ❑ Data plane programming
- ❑ FRR BGP for control plane advertisement
- ❑ FRR can program the control plane & via Linux Kernel API call program the data plane FIB entries
- ❑ Alternatively, FRR can program the control plane with hook back to Linux Kernel to program the data plane FIB entries

Option #3 FD.IO VPP (Vector Packet Processing) & SRv6 uSID TE Capabilities

- VPP Connects to global table ⇔ linkage of host fabric to DC fabric
- VPP Provides Traffic Engineering capabilities via SRv6 uSID
- VPP Provides VPN overlay - Workload Container, VM, CNF, VNF

Details

- Data plane programming
- FRR BGP for Control Plane Advertisement
- VPP Seizes Control of the Linux Hosts NIC
- Requires Netlink or other method to program VPP FIB
- VPP (Vector Packet Processing) is a high performance network stack that can support high bandwidth & CPU intensive applications

Option #4 Router-in-Container (RIC) & SRv6 uSID TE Capabilities

- ❑ CNF Connects to global table ⇔ linkage of host fabric to DC fabric
- ❑ CNF Provides Traffic Engineering capabilities via SRv6 uSID
- ❑ CNF Provides VPN overlay - Workload Container, VM, CNF, VNF

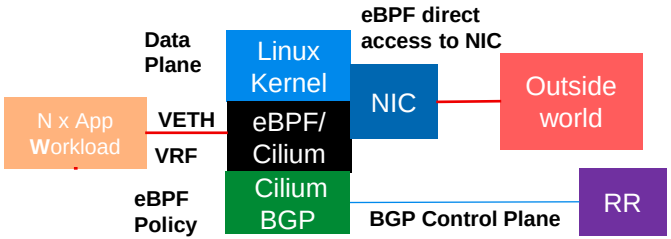
Details

Router-in-container options (xRD, SONiC, Nokia, Juniper cRPD)

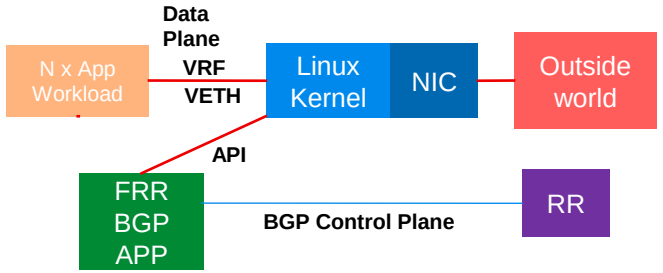
- ❑ Control plane & Data plane programming
- ❑ Requires Linux bridge stitching between Linux Kernel & CNF
- ❑ Container runs in user space so is beneficial for cases where only certain application requires traffic engineering capabilities
- ❑ User space applications can connect to separate virtual interfaces on router-in-container without any theoretical interface limit thus can support n-app workloads

Host Networking Stacks

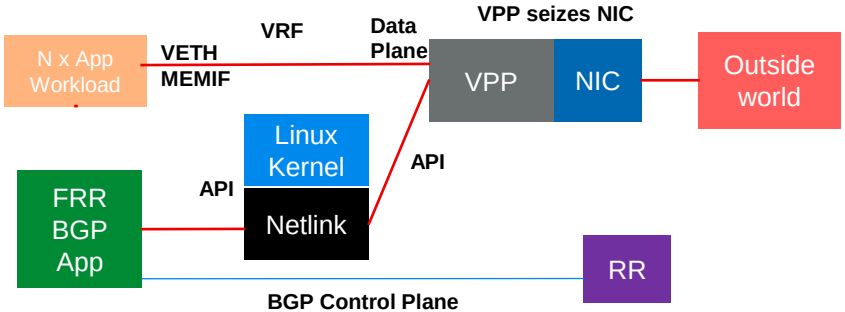
Option #1 eBPF/Cilium



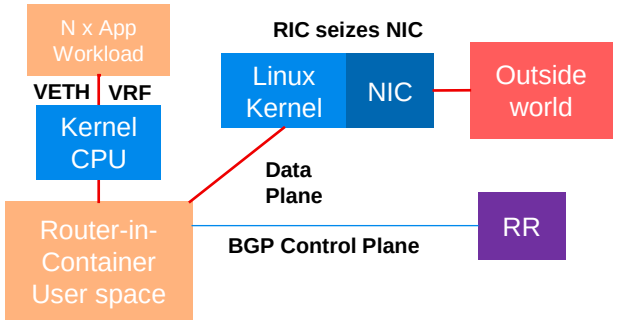
Option #2 Linux Kernel



Option #3 FD.io VPP



Option #4 Router-in-Container (RIC)



Use-Case 1b: SRv6 uSID E2E w/ SRv6 uSID DC & IPv6 Core

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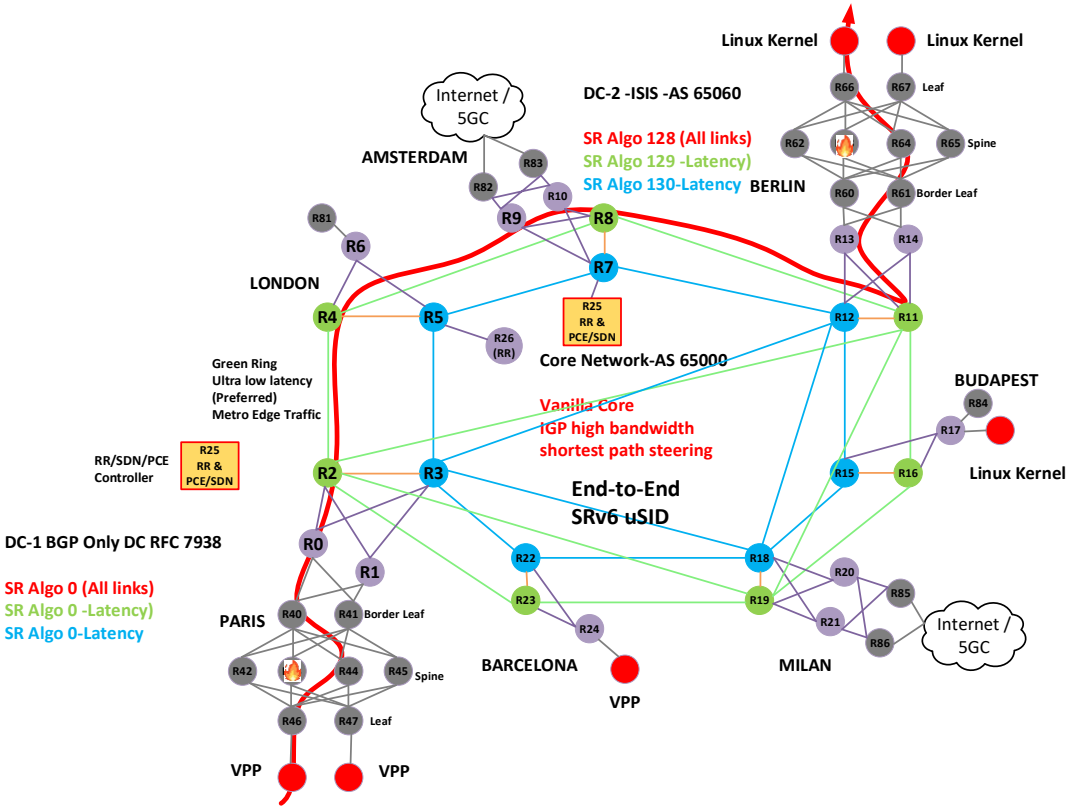
- ❑ Host-to-Host multi-pod across the metro
- ❑ Policy programmed from Linux Kernel & VPP host
- ❑ Policy programmed from Router-In-Container (XRD)

- **Use-case 1: SRv6 uSID BGP-Only DC & Single AS DC**
  - ***SRv6 uSID DC*** **⇔ IPv6 Core ⇔** ***SRv6 uSID DC (1b)***

Use-Case 1b: SRv6 uSID E2E w/ SRv6 uSID DC & IPv6 Core



Use-Case 1: SRv6 uSID DC Fabric Packet Capture & Screen Scrapes

SRv6 uSID IPv4/IPv6 payload steer DC-2 Paris ⇔ Core ⇔ DC-1 Berlin using VPP Host attached to DC fabric

SRv6 uSID IPv4 payload steering policy

vpp#sr policy add bsid 40::40 next fc00:0:44:40:4:64:66:e000 encap

vpp#sr steer l3 10.0.0.66/32 via bsid 40::40

```
vpp# show sr policies
SR policies:
[0].-   BSID: 40::40
        Behavior: Encapsulation
        EncapSrcIP: fc00:0:46:1::3
        Type: Default
        FIB table: 0
        Segment Lists:
        [0].- < fc00:0:44:40:4:64:66:e000 > weight: 1

vpp# show sr steering-policies
SR steering policies:
Traffic         SR policy BSID
L3 10.0.0.66/32 40::40
```

SRv6 uSID IPv6 payload steer:

vpp#sr policy add bsid 41::41 next fc00:0:44:40:4:64:66:e000 encap

vpp# sr steer l3 fc00:0:66::1/128 via bsid 41::41

```
vpp# show sr policies
SR policies:
[1].-   BSID: 94::94
        Behavior: Encapsulation
        EncapSrcIP: fc00:0:46:1::3
        Type: Default
        FIB table: 0
        Segment Lists:
        [1].- < fc00:0:45:41:66:e000:: > weight: 1
----------
vpp# show sr steering-policies
SR steering policies:
Traffic         SR policy BSID
L3 fc00:0:66::1/128     41::41
```

IPv4 payload packet capture xrd61-xrd64

```
04:41:56.724814 IP6 fc00:0:46:1::3 > fc00:0:64:66:e000::: IP 10.11.46.2 > 10.0.0.66: ICMP echo request, id 113, seq 463, length 64
04:41:57.724271 IP6 fc00:0:46:1::3 > fc00:0:64:66:e000::: IP 10.11.46.2 > 10.0.0.66: ICMP echo request, id 113, seq 464, length 64
```

IPv6 payload packet capture xrd61-xrd64:

```
04:55:37.285381 IP6 fc00:0:46:1::3 > fc00:0:64:66:e000::: IP6 fc00:0:46:2::2 > fc00:0:66::1: ICMP6, echo request, seq 368, length 64
04:55:38.285012 IP6 fc00:0:46:1::3 > fc00:0:64:66:e000::: IP6 fc00:0:46:2::2 > fc00:0:66::1: ICMP6, echo request, seq 369, length 64
```

Use-Case 2: SRv6 uSID Inter-DC Packet Capture & Screen Scrapes

SRv6 uSID IPv4 payload steer DC-1 Berlin ⇔ Core ⇔ DC-2 Paris using Linux host attached to DC fabric

SRv6 uSID IPv6 payload steering policy:

root@ubuntu-linux-srv6:sudo ip route add 10.0.0.46/32 encap seg6 mode encap segs fc00:0:64:61:4:44:46:e000 dev ens7
root@ubuntu-linux-srv6:/home/cisco# ip route
default via 192.168.122.1 dev ens8 proto dhcp src 192.168.122.88 metric 100
10.0.0.0/24 via 10.10.66.2 dev ens7 proto static
10.0.0.46 encap seg6 mode encap segs 1 [fc00:0:64:61:4:44:46:e000] dev ens7 scope link----------->SRv6 uSID steering programmed IPv4 payload

SRv6 uSID IPv4 payload steer capture DC-2 Paris:

xrd41-xrd44

20:30:23.274808 IP6 fc00:0:66:1:5054:2ff:fe41:b107 > fc00:0:44:46:e000::: srcrt (len=2, type=4, segleft=0[|srcrt]
20:30:24.275510 IP6 fc00:0:66:1:5054:2ff:fe41:b107 > fc00:0:44:46:e000::: srcrt (len=2, type=4, segleft=0[|srcrt]

SRv6 uSID IPv6 payload steering policy:

root@ubuntu-linux-srv6:sudo ip -6 route add fc00:0:46::1 encap seg6 mode encap segs fc00:0:64:61:4:44:46:e000 dev ens7
root@ubuntu-linux-srv6:/home/cisco# ip -6 route
::1 dev lo proto kernel metric 256 pref medium
fc00:0:46::1 encap seg6 mode encap segs 1 [fc00:0:64:61:4:44:46:e000] dev ens7 metric 1024 pref medium--->SRv6 uSID steering programmed IPv6 payload

SRv6 uSID IPv6 payload steer capture DC-2 Paris:

xrd44-xrd46

20:40:32.890109 IP6 fc00:0:66:1:5054:2ff:fe41:b107 > fc00:0:46:e000::: srcrt (len=2, type=4, segleft=0[|srcrt]
20:40:32.890994 IP6 fc00:0:46::1 > fc00:0:66:1:5054:2ff:fe41:b107: ICMP6, parameter problem, code-#4, length 176

SRv6 uSID features configured in the topology

SRv6 uSID Features List:

- ❑ Unreachable Prefix Advertisement (UPA) – BGP PIC Trigger
- ❑ SR Policy, ODN with Algo 0, 128, 129, 130 locators, candidate path with weighted SID list (UCMP), Static ERO, Dynamic ERO with Stateful PCE
- ❑ TI-LFA & Microloop Avoidance (uLoop)
- ❑ SR-PM all nodes including router-in-container host attachment
- ❑ PCE all nodes including router-in-container host attachment