



SRv6 uSID in FRR

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About Me

- Carmine Scarpitta
 - Software Engineer @ Cisco Systems
 - PhD from the university of Rome Tor Vergata
 - Focus on SRv6 (FRR, SONiC, ...)
- FRR maintainer focusing on the SRv6 code



SRv6 uSID in FRR – Very Mature Support

- Supported since FRR release 8.1 (2021)
- ~250 Pull Requests
- ~700 Commits
- Main contributors:
 - Cisco, Alibaba, LINE Corporation, 6WIND
- Thanks to the FRR community:
 - Donald Sharp, Russ White, Donatas Abraitis, Philippe Guibert, Dmytro Shytyi

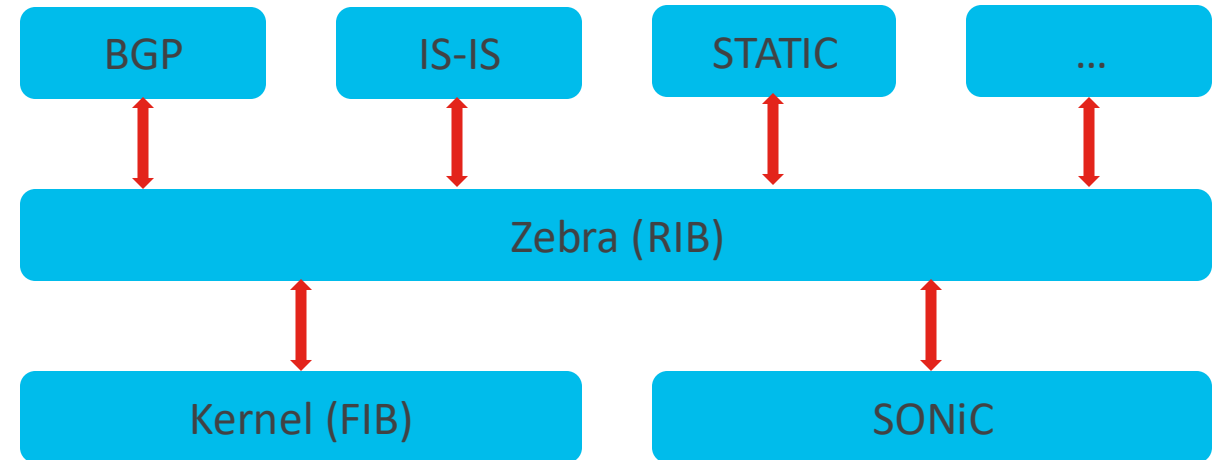
SRv6 uSID in FRR – Very Mature Support

- BGP L3VPN Services (RFC 9252)
 - VPNv4: IPv4 address family
 - VPNv6: IPv6 address family
 - VPNv46: IPv4 and IPv6 using a single SID uDT46
- IS-IS Underlay (RFC 9352)
- Static SID allocation
- Static Traffic Steering into SRv6 SID List
- SID Manager
 - SRv6 uSID deployment blueprint
 - Interoperability between FRR, Cisco IOS-XR, and other vendors

SRv6 in FRR: Base config

FRR Reminder

- FRR is open-source Internet routing protocol suite
 - BGP, IS-IS, ...
 - Full SRv6 uSID supports
- FRR is the routing stack used by SONiC



SRv6 in FRR – Base config

- Configure the locator
 - Prefix, format
- Protocols get SIDs from this locator

```
!  
segment-routing  
  srv6  
    locators  
      locator MAIN  
        prefix fcbb:bbbb:1::/48  
        format usid-f3216  
  !  
!
```

```
router# show segment-routing srv6 locator  
Locator:  
Name                ID      Prefix                Status  
-----  
MAIN                1 fcbb:bbbb:1::/48      Up
```

SRv6 SID Manager

SRv6 SID Manager

- The brain of SRv6 in FRR
- Management of locators and SIDs
- Maintains the SRv6 databases:
 - Configured locators
 - SIDs allocated
- Exposes API to protocol daemons to
 - Allocate SIDs
 - Release SIDs
- Allow SID sharing between different daemons

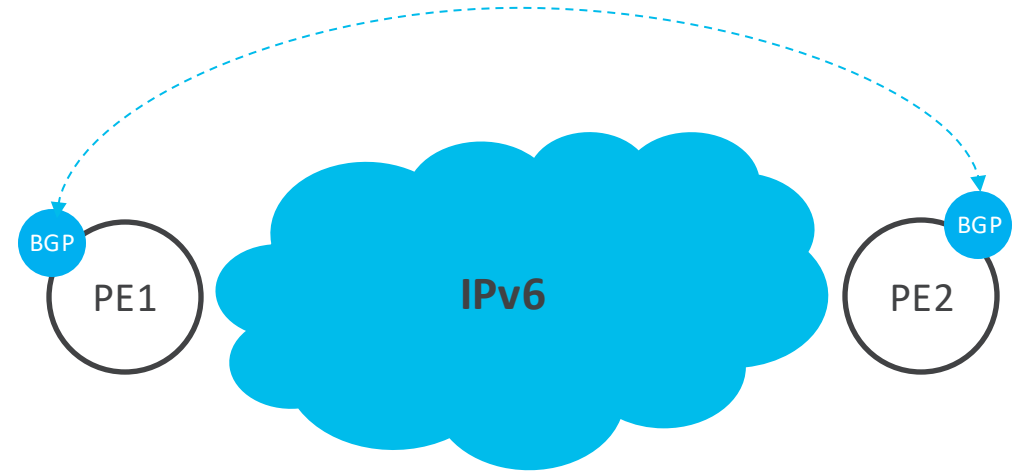
SRv6 uSID: BGP L3VPN Services

SRv6 uSID - BGP L3VPN Services

- SRv6 uSID BGP L3VPN Services (RFC 9252)
 - VPNv4: IPv4 address family
 - VPNv6: IPv6 address family
 - VPNv46: IPv4 and IPv6 using a single SID uDT46

SRv6 uSID BGP L3VPN Services

- Egress PE allocates an SRv6 uDT* SID for each VRF
- Egress PE advertises his prefixes with the SRv6 SID
 - SRv6 L3VPN Service TLV
 - SRv6 SID Information Sub-TLV
 - SRv6 SID Structure Sub-Sub-TLV
- Ingress PE programs the prefix and SID into his FIB



FRR supports all TLVs

SRv6 uSID BGP L3VPN Services - Configuration

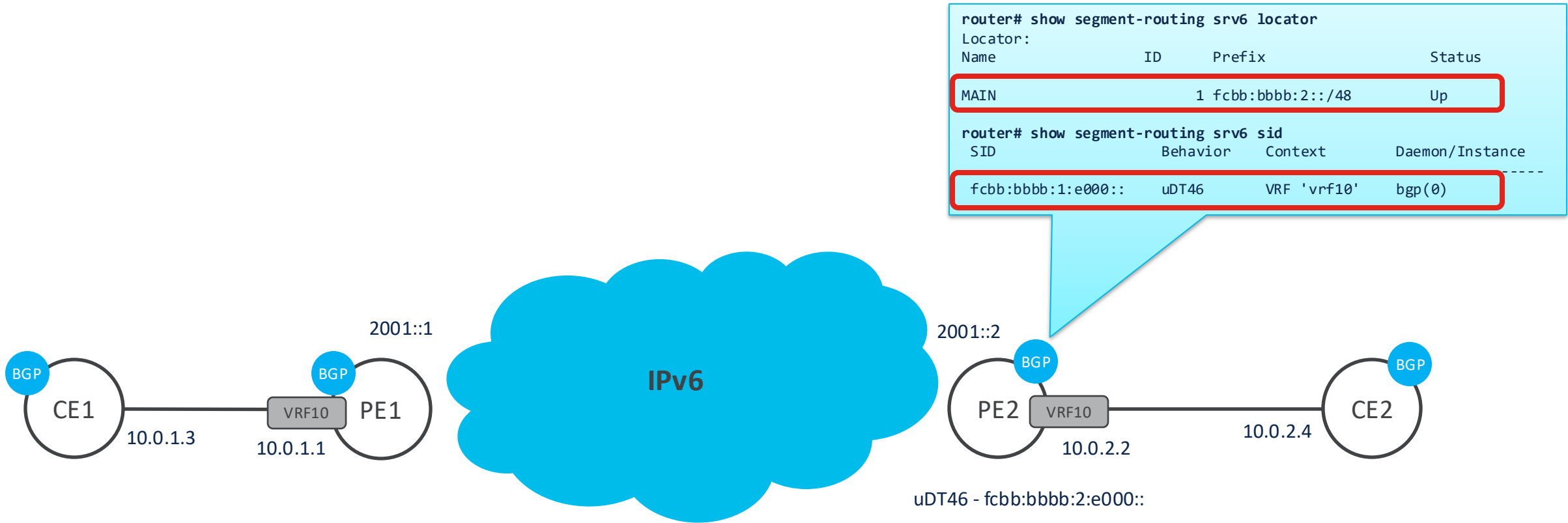


SRv6 uSID BGP L3VPN Services - Configuration

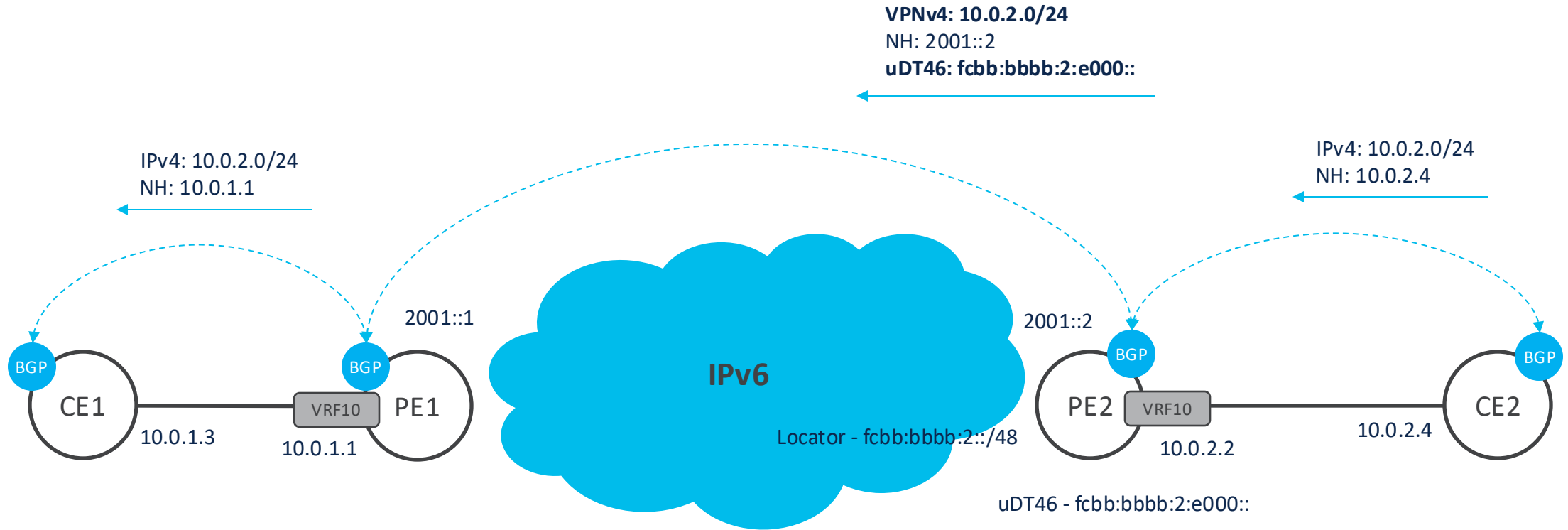


```
PE2# show running-config
...
router bgp 65002
  bgp router-id 2.2.2.2
  no bgp ebgp-requires-policy
  neighbor 2001::1 remote-as 65001
  neighbor 2001::1 capability extended-nexthop
...
  address-family ipv4 vpn
    neighbor 2001::1 activate
    exit-address-family
  !
  address-family ipv6 vpn
    neighbor 2001::1 activate
    exit-address-family
  !
  segment-routing srv6
    locator MAIN
  !
  !
router bgp 65002 vrf vrf10
  bgp router-id 2.2.2.2
  no bgp ebgp-requires-policy
  sid vpn per-vrf export auto
  !
  address-family ipv4 unicast
    nexthop vpn export 2001::2
    rd vpn export 2:10
    rt vpn both 99:99
    import vpn
    export vpn
    redistribute connected
    exit-address-family
  !
  address-family ipv6 unicast
    rd vpn export 2:10
    rt vpn both 99:99
    import vpn
    export vpn
    redistribute connected
    exit-address-family
...
```

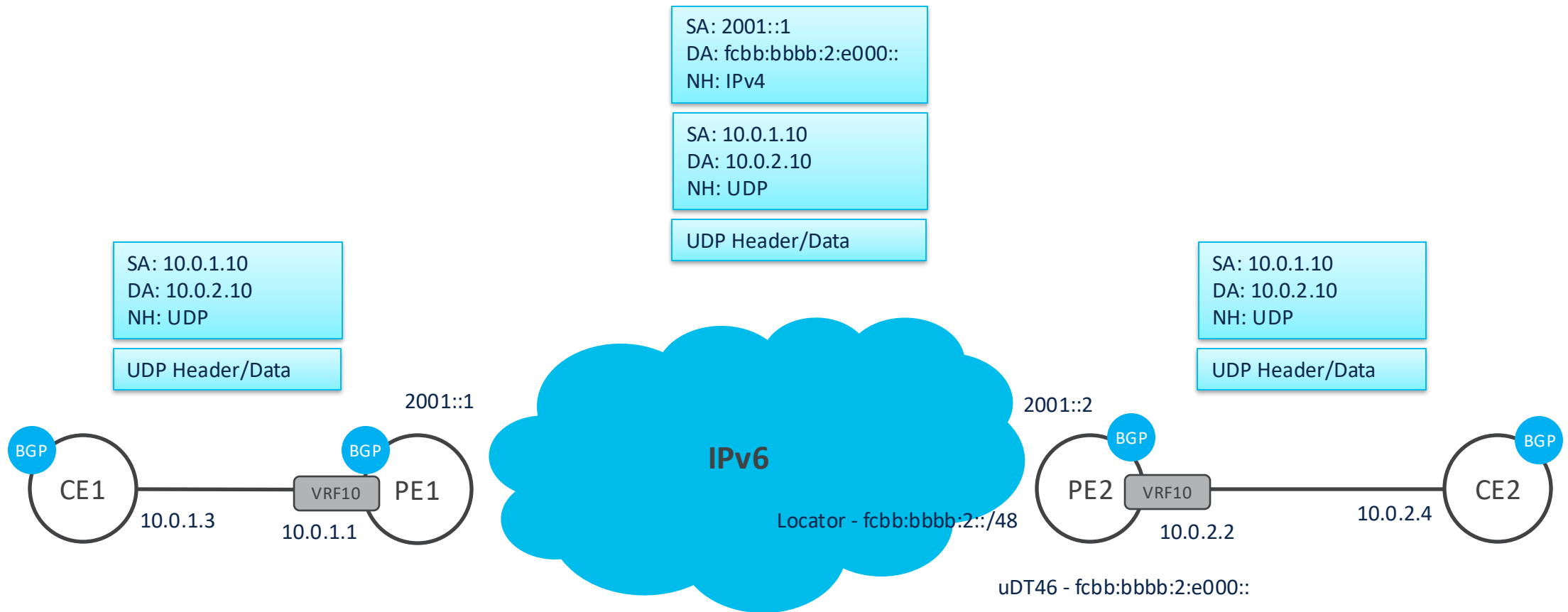
SRv6 uSID BGP L3VPN Services - Verification



SRv6 uSID BGP L3VPN Services – Control Plane



SRv6 uSID BGP L3VPN Services – Data Plane



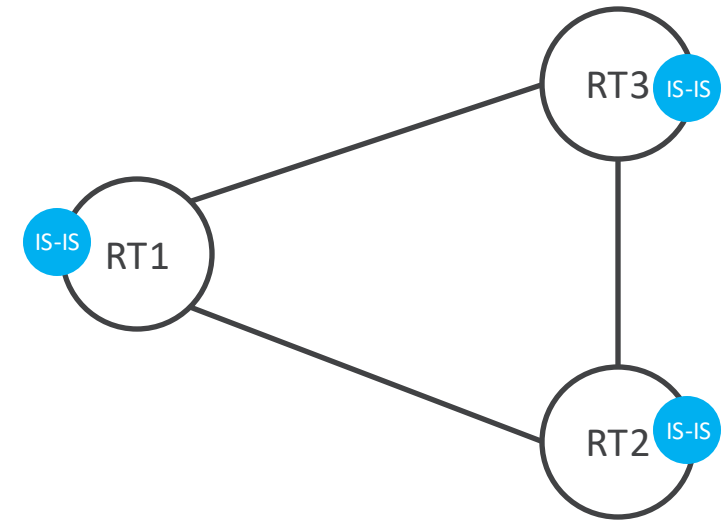
SRv6 uSID IS-IS Underlay

SRv6 uSID IS-IS Underlay

- IS-IS Extensions to Support SRv6 Data Plane (RFC 9352)
- New TLVs to advertise SRv6 information:
 - SRv6 Capabilities Sub-TLV
 - SRv6 Locator TLV
 - SRv6 End SID Sub-TLV
 - SRv6 End.X SID Sub-TLV
 - SRv6 LAN End.X SID Sub-Sub-TLV
 - SRv6 SID Structure

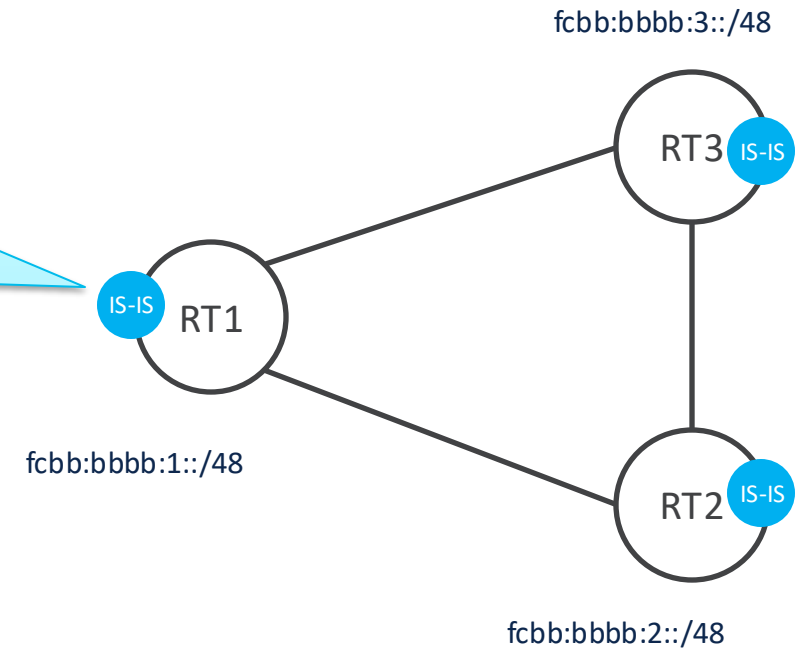
FRR supports all TLVs

SRv6 uSID IS-IS Underlay – Configuration



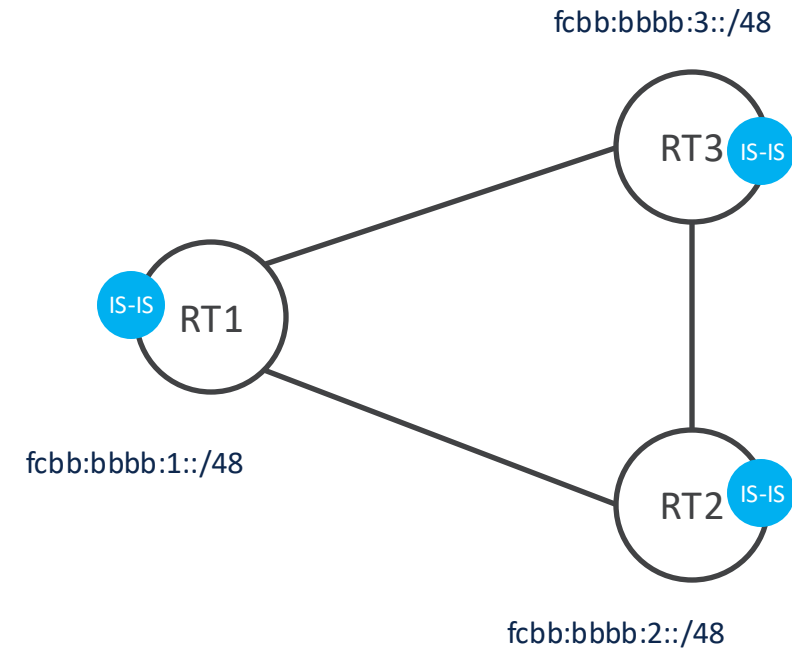
SRv6 uSID IS-IS Underlay – Configuration

```
!  
segment-routing  
  srv6  
    locators  
      locator MAIN  
        prefix fcbb:bbbb:1::/48  
        format usid-f3216  
    !  
  !  
  router isis F00  
    net 49.0000.0000.0000.0001.00  
    is-type level-1  
    segment-routing srv6  
      locator MAIN  
    !  
  !  
!
```



SRv6 uSID IS-IS Underlay - Verification

- IS-IS on each node
- Locator on each node
- uN SID
- uA SID
- IS-IS advertises locator and SIDs



SRv6 uSID IS-IS Underlay – Verification

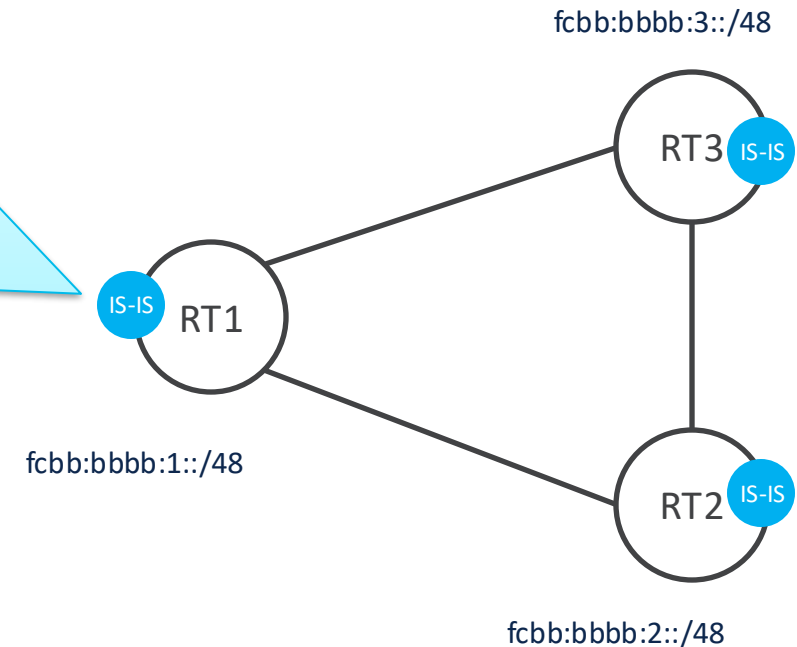
```
rt1# show segment-routing srv6 locator
```

Locator:

Name	ID	Prefix	Status
MAIN	1	fcbb:bbbb:1::/48	Up

```
rt1# show segment-routing srv6 sid
```

SID	Behavior	Context	Daemon/Instance
fcbb:bbbb:1::	uN	-	isis(0)
fcbb:bbbb:1:e000::	uA	interface eth0	isis(0)
fcbb:bbbb:1:e001::	uA	interface eth1	isis(0)



SRv6 uSID IS-IS Underlay – Verification

```
rt1# show isis database detail
```

```
Area 1:
```

```
IS-IS Level-1 link-state database:
```

LSP ID	PduLen	SeqNumber	Chksum	Holdtime	ATT/P/OL
rt1.00-00	*	301	0x00000017	0xbaba	627 0/0/0

```
Protocols Supported: IPv4, IPv6
```

```
Area Address: 49.0000
```

```
MT Router Info: ipv4-unicast
```

```
MT Router Info: ipv6-unicast
```

```
Hostname: rt1
```

```
TE Router ID: 1.1.1.1
```

```
Router Capability: 1.1.1.1 , D:0, S:0
```

```
SR Algorithm:
```

```
0: SPF
```

```
SRv6: 0:0
```

```
Extended Reachability: 0000.0000.0002.02 (Metric: 10)
```

```
MT Reachability: 0000.0000.0002.02 (Metric: 10) ipv6-unicast
```

```
SRv6 Lan End.X SID: fcbb:bbbb:1:e000::, Algorithm: SPF, Weight: 0, Endpoint Behavior: uA, Flags: B:0, S:0, P:0 Neighbor-ID: 0000.0000.0002
```

```
SRv6 SID Structure Locator Block length: 32, Locator Node length: 16, Function length: 16, Argument length: 0
```

```
SRv6 Lan End.X SID: fcbb:bbbb:1:e001::, Algorithm: SPF, Weight: 0, Endpoint Behavior: uA, Flags: B:0, S:0, P:0 Neighbor-ID: 0000.0000.0003
```

```
SRv6 SID Structure Locator Block length: 32, Locator Node length: 16, Function length: 16, Argument length: 0
```

```
IPv4 Interface Address: 1.1.1.1
```

```
Extended IP Reachability: 10.0.1.0/24 (Metric: 10)
```

```
Extended IP Reachability: 1.1.1.1/32 (Metric: 10)
```

```
MT IPv6 Reachability: fc00:0:1::/48 (Metric: 0) ipv6-unicast
```

```
MT IPv6 Reachability: 2001:db8:1::/64 (Metric: 10) ipv6-unicast
```

```
MT IPv6 Reachability: fc00:0:1::1/128 (Metric: 10) ipv6-unicast
```

```
SRv6 Locator: fc00:0:1::/48 (Metric: 0) standard
```

```
Sub-TLVs:
```

```
SRv6 End SID Endpoint Behavior: uN, SID value: fc00:0:1::
```

```
Sub-Sub-TLVs:
```

```
SRv6 SID Structure Locator Block length: 32, Locator Node length: 16, Function length: 0, Argument length: 0
```

```
...
```


SRv6 uSID Static SIDs

SRv6 uSID Static SIDs

- Main use case: SRv6 SDN deployment
- Static SRv6 programmed from the SDN controller
- Microsoft SRv6 SDN deployment in SONiC:
 - https://github.com/sonic-net/SONiC/blob/master/doc/srv6/srv6_static_config_hld.md
 - Collaboration between Cisco, Alibaba, Microsoft, and Nvidia

SRv6 uSID Static SIDs

- Configure SRv6 SIDs statically
- FRR supports static configuring of the following SRv6 behaviors:

Behavior	Description
uN	Shift and forward
uA	Shift and Layer-3 cross-connect
uDT4	Decapsulation and IPv4 table lookup
uDT6	Decapsulation and IPv6 table lookup
uDT46	Decapsulation and IP table lookup

SRv6 uSID Static SIDs - Configuration

```
segment-routing
srv6
  locators
    locator MAIN
    prefix fcbb:bbbb:1::/48
    format usid-f3216
  !
  static-sids
    sid fcbb:bbbb:1::/48 locator MAIN behavior uN
    sid fcbb:bbbb:1:fe10::/64 locator MAIN behavior uDT4 vrf Vrf10
    sid fcbb:bbbb:1:fe20::/64 locator MAIN behavior uDT6 vrf Vrf20
    sid fcbb:bbbb:1:fe30::/64 locator MAIN behavior uDT46 vrf Vrf30
    sid fcbb:bbbb:1:fe40::/64 locator MAIN behavior uA interface eth0
```

rt1# show segment-routing srv6 locator

Locator:

Name	ID	Prefix	Status
MAIN	1	fcbb:bbbb:1::/48	Up

rt1# show segment-routing srv6 sid

SID	Behavior	Context	Daemon/Instance
fcbb:bbbb:1::	uN	-	static(0)
fcbb:bbbb:1:fe10::	uDT4	VRF 'Vrf10'	static(0)
fcbb:bbbb:1:fe20::	uDT6	VRF 'Vrf20'	static(0)
fcbb:bbbb:1:fe30::	uDT46	VRF 'Vrf30'	static(0)
fcbb:bbbb:1:fe40::	uA	interface eth1	static(0)

Static Traffic Steering into SRv6

Static Traffic Steering into SRv6

- Steers IPv4/IPv6 traffic over a specific path defined by an SRv6 SID list
- FRR supports two different encap behaviors:

Behavior	Description
H.Encaps	SR Headend with Encapsulation in an SR Policy
H.Encaps.Red	H.Encaps with Reduced Encapsulation

Static Traffic Steering into SRv6 – Configuration & Verification

...

```
ipv6 route 2001:db8:1:2::/64 eth0 segments fcbb:bbbb:2:3:fe00::  
ip route 192.0.2.0/24 eth0 segments fcbb:bbbb:2:3:fe00::
```

```
ipv6 route 2001:db8:1:3::/64 eth0 segments fcbb:bbbb:2:3:fe00:: encap-behavior H_Encaps_Red  
ip route 192.0.3.0/24 eth0 segments fcbb:bbbb:2:3:fe00:: encap-behavior H_Encaps_Red
```

...

router# show ipv6 route

Codes: K - kernel route, C - connected, L - local, S - static,
O - OSPFv3, I - IS-IS, B - BGP, T - Table, v - VNC,
V - VNC-Direct, D - SHARP, f - OpenFabric,
t - Table-Direct,
> - selected route, * - FIB route, q - queued, r - rejected, b - backup
t - trapped, o - offload failure

IPv6 unicast VRF default:

```
S>* 2001:db8:1:2::/64 [1/0] is directly connected, eth0, seg6 fcbb:bbbb:2:3:fe00::, encap behavior H.Encaps, weight 1, 00:00:27  
S>* 2001:db8:1:3::/64 [1/0] is directly connected, eth0, seg6 fcbb:bbbb:2:3:fe00::, encap behavior H.Encaps.Red, weight 1,  
00:00:27  
S>* fcbb:bbbb:2::/64 [1/0] is directly connected, eth0, weight 1, 00:00:27  
C>* fe80::/64 is directly connected, dummy0, weight 1, 00:00:29
```

Conclusion

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- SRv6 uSID in FRR – Very Mature Support
 - BGP L3VPN Services (RFC 9252)
 - IS-IS Underlay (RFC 9352)
 - Static SID allocation
 - Static Traffic Steering into SRv6 SID List
 - SID Manager
- Very rich ecosystem
 - Cisco, Alibaba, 6WIND, LINE Corporation
- We are committed to supporting SRv6 in FRR:
 - New features, bugfixes, testing, ...

