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The bridge to possible

Simplified Network Fabric deployment using RFC 5549

Network Designs for the modern Data Center

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BRKDCN-2828

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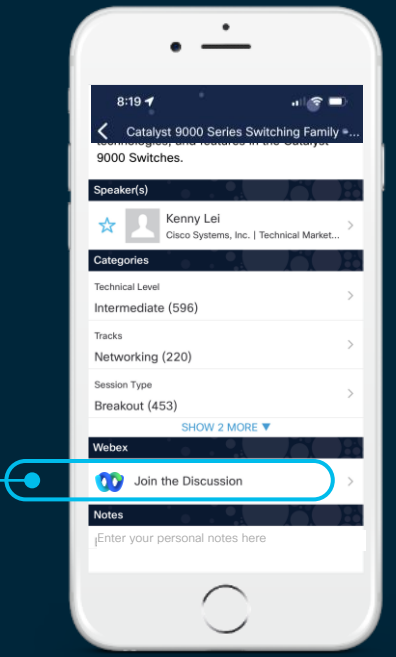

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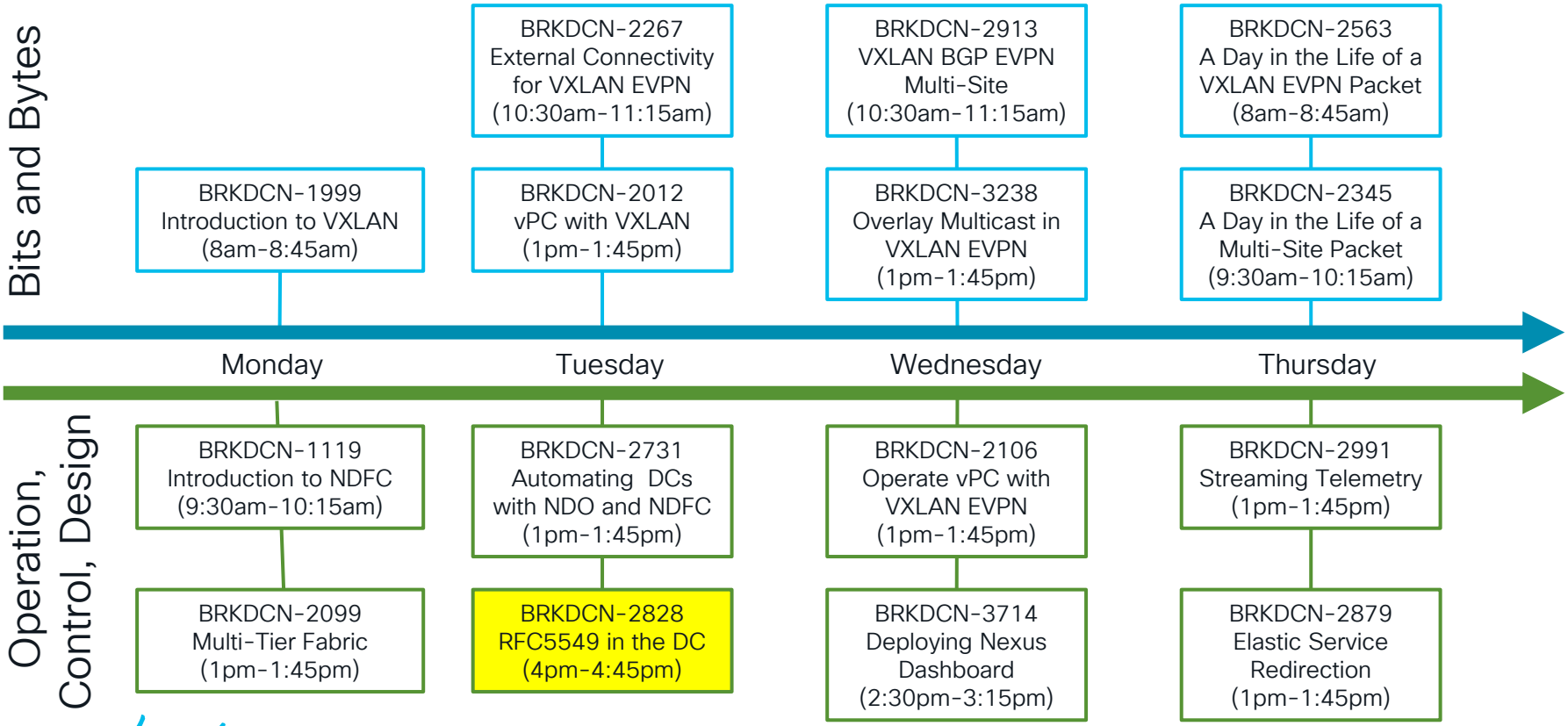
Webex spaces will be moderated by the speaker until June 17, 2022.

Abstract

What is RFC5549 ? Think of a network that speaks IPv4 and IPv6 without introducing overlays? This is what RFC5549 does and it enables a simple approach for network infrastructure addressing and scalability. Join us to talk about RFC5549 and how IPv6 makes some things much simpler than you could think about (yes, IPv6 between switches can solve a lot of headache).

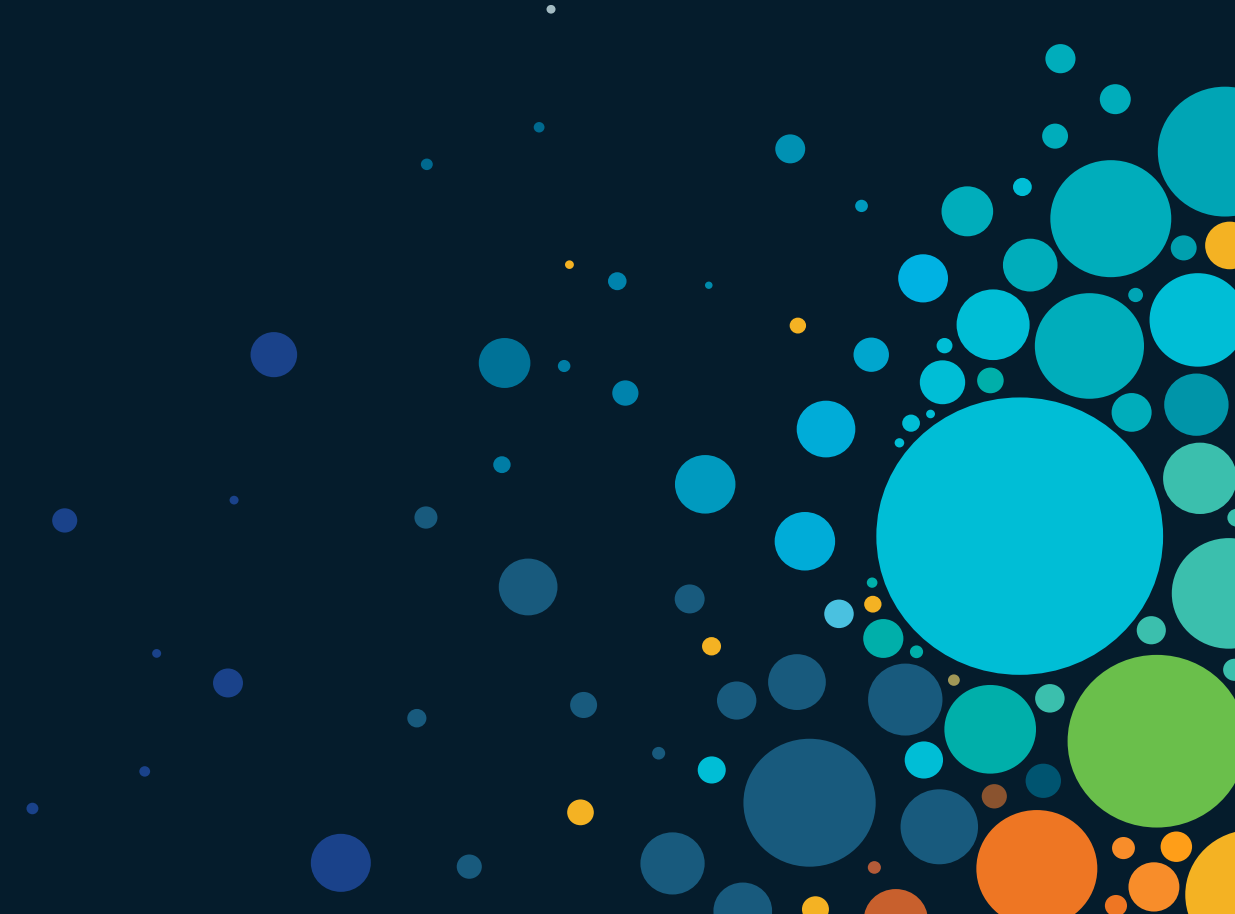
Companion Sessions – Week at a Glance



Agenda

- Introduction
- What is RFC 5549?
- Use Cases
- BGP Auto-Fabric
- Conclusion

Introduction



Introduction

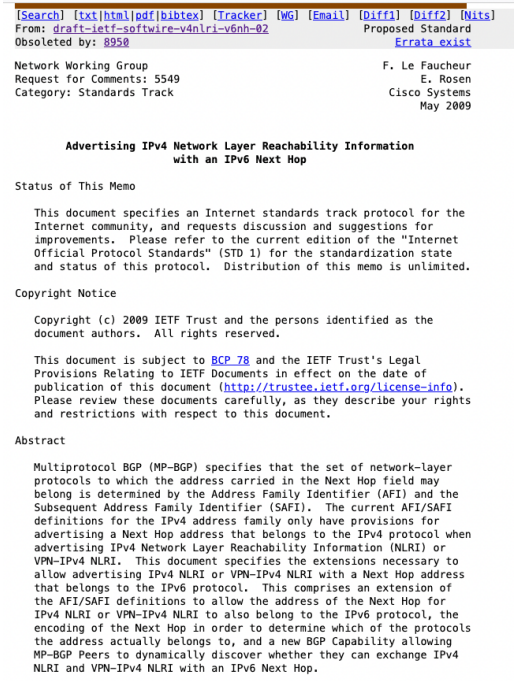
- A brief touchpoint of the work at the IETF (Internet Engineering Task Force) and what RFC (Request for Comment) are Standard and what Informational
- What is this RFC 5549 about – why do we have it and what is it good for
- Deployment Scenarios in Service Provider (SP) and Data Center (DC)
- How to make Layer-3 BGP Fabric deployments even simpler
- Addressing modern Cloud Native Applications needs

What is RFC 5549?

Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop

https://datatracker.ietf.org/doc/html/rfc5549

What is RFC 5549?
By the Standards Body



[Search] [txt|html|pdf|bibtex] [Tracker] [WG] [Email] [Diff1] [Diff2] [Nits]
From: draft-ietf-softwire-v4nlri-v6nh-02 Proposed Standard
Obsoleted by: 8950 Errata exist

Network Working Group F. Le Faucheur
Request for Comments: 5549 E. Rosen
Category: Standards Track Cisco Systems
May 2009

Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

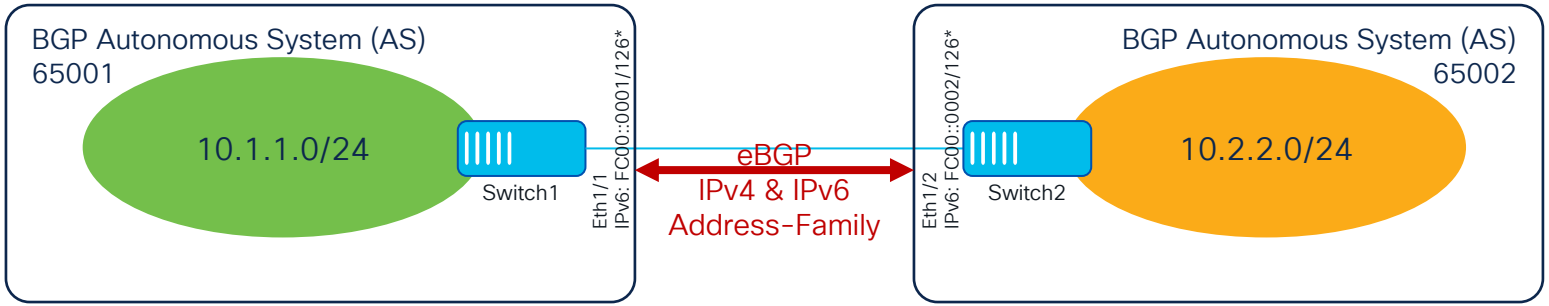
Multiprotocol BGP (MP-BGP) specifies that the set of network-layer protocols to which the address carried in the Next Hop field may belong is determined by the Address Family Identifier (AFI) and the Subsequent Address Family Identifier (SAFI). The current AFI/SAFI definitions for the IPv4 address family only have provisions for advertising a Next Hop address that belongs to the IPv4 protocol when advertising IPv4 Network Layer Reachability Information (NLRI) or VPN-IPv4 NLRI. This document specifies the extensions necessary to allow advertising IPv4 NLRI or VPN-IPv4 NLRI with a Next Hop address that belongs to the IPv6 protocol. This comprises an extension of the AFI/SAFI definitions to allow the address of the Next Hop for IPv4 NLRI or VPN-IPv4 NLRI to also belong to the IPv6 protocol, the encoding of the Next Hop in order to determine which of the protocols the address actually belongs to, and a new BGP Capability allowing MP-BGP Peers to dynamically discover whether they can exchange IPv4 NLRI and VPN-IPv4 NLRI with an IPv6 Next Hop.

- Internet Engineering Task Force (IETF) Request for Comment (RFC)
- Categorized for Standards Track
- Internet Standard since 2009
- Updated by RFC 8950
  - aka RFC 5549bis
- Industry wide adoption for more than 10 years
- Invented and Authored by Cisco

- RFC 5549
  - https://datatracker.ietf.org/doc/html/rfc5549
- RFC 8950
  - https://datatracker.ietf.org/doc/html/rfc8950

What is RFC 5549 for?

- Defines a specific behavior in Border Gateway Protocol (BGP)
- Allows IPv4 Network Layer Reachability via a IPv6 Next-Hop

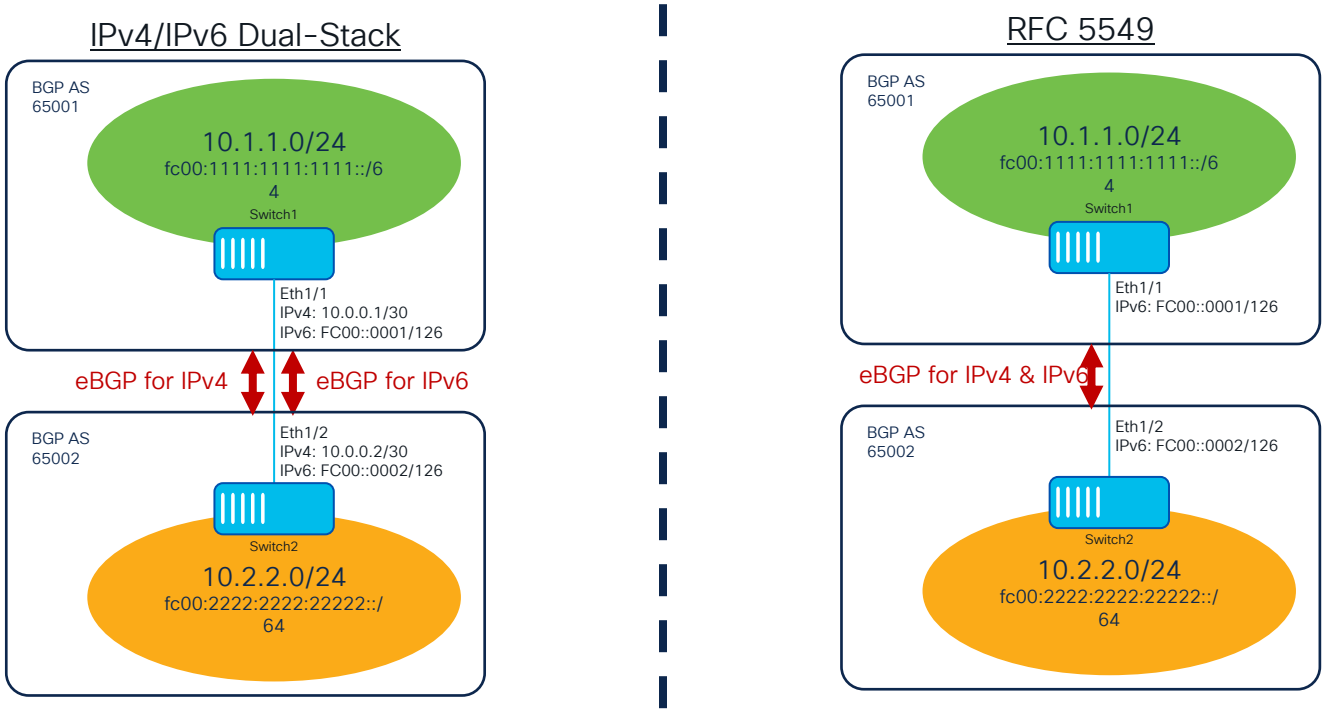



```
[Output]
Switch1# show ip bgp
BGP routing table information for VRF default, address family IPv4 Unicast
BGP table version is 7, Local Router ID is 1.1.1.1
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

   Network          Next Hop            Metric     LocPrf     Weight Path
*>e10.2.2.0/24      fc00::0002               0                     0 65002 ?
```

*I don't think you will see /126 in real world, more likely this is going to be a /64 or better /127

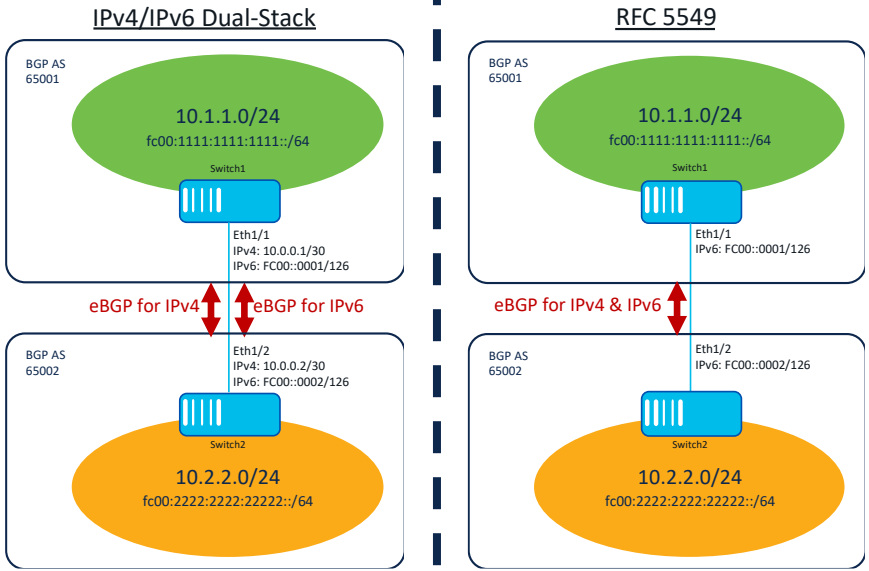
Side-by-Side
IPv4/IPv6 Dual-Stack and RFC 5549



Side-by-Side – Config with IPv6 Numbered
IPv4/IPv6 Dual-Stack and RFC 5549

Per-Address-Family Peering

```
[Config]
router bgp 65001
  neighbor 10.0.0.2
    remote-as 65001
    address-family ipv4 unicast
  neighbor FC00:0001
    remote-as 65001
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 FC00:0001/126
 ip address 10.0.0.1/30
```



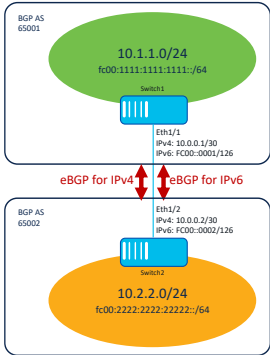
Per-Neighbor Peering

```
[Config]
router bgp 65001
  neighbor FC00:0001
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 FC00:0001/126
 ip forward
```

*IPv6 GUA – IPv6 Global Unicast Address

Side-by-Side – Oper with IPv6 Numbered
IPv4/IPv6 Dual-Stack and RFC 5549

IPv4/IPv6 Dual-Stack



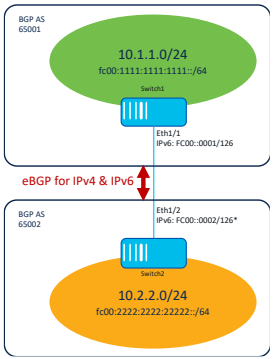

```
[Output]
Switch1# show ip bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>e10.2.2.0/24     10.0.0.2                 0                     0 65002 ?


Switch1# show ipv6 bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>efc00:2222:2222:2222::/64
                   fc00::0002               0                     0 65002 ?
```

RFC 5549




```
[Output]
Switch1# show ip bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>e10.2.2.0/24     fc00::0002               0                     0 65002 ?

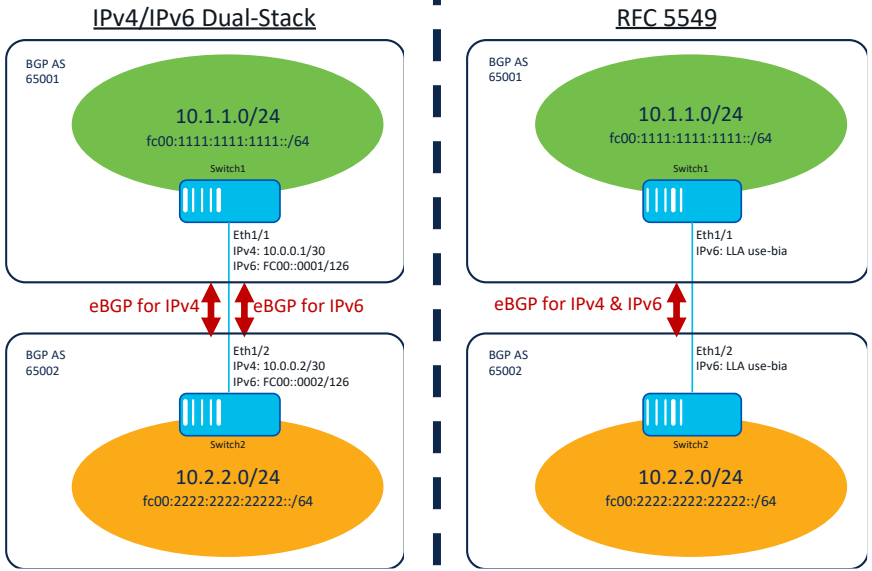

Switch1# show ipv6 bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>efc00:2222:2222:2222::/64
                   fc00::0002               0                     0 65002 ?
```

Side-by-Side – Config with Unnumbered (LLA)
IPv4/IPv6 Dual-Stack and RFC 5549

Per-Address-Family Peering

```
[Config]
router bgp 65001
  neighbor 10.0.0.2
    remote-as 65001
    address-family ipv4 unicast
  neighbor FC00:0001
    remote-as 65001
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 FC00:0001/126
 ip address 10.0.0.1/30
```



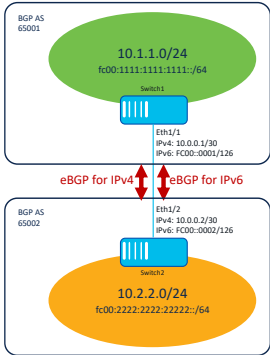
Per-Neighbor **Unnumbered** Peering

```
[Config]
router bgp 65001
  neighbor Ethernet1/1
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

Removing the need for Interface IP Addressing or BGP Peer Configuration with IPv6 Link-Local Addressing and BGP interface peering (unnumbered)

Side-by-Side – Oper with Unnumbered (LLA)
IPv4/IPv6 Dual-Stack and RFC 5549

IPv4/IPv6 Dual-Stack




```
[Output]
Switch1# show ip bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>e10.2.2.0/24     10.0.0.2                 0                     0 65002 ?


Switch1# show ipv6 bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>efc00:2222:2222:2222::/64
                   fc00::0002               0                     0 65002 ?
```

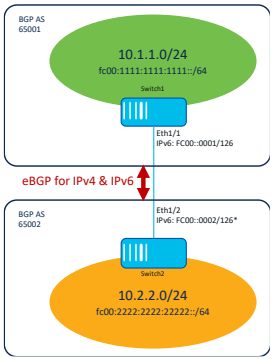
```
[Output]
Switch1# show ip bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>e10.2.2.0/24     fe80::720f:6aff:fe4d:a7f0
                                            0                     0 65002 ?


Switch1# show ipv6 bgp

Network            Next Hop            Metric     LocPrf     Weight Path
*>efc00:2222:2222:2222::/64
                   fe80::720f:6aff:fe4d:a7f0
                                            0                     0 65002 ?
```

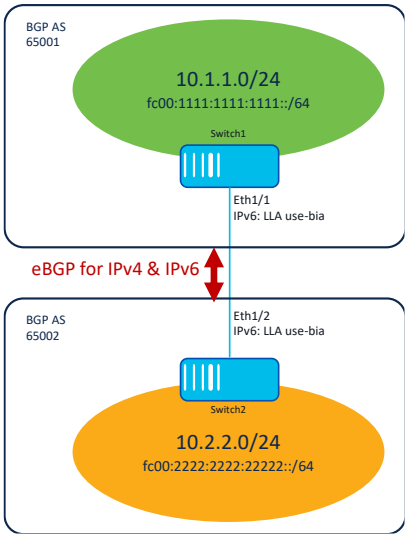
RFC 5549



Deployment Simplification
Using IPv6 Link-Local and BGP Interface Peering

For the rest of this Presentation, we are using IPv6 Link-Local and BGP Interface Peering

RFC 5549



Per-Neighbor **Unnumbered** Peering

```
[Config]
router bgp 65001
  neighbor Ethernet1/1
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

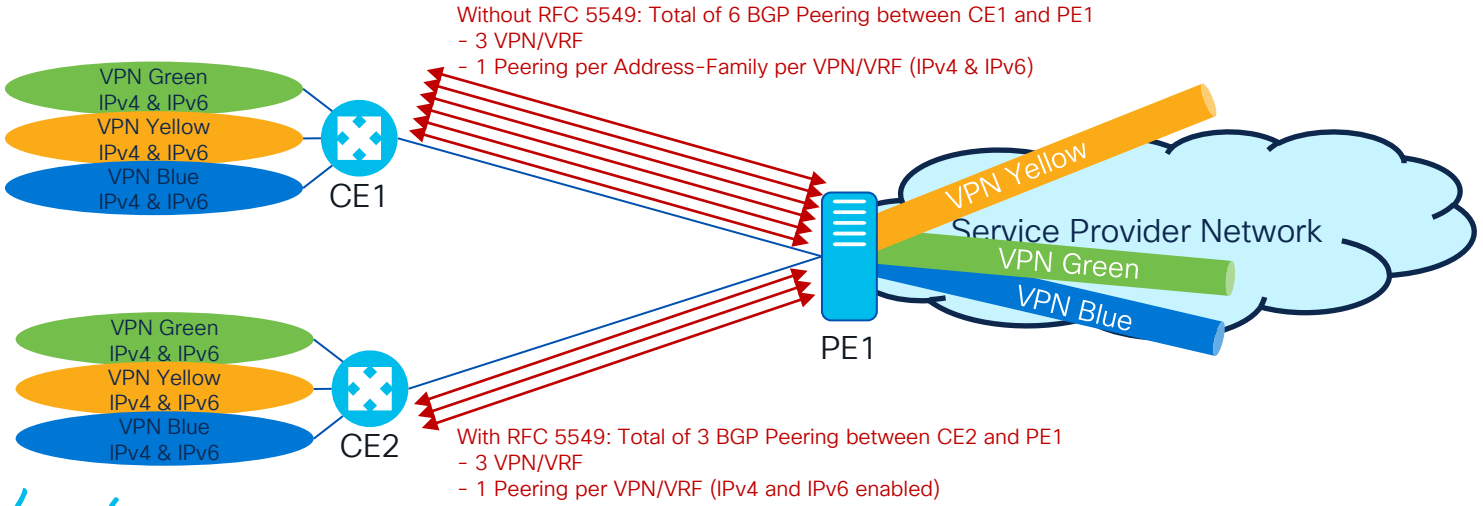
Removing the need for Interface IP Addressing or BGP Peer Configuration with IPv6 Link-Local Addressing and BGP interface peering

For the rest of this Presentation, we are using IPv6 Link-Local and BGP Interface Peering

Use Cases

RFC 5549 Use Cases?
From the Service Provider Playbook

- For Example, the CE-PE Scenario with or without Inter-AS Option A
  - CE (Customer Edge) to PE (Provider Edge)
- Single BGP session, per-VRF, for IPv4 and IPv6 Prefixes
  - Better BGP Session Scale on PE (Fan Out)
  - Less Point-to-Point IP addressing and BGP Peering configuration

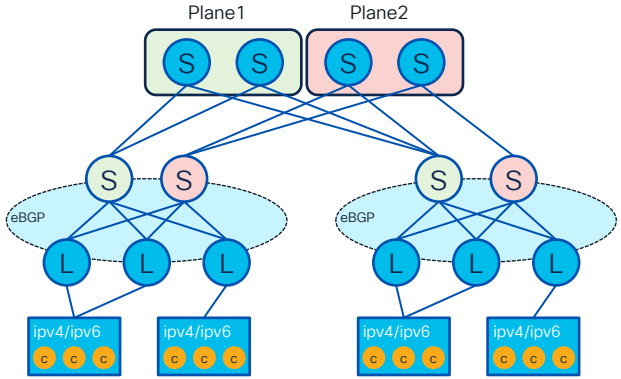


How does this fit in the Data Center?

RFC 5549 Use Cases

RFC 5549 Use Cases?
From the Data Center Playbook

- For Example, Use of BGP for Routing in Large-Scale Data Centers
  - RFC 7938 https://datatracker.ietf.org/doc/html/rfc7938
- Used as Routing Protocol between Leaf, Spine and other Tiers (ie Super-Spine)
  - IPv4 and IPv6 Prefix with a single Routing Protocol Session – No VRF, VPNs or Overlays
  - Ready for “Cloud Native Applications”* – no need for Layer-2
  - Better BGP Session Scale on Leaf to Server (Fan Out) - Less Point-to-Point IP Addressing

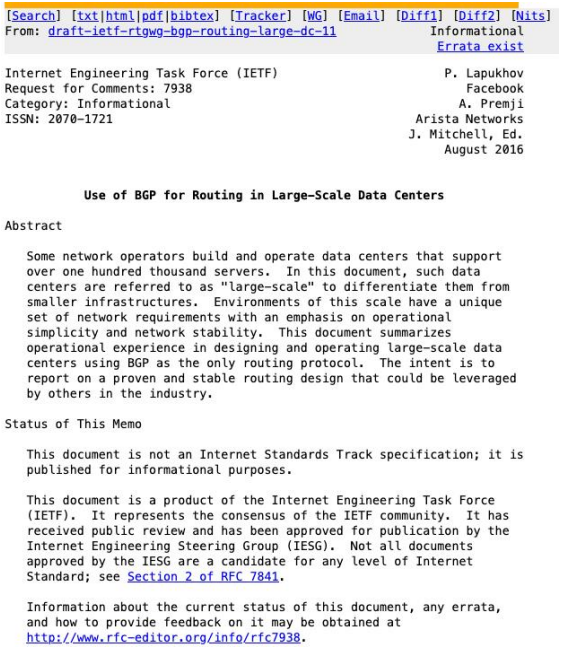


*”Cloud Native Applications” are generally defined as Container- or Kubernetes-based Applications

Reducing the number of Control- and Data-Plane Protocols in the Data Center

Building for the “Cloud Native Application” … and other use cases

What is RFC 7938?
By the Standards Body



[Search] [txt|html|pdf|bibtex] [Tracker] [WG] [Email] [Diff1] [Diff2] [Nits]
From: draft-ietf-rtgwg-bgp-routing-large-dc-11 Informational
Errata exist

Internet Engineering Task Force (IETF) P. Lapukhov
Request for Comments: 7938 Facebook
Category: Informational A. Premji
ISSN: 2070-1721 Arista Networks
J. Mitchell, Ed.
August 2016

Use of BGP for Routing in Large-Scale Data Centers

Abstract

Some network operators build and operate data centers that support over one hundred thousand servers. In this document, such data centers are referred to as "large-scale" to differentiate them from smaller infrastructures. Environments of this scale have a unique set of network requirements with an emphasis on operational simplicity and network stability. This document summarizes operational experience in designing and operating large-scale data centers using BGP as the only routing protocol. The intent is to report on a proven and stable routing design that could be leveraged by others in the industry.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for informational purposes.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Not all documents approved by the IESG are a candidate for any level of Internet Standard; see Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7938.

- Categorized as Informational RFC
- Basically, a Design Guide for Leaf/Spine Topologies
  - Checkout my Multi-Tier session
- Chooses EBGP as Routing Protocol for the Data Center
  - A flat Layer-3 only approach
  - No Network Overlays considered
- Is RFC 7938 dated?
  - No specific reference to IPv6
  - Only 2-Byte ASN reference
  - Talks about TRILL for Layer-2

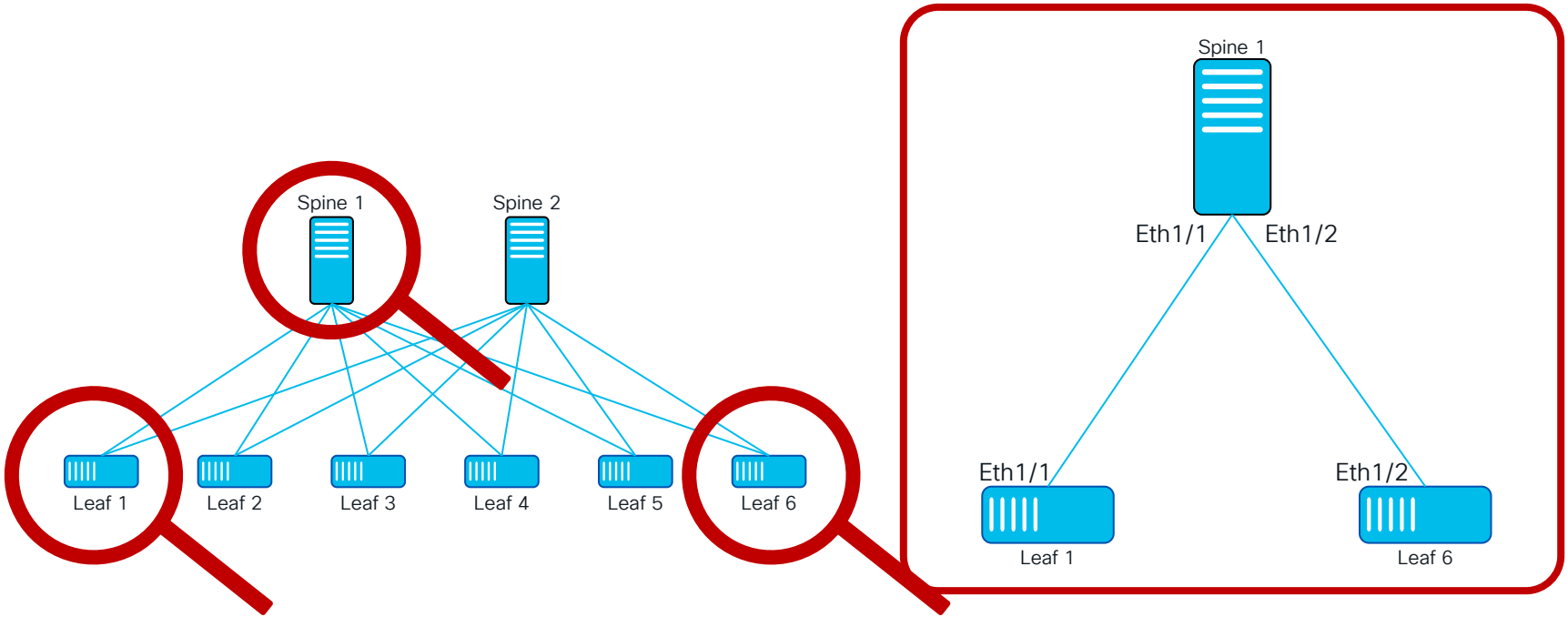
- RFC 7938
  - https://datatracker.ietf.org/doc/html/rfc7938

Advertising IPv4 & IPv6 Prefix Information with an IPv6 Next Hop enables *BGP for Routing in Large-Scale Data Centers* to carry *IPv4 & IPv6 Address-Family*

How RFC 7938 can leverage RFC 5549 (RFC 8950)

Deployments with RFC 5549 at a glance

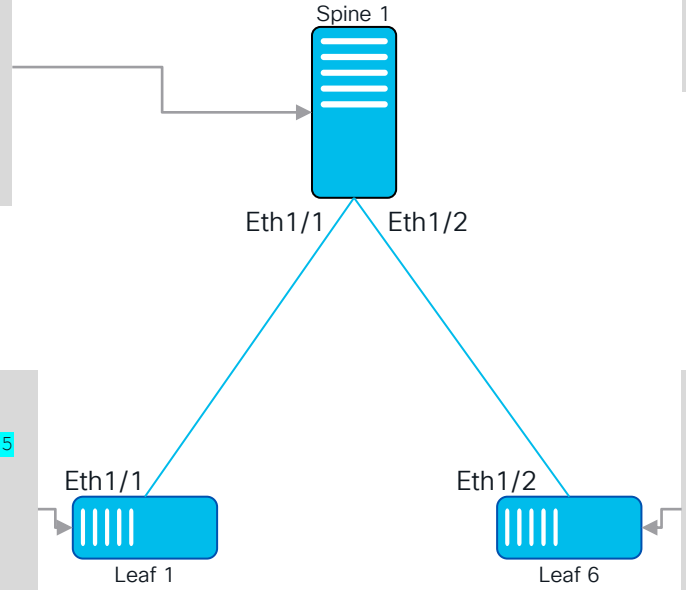
Magnifying some Nodes



local bgp ASN
local bgp RID
bgp neighbor / next-hop / if
peer bgp ASN
IPv6 Link-Local

Adding some Loopacks

[Config]
```
interface loopback0
  ip address 10.51.51.51/32 tag 12345
  ipv6 address fc00::51/128 tag 12345
!
router bgp 65111
 address-family ipv4 unicast
  redistribute direct route-map TAG
 address-family ipv6 unicast
  redistribute direct route-map TAG
```



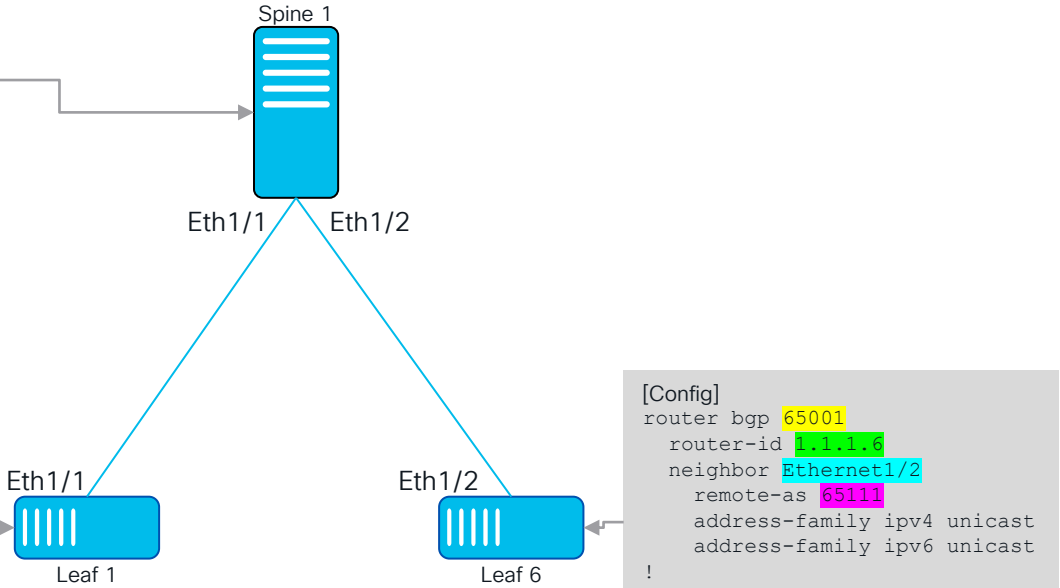
[Config]
```
route-map TAG permit 10
  match tag 12345
```

[Config]
```
interface loopback0
  ip address 10.131.131.131/32 tag 12345
  ipv6 address fc00::131/128 tag 12345
!
router bgp 65001
 address-family ipv4 unicast
  redistribute direct route-map TAG
 address-family ipv6 unicast
  redistribute direct route-map TAG
```

[Config]
```
interface loopback0
  ip address 10.132.132.132/32 tag 12345
  ipv6 address fc00::132/128 tag 12345
!
router bgp 65001
 address-family ipv4 unicast
  redistribute direct route-map TAG
 address-family ipv6 unicast
  redistribute direct route-map TAG
```

Config per RFC7938 (Dual-AS)

```
[Config]
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1-2
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1-2
 ipv6 link-local use-bia
 ip forward
```




```
[Config]
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

```
[Config]
router bgp 65001
  router-id 1.1.1.6
  neighbor Ethernet1/2
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/2
 ipv6 link-local use-bia
 ip forward
```

This is NOT just going to work (Source AS = Destination AS) – 2 Different Ways to Remediate

Oper IPv4 per RFC7938 (Dual-AS)

[Config]
```
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1-2
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1-2
 ipv6 link-local use-bia
 ip forward
```

[Config]
```
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Output]
```
Leaf1# show ip route
IP Route Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

10.131.131.131/32, ubest/mbest: 2/0, attached
    *via 10.131.131.131, Lo0, [0/0], 00:19:19, local, tag 12345
    *via 10.131.131.131, Lo0, [0/0], 00:19:19, direct, tag 12345

Leaf1# show ip bgp
BGP routing table information for VRF default, address family IPv4 Unicast
BGP table version is 8, Local Router ID is 1.1.1.1
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

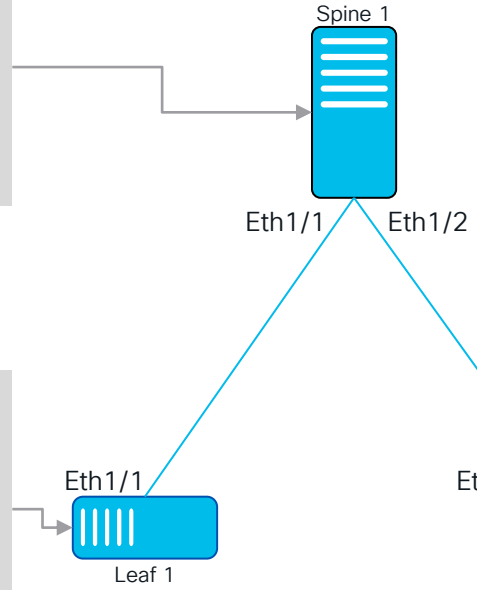

   Network            Next Hop            Metric     LocPrf     Weight Path
*>r10.131.131.131/32  0.0.0.0                  0        100      32768 ?
```

No Routes from the other Leaf (same ASN)

This is NOT just going to work (Source AS = Destination AS) – 2 Different Ways to Remediate

Config per RFC7938 (Dual-AS with knobs)

```
[Config]
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1-2
    remote-as 65001
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/1-2
 ipv6 link-local use-bia
 ip forward
```




```
[Config]
template peer DISABLE-AS-PATH-CHECK
  address-family ipv4 unicast
    allowas-in
    disable-peer-as-check
```

```
[Config]
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

```
[Config]
router bgp 65001
  router-id 1.1.1.6
  neighbor Ethernet1/2
    remote-as 65111
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/2
 ipv6 link-local use-bia
 ip forward
```

Option #1 – Dual-AS; Let's turn some BGP knobs

Oper IPv4 per RFC7938 (Dual-AS with knobs)

[Config]
```
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1-2
    remote-as 65001
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/1-2
 ipv6 link-local use-bia
 ip forward
```

[Config]
```
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Output]
```
Leaf1# show ip route
IP Route Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

10.131.131.131/32, ubest/mbest: 2/0, attached
    *via 10.131.131.131, Lo0, [0/0], 00:19:19, local, tag 12345
    *via 10.131.131.131, Lo0, [0/0], 00:19:19, direct, tag 12345
10.132.132.132/32, ubest/mbest: 1/0
    *via fe80::720f:6aff:fe0b:6196%default, Eth1/1, [20/0], 00:00:23, bgp-65001, external, tag 65111

Leaf1# show ip bgp
BGP routing table information for VRF default, address family IPv4 Unicast
BGP table version is 6, Local Router ID is 1.1.1.1
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

   Network            Next Hop            Metric     LocPrf     Weight Path
*>r10.131.131.131/32  0.0.0.0                  0        100      32768 ?
*>e10.132.132.132/32  fe80::720f:6aff:fe0b:6196
                                                                      0 65111 65001 ?
```

Option #1 – Dual-AS; Let's turn some BGP knobs

Oper IPv6 per RFC7938 Dual-AS

[Config]
```
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1-2
    remote-as 65001
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/1-2
 ipv6 link-local use-bia
 ip forward
```

[Config]
```
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    inherit peer DISABLE-AS-PATH-CHECK
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Output]
```
Leaf1# show ipv6 route
IPv6 Routing Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]

fc00::131/128, ubest/mbest: 2/0, attached
    *via fc00::131, Lo0, [0/0], 09:48:14, direct, , tag 12345
    *via fc00::131, Lo0, [0/0], 09:48:14, local, tag 12345
fc00::132/128, ubest/mbest: 1/0
    *via fe80::720f:6aff:fe0b:6196, Eth1/1, [20/0], 00:00:25, bgp-65001, external, tag 65111

Leaf1# show ipv6 bgp
BGP routing table information for VRF default, address family IPv6 Unicast
BGP table version is 11, Local Router ID is 1.1.1.1
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

   Network            Next Hop            Metric     LocPrf     Weight Path
*>rfc00::131/128      0::                      0        100      32768 ?
*>efc00::132/128      fe80::720f:6aff:fe0b:6196
                                                                      0 65111 65001 ?
```

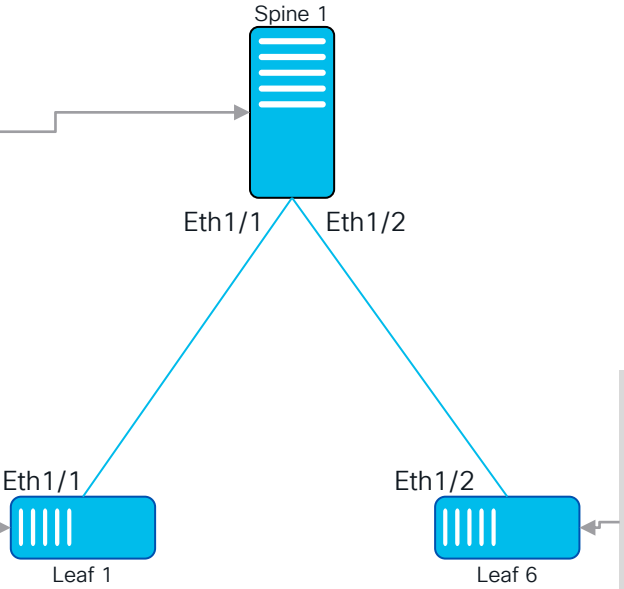
Option #1 – Dual-AS; Let's turn some BGP knobs

Config of Multi-AS

```
[Config]
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
 neighbor Ethernet1/2
    remote-as 65006
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

```
[Config]
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

```
[Config]
router bgp 65006
  router-id 1.1.1.6
  neighbor Ethernet1/2
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/2
 ipv6 link-local use-bia
 ip forward
```



Option #2 - Multi-AS; each Switch will get its own AS (more in BGP Auto-Fabric)

Oper of IPv4 in Multi-AS

[Config]

```
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
 neighbor Ethernet1/2
    remote-as 65006
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Config]

```
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Output]

```
Leaf1# show ip route
IP Route Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

10.131.131.131/32, ubest/mbest: 2/0, attached
    *via 10.131.131.131, Lo0, [0/0], 00:19:19, local, tag 12345
    *via 10.131.131.131, Lo0, [0/0], 00:19:19, direct, tag 12345
10.132.132.132/32, ubest/mbest: 1/0
    *via fe80::720f:6aff:fe0b:6196%default, Eth1/1, [20/0], 00:00:23, bgp-65001, external, tag 65111

Leaf1# show ip bgp
BGP routing table information for VRF default, address family IPv4 Unicast
BGP table version is 6, Local Router ID is 1.1.1.1
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

   Network            Next Hop            Metric     LocPrf     Weight Path
*>r10.131.131.131/32  0.0.0.0                  0        100      32768 ?
*>e10.132.132.132/32  fe80::720f:6aff:fe0b:6196
                                                                      0 65111 65006 ?
```

Option #2 - Multi-AS; each Switch will get its own AS (more in BGP Auto-Fabric)

Oper of IPv6 in Multi-AS

[Config]
```
router bgp 65111
  router-id 111.1.1.1
  neighbor Ethernet1/1
    remote-as 65001
    address-family ipv4 unicast
    address-family ipv6 unicast
 neighbor Ethernet1/2
    remote-as 65006
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Config]
```
router bgp 65001
  router-id 1.1.1.1
  neighbor Ethernet1/1
    remote-as 65111
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

[Output]
```
Leaf1# show ipv6 route
IPv6 Routing Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]

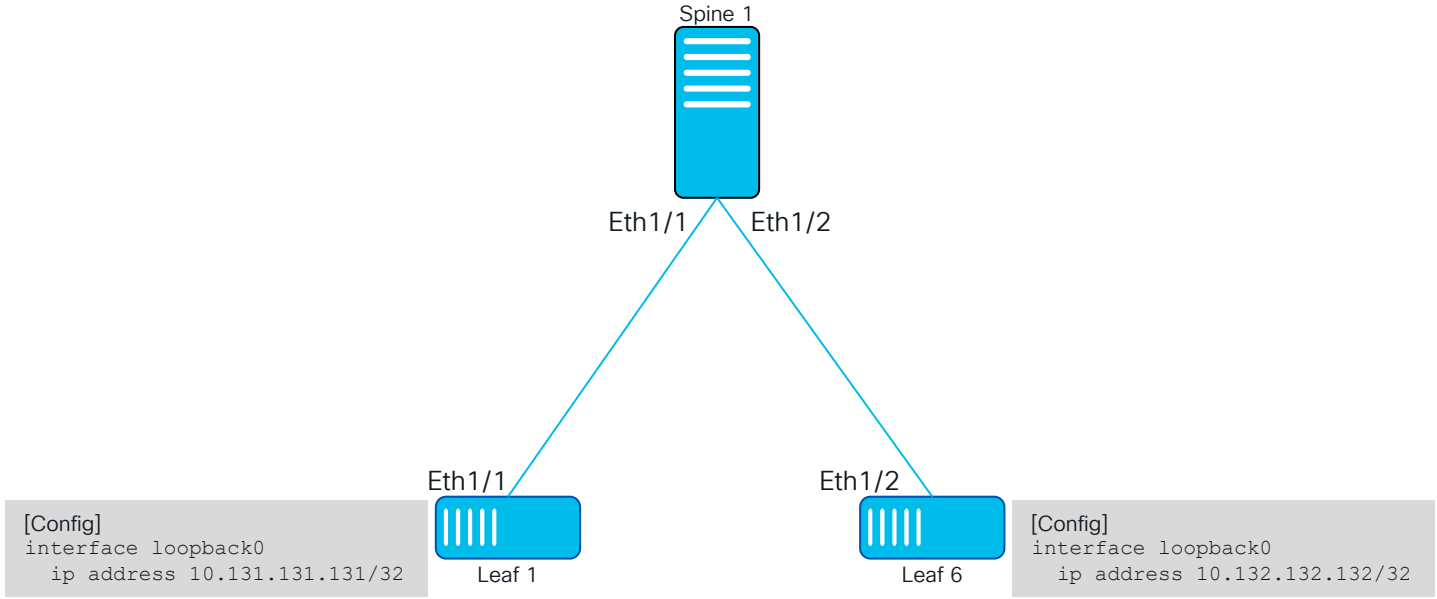
fc00::131/128, ubest/mbest: 2/0, attached
    *via fc00::131, Lo0, [0/0], 09:48:14, direct, , tag 12345
    *via fc00::131, Lo0, [0/0], 09:48:14, local, tag 12345
fc00::132/128, ubest/mbest: 1/0
    *via fe80::720f:6aff:fe0b:6196, Eth1/1, [20/0], 00:00:25, bgp-65001, external, tag 65111

Leaf1# show ipv6 bgp
BGP routing table information for VRF default, address family IPv6 Unicast
BGP table version is 11, Local Router ID is 1.1.1.1
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

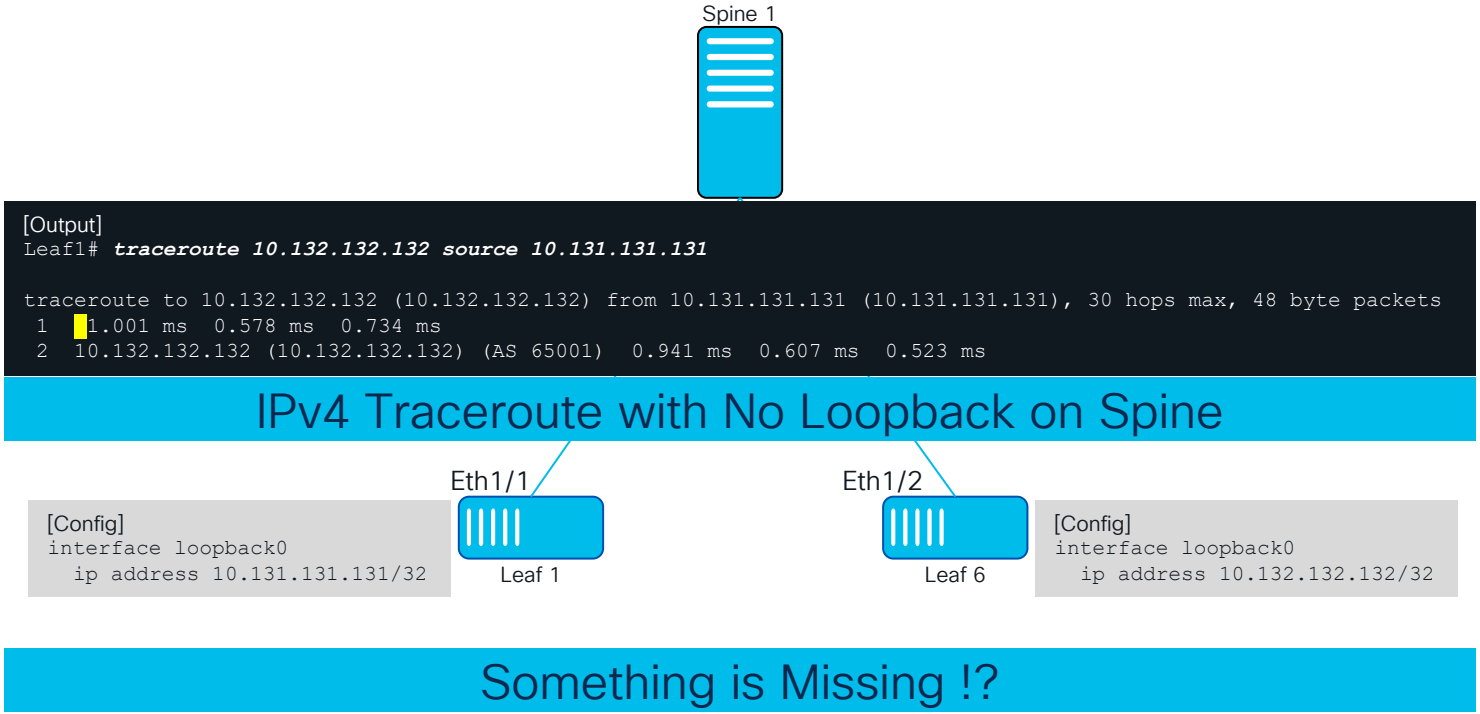
   Network            Next Hop            Metric     LocPrf     Weight Path
*>rfc00::131/128      0::                      0        100      32768 ?
*>efc00::132/128      fe80::720f:6aff:fe0b:6196
                                                                      0 65111 65006 ?
```

Option #2 - Multi-AS; each Switch will get its own AS (more in BGP Auto-Fabric)

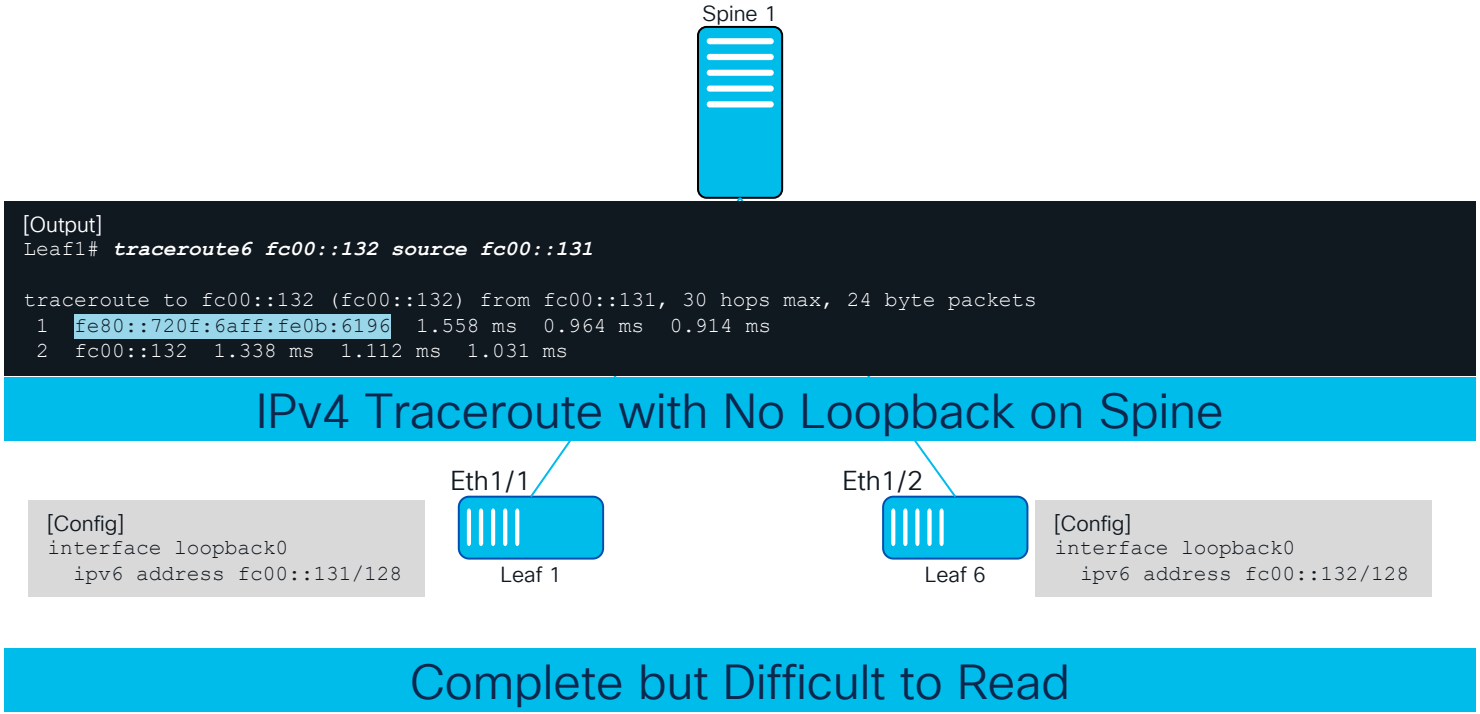
Ping and Traceroute – we need some Loopbacks



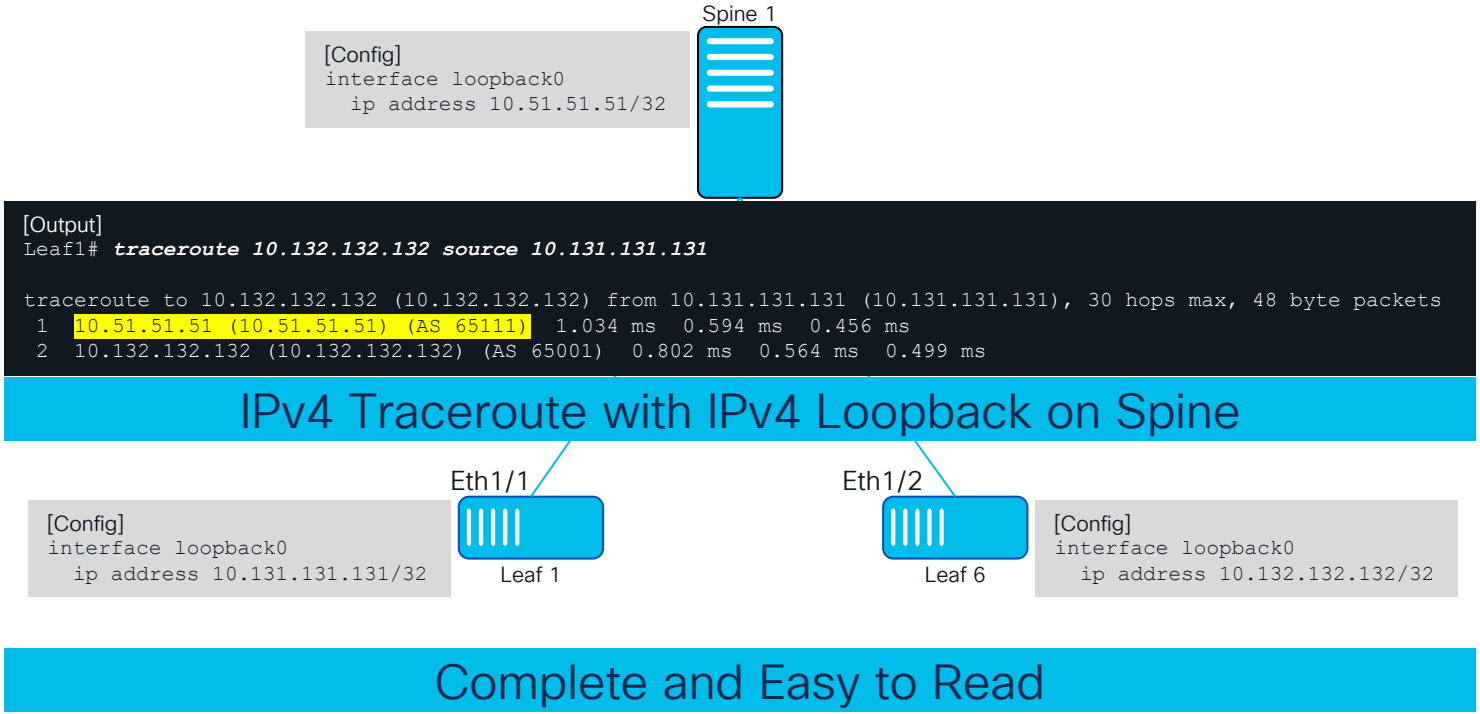
Ping and Traceroute – we need some Loopbacks



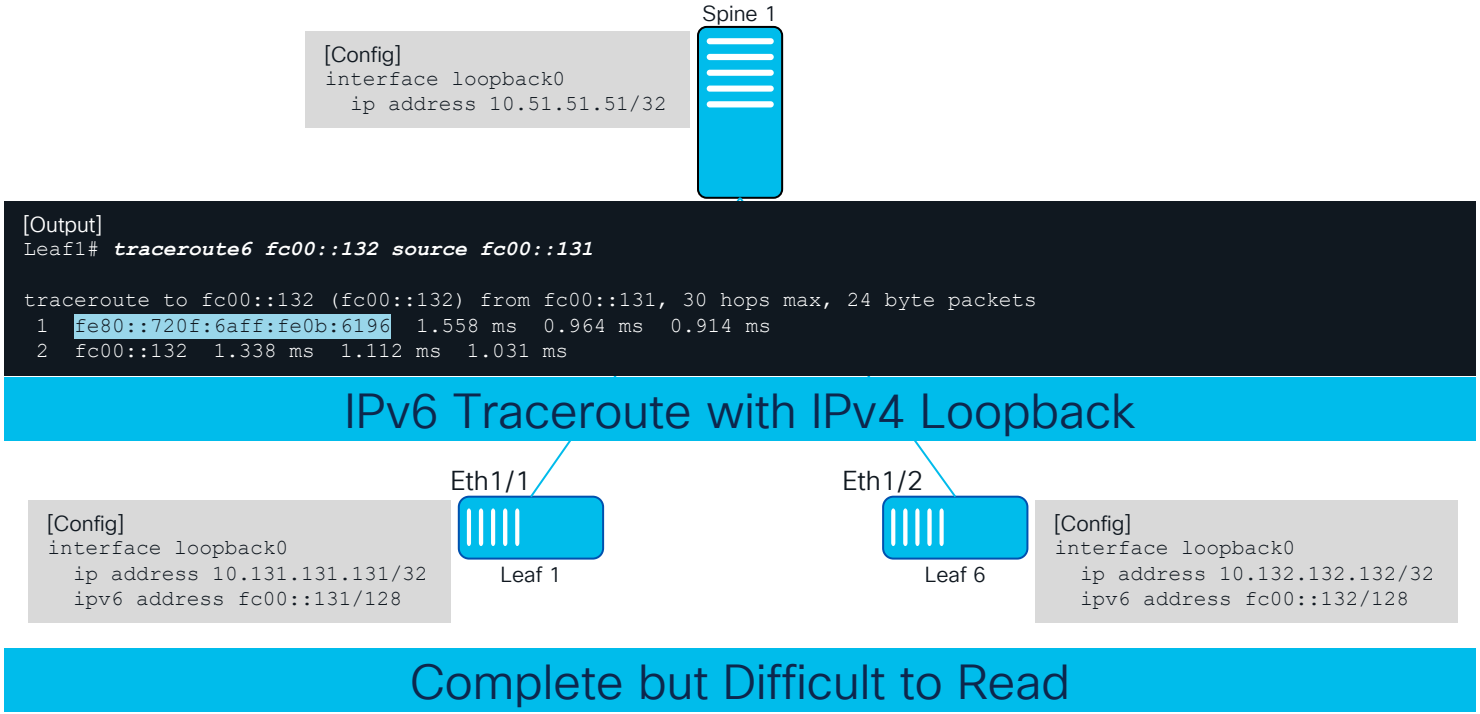
Ping and Traceroute – we need some Loopbacks



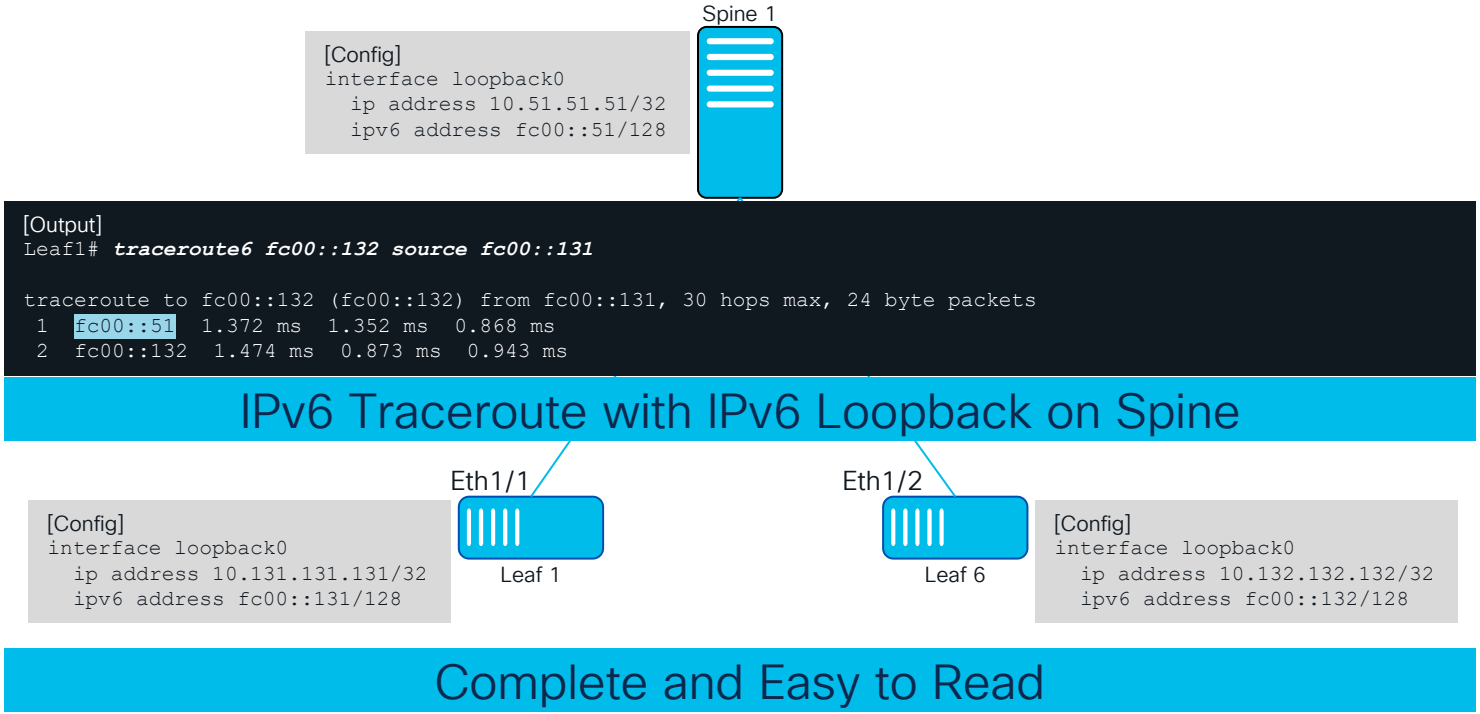
Ping and Traceroute – we need some Loopbacks



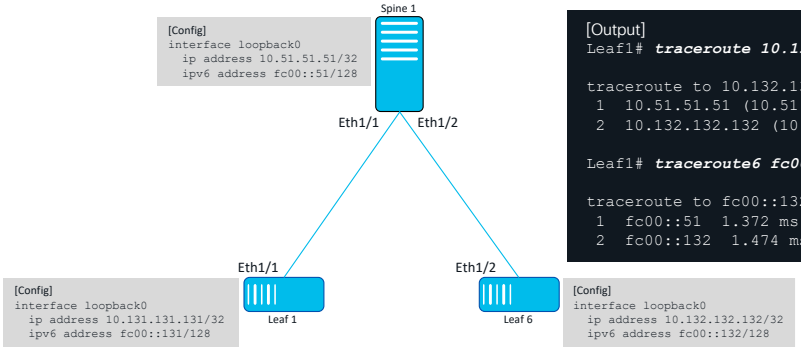
Ping and Traceroute – we need some Loopbacks



Ping and Traceroute – we need some Loopbacks



Ping and Traceroute – we need some Loopbacks




```
[Output]
Leaf1# traceroute 10.132.132.132 source 10.131.131.131

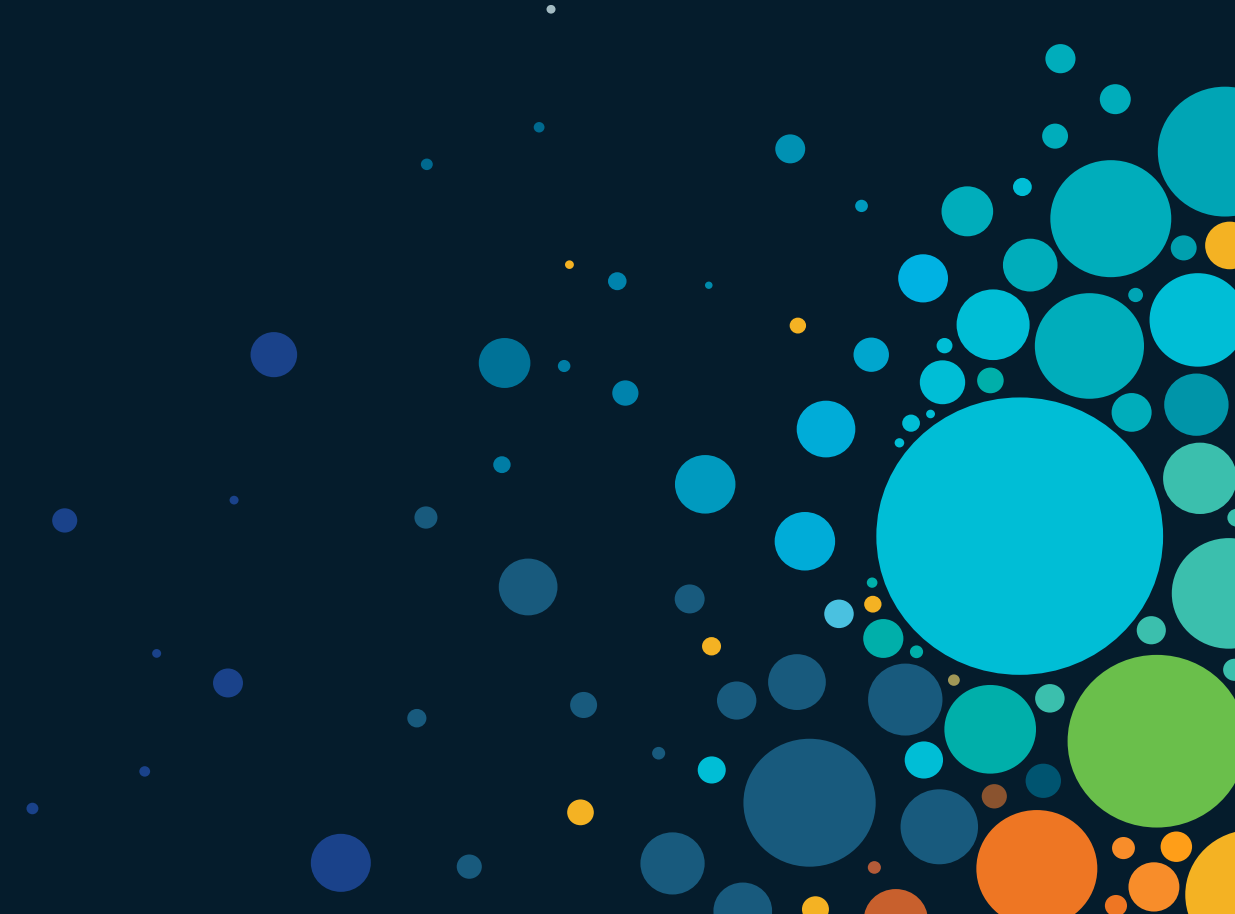
traceroute to 10.132.132.132 (10.132.132.132) from 10.131.131.131 (10.131.131.131), 30 hops max, 48 byte packets
 1  10.51.51.51 (10.51.51.51) (AS 65111)  1.034 ms  0.594 ms  0.456 ms
 2  10.132.132.132 (10.132.132.132) (AS 65001)  0.802 ms  0.564 ms  0.499 ms

Leaf1# traceroute6 fc00::132 source fc00::131

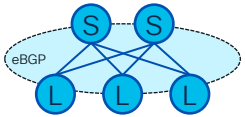
traceroute to fc00::132 (fc00::132) from fc00::131, 30 hops max, 24 byte packets
 1  fc00::51  1.372 ms  1.352 ms  0.868 ms
 2  fc00::132  1.474 ms  0.873 ms  0.943 ms
```

- A Loopback per Switch helps in Operational Tasks
  - For IPv4, add a IPv4 Loopback. For IPv6, add a IPv6 Loopback
- Ping for Connectivity Test
  - Loopback to Loopback
  - Physical Interface to Physical Interface (Link-Local Address)
- Traceroute becomes easy to Read
  - Each Hop clearly identified by the Loopback IP address (IPv4 or IPv6)
  - In Leaf/Spine, Loopback address is sufficient (there is no other path)
- In-band Management (Loopback to Loopback or LLA to LLA)

BGP Auto-Fabric

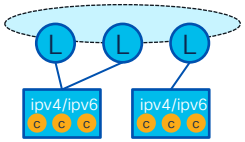


What is BGP Auto-Fabric?



Self Organized BGP Fabric

Autonomously Derives Key Values for BGP
Avoids Per-Interface IP Addressing
Automates BGP ASN and Router-ID
Simplifies BGP Peer Configuration



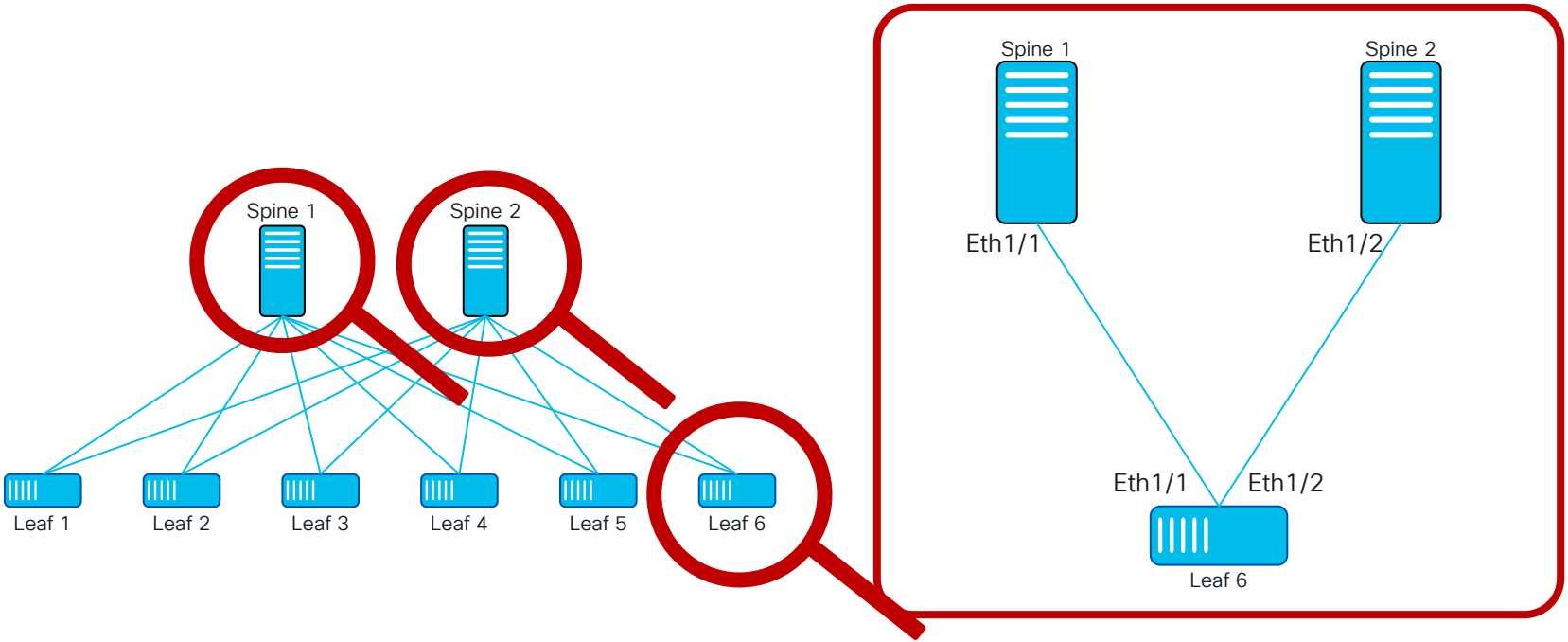
For IPv4 and IPv6 Needs

No Requirement for Dual-Stack Config
Simplifies BGP peering with End-Points
Autonomous Node IP Assignment
Ready for “Cloud Native Applications”*

*”Cloud Native Applications” are generally defined as Container- or Kubernetes-based Applications

BGP Auto-Fabric at a glance

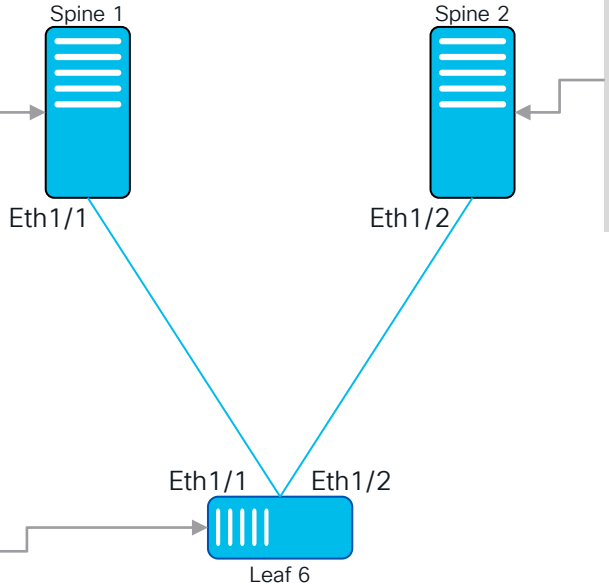
Magnifying some Nodes



Config - BGP Auto-Fabric at a glance

```
[Config]
router bgp auto
  router-id auto
  neighbor Ethernet1/1
    remote-as external
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

```
[Config]
router bgp auto
  router-id auto
  neighbor Ethernet1/2
    remote-as external
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/2
 ipv6 link-local use-bia
 ip forward
```




```
[Config]
router bgp auto
  router-id auto
  neighbor Ethernet1/1-2*
    remote-as external
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1-2
 ipv6 link-local use-bia
 ip forward
```

*BGP interface peering with interface range definition will be available in a subsequent release (roadmap)

Config Results - Auto Derived

```
[Config]
router bgp auto
  router-id auto
  neighbor Ethernet1/1
    remote-as external
    address-family ipv4 unicast
    address-family ipv6 unicast
!
interface Ethernet1/1
 ipv6 link-local use-bia
 ip forward
```

Auto/Peering Seed Values
Global: [System MAC]-[-]-[-]
Per-Interface: [Interface MAC]-[-]-[-]

```
[Output]
Spine1# show bgp sessions
Total peers 1, established peers 1
ASN 4272508914
VRF default, local ASN 4272508914
peers 1, established peers 1, local router-id 21.77.167.239
State: I-Idle, A-Active, O-Open, E-Established, C-Closing, S-Shutdown

Neighbor        ASN     Flaps LastUpDn|LastRead|LastWrit St Port(L/R)  Notif(S/R)
fe80::720f:6aff:fe0b:6196%Ethernet1/1
                4268165528 0     01:01:59|00:00:52|00:00:19 E   23388/179        0/0

Spine1#
Spine1# show ipv6 interface brief
IPv6 Interface Status for VRF "default"(1)
Interface        IPv6 Address/Link-local Address          Interface Status
                                                          prot/link/admin
Eth1/1           fe80::720f:6aff:fe4d:a7f0                up/up/up
                 fe80::720f:6aff:fe4d:a7f0

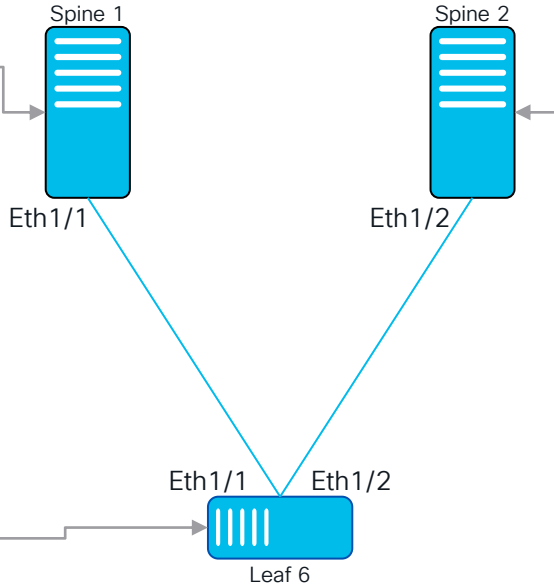
Spine1#
Spine1# show ip interface brief

IP Interface Status for VRF "default"(1)
Interface            IP Address      Interface Status
Eth1/1               forward-enabled protocol-up/link-up/admin-up
```

local bgp ASN
local bgp RID
bgp neighbor / next-hop / if
peer bgp ASN
IPv6 Link-Local

Adding some Loopacks

[Config]
```
interface loopback0
  ip address 10.131.131.131/32 tag 12345
  ipv6 address fc00::131/128 tag 12345
!
router bgp auto
 address-family ipv4 unicast
  redistribute direct route-map TAG
 address-family ipv6 unicast
  redistribute direct route-map TAG
```

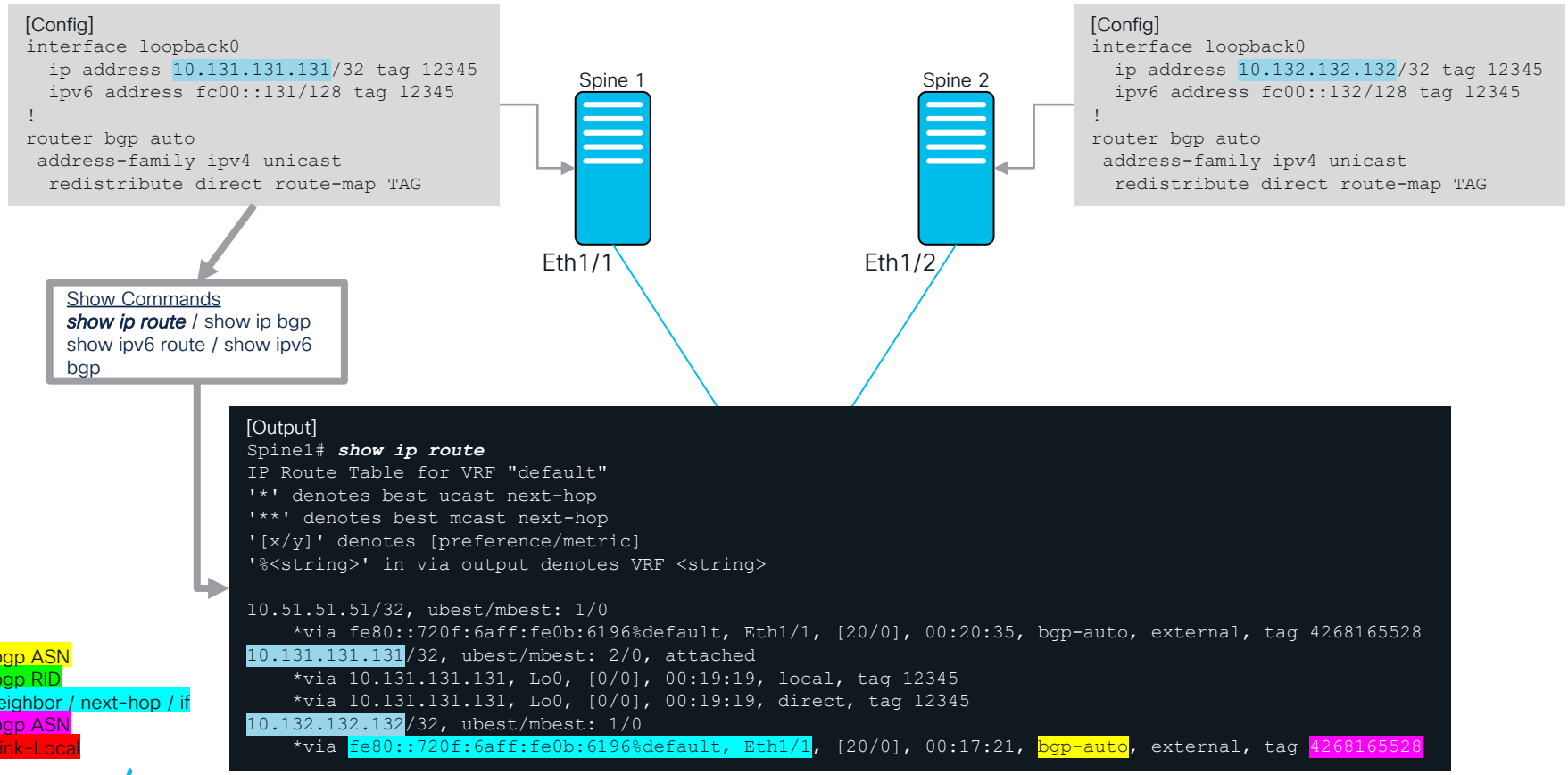


[Config]
```
interface loopback0
  ip address 10.132.132.132/32 tag 12345
  ipv6 address fc00::132/128 tag 12345
!
router bgp auto
 address-family ipv4 unicast
  redistribute direct route-map TAG
 address-family ipv6 unicast
  redistribute direct route-map TAG
```

[Config]
```
route-map TAG permit 10
  match tag 12345
```

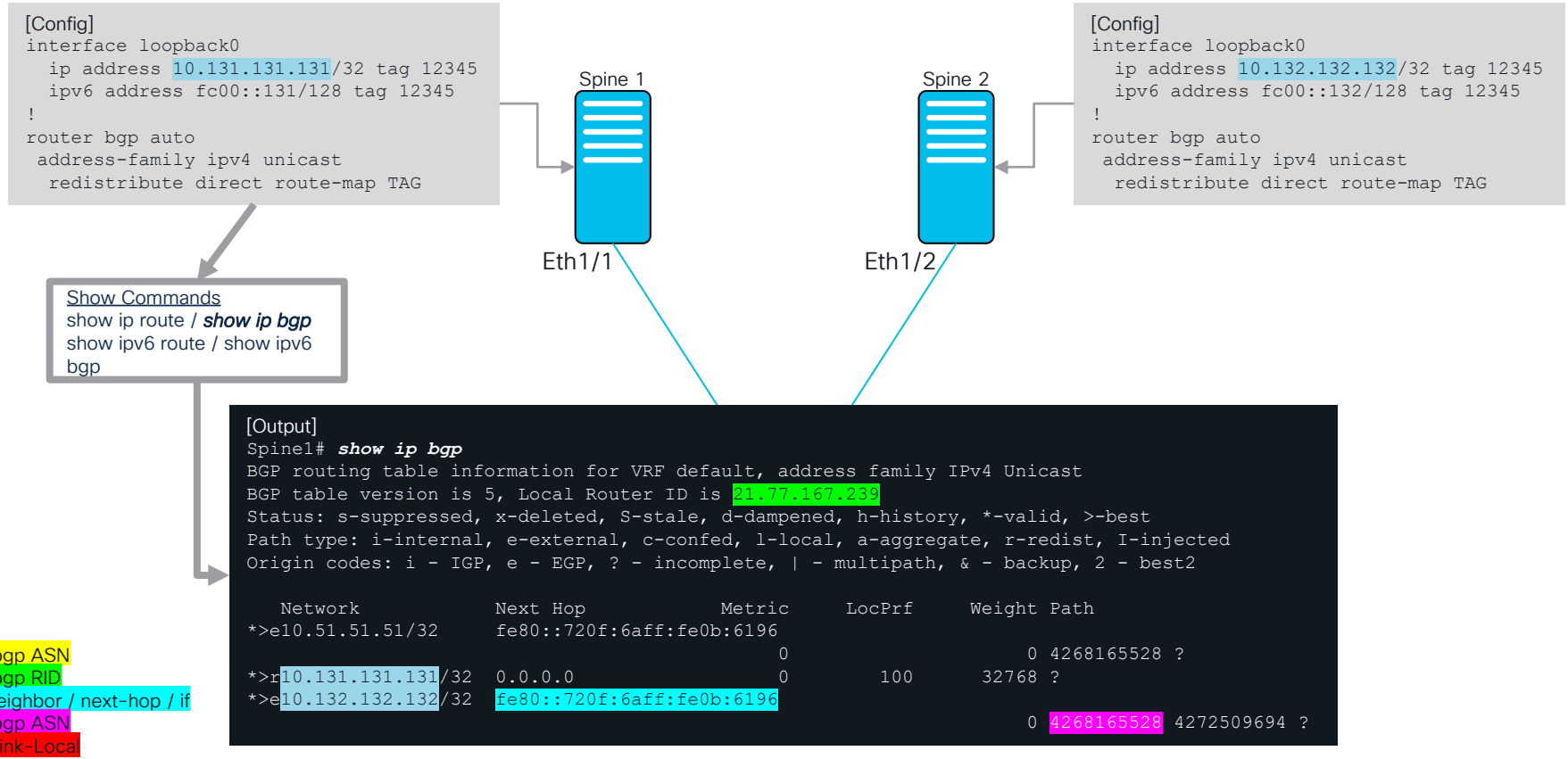
[Config]
```
interface loopback0
  ip address 10.51.51.51/32 tag 12345
  ipv6 address fc00::51/128 tag 12345
!
router bgp auto
 address-family ipv4 unicast
  redistribute direct route-map TAG
 address-family ipv6 unicast
  redistribute direct route-map TAG
```

IPv4 Routing Output Example

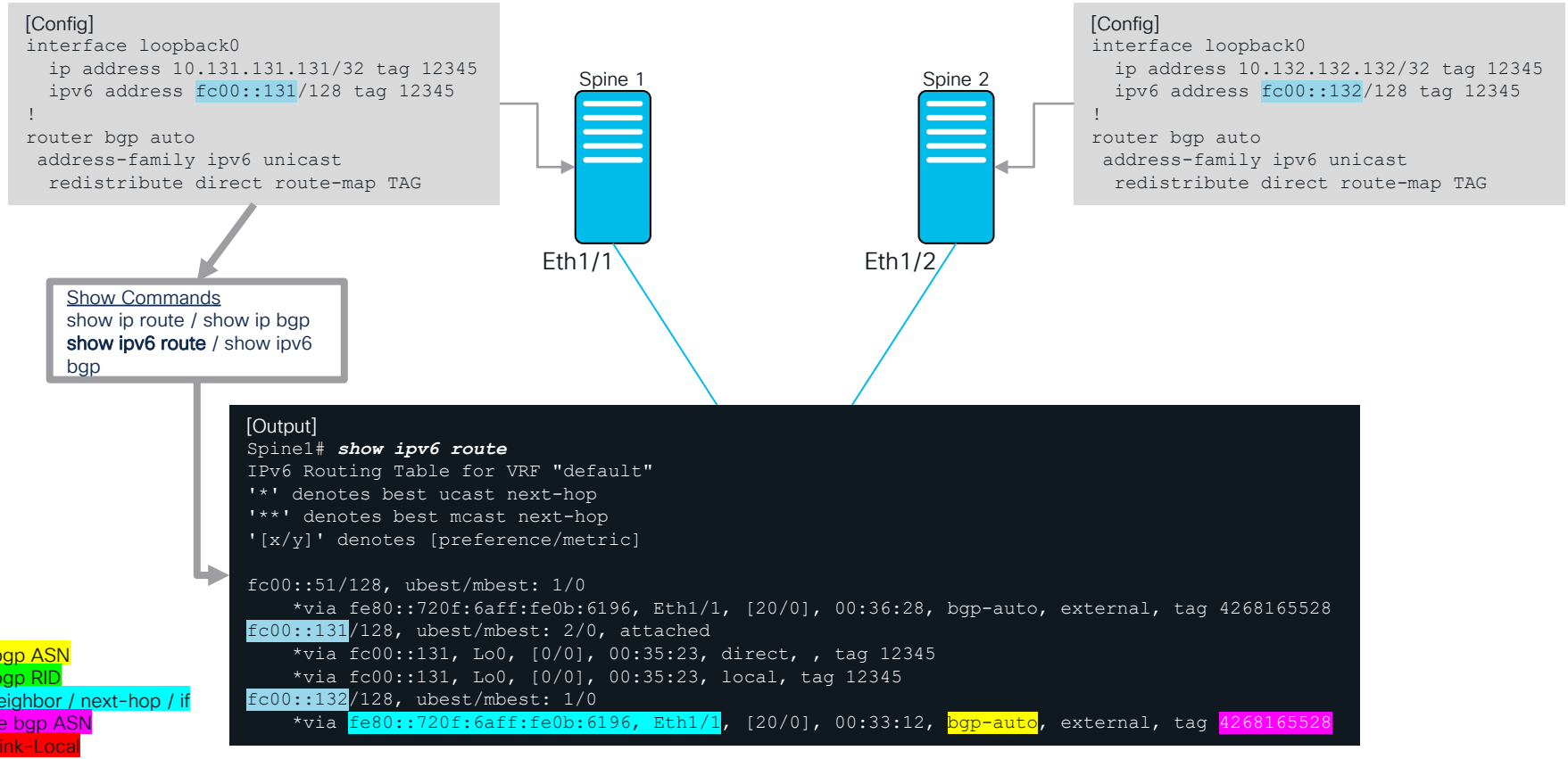


local bgp ASN
local bgp RID
bgp neighbor / next-hop / if
peer bgp ASN
IPv6 Link-Local

IPv4 Routing Output Example



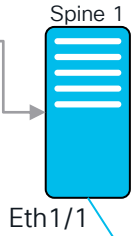
IPv6 Routing Output Example



IPv6 Routing Output Example

```
[Config]
interface loopback0
  ip address 10.131.131.131/32 tag 12345
  ipv6 address fc00::131/128 tag 12345
!
router bgp auto
 address-family ipv6 unicast
  redistribute direct route-map TAG
```

```
[Config]
interface loopback0
  ip address 10.132.132.132/32 tag 12345
  ipv6 address fc00::132/128 tag 12345
!
router bgp auto
 address-family ipv6 unicast
  redistribute direct route-map TAG
```



Show Commands
show ip route / show ip bgp
show ipv6 route / ***show ipv6 bgp***

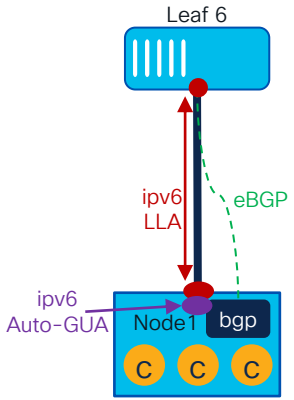
```
[Output]
Spine1# show ipv6 bgp
BGP routing table information for VRF default, address family IPv6 Unicast
BGP table version is 6, Local Router ID is 21.77.167.239
Status: s-suppressed, x-deleted, S-stale, d-dampened, h-history, *-valid, >-best
Path type: i-internal, e-external, c-confed, l-local, a-aggregate, r-redist, I-injected
Origin codes: i - IGP, e - EGP, ? - incomplete, | - multipath, & - backup, 2 - best2

   Network            Next Hop            Metric     LocPrf     Weight Path
*>efc00::51/128       fe80::720f:6aff:fe0b:6196
                                                0                     0 4268165528 ?
*>rfc00::131/128      0::                       0        100      32768 ?
*>efc00::132/128      fe80::720f:6aff:fe0b:6196
                                                                      0 4268165528 4272509694 ?
```

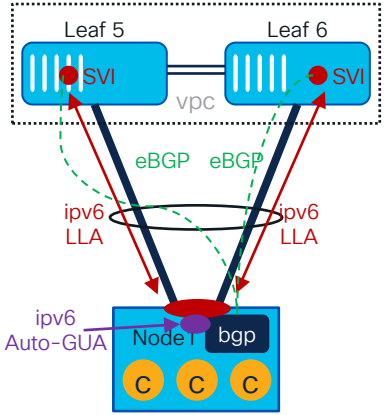
local bgp ASN
local bgp RID
bgp neighbor / next-hop / if
peer bgp ASN
IPv6 Link-Local

Host Attachments
BGP Auto-Fabric at a glance

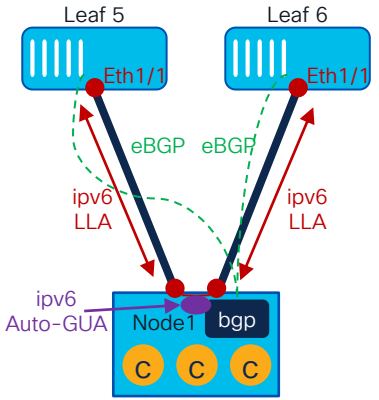
Single Attached Host



Dual Attached Host
(Multi-Chassis LAG)



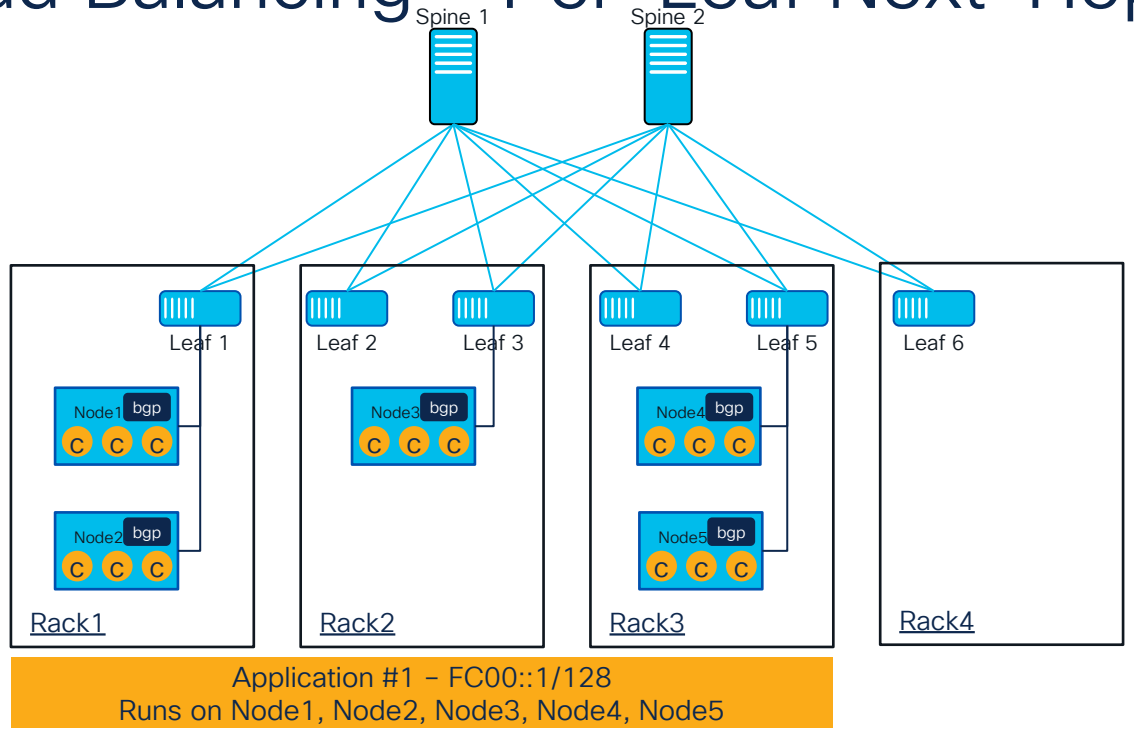
Dual Attached Host
(Layer-3 ECMP)



Kubernetes (K8s) Infrastructure Connectivity – Network Designs for the Modern Data Center

BRKDCN-2410 - Wednesday 4pm-4:45pm

BGP Load Balancing – Per-Leaf Next-Hop



Node IP Addressing Example:
IPv6 LLA – FE80::MAC
IPv6 GUA – FC00::RackID:NodeID

Node1 bgp C C C

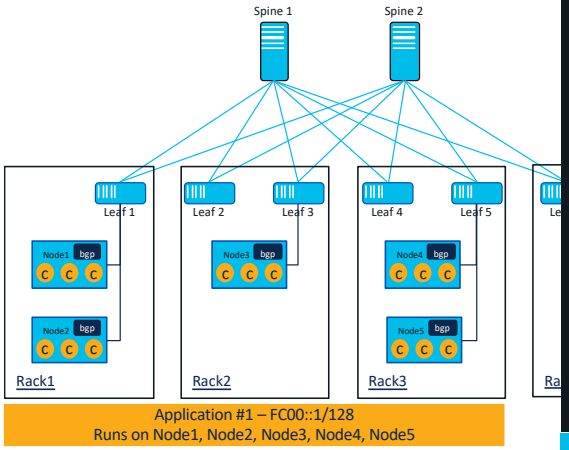
MAC Address – a1:b1:c1:d1:e1:11
IPv6 Link-Local Address – FE80::a1b1:c1d1:e111/64
IPv6 Global Unicast Address – FC00::0001:a1b1:c1d1:e111/64

Node5 bgp C C C

MAC Address – a5:b5:c5:d5:e5:55
IPv6 Link-Local Address – FE80::a5b5:c5d5:e555/64
IPv6 Global Unicast Address – FC00::0003:a5b5:c5d5:e55

BGP Load Balancing – Per-Leaf Next-Hop

Per-Leaf Next-Hop




```
[Output]
Spine1# show ipv6 route
IPv6 Routing Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]

fc00::1/128, ubest/mbest: 2/0
    *via fe80::720f:6aff:fe4d:a7f0, Eth1/1, [20/0], 00:08:08, bgp-auto, external, tag Rack1-4byteASN
    *via fe80::720f:6aff:fe4d:ab00, Eth1/3, [20/0], 00:17:22, bgp-auto, external, tag Rack2-4byteASN
    *via fe80::720f:6aff:fe4d:a766, Eth1/5, [20/0], 00:22:52, bgp-auto, external, tag Rack3-4byteASN

fc00::0001:a1b1:c1d1:e111/128, ubest/mbest: 1/0
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fc00::0002:a3b3:c3d3:e333/128, ubest/mbest: 1/0
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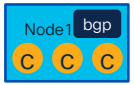
    *via fe80::720f:6aff:fe4d:a766, Eth1/5, [20/0], 04:18:47, bgp-auto, external, tag Rack3-4byteASN
```

Load Balancing to where the Server connects (Leaf)

Node IP Addressing Example:
IPv6 LLA – FE80::MAC
IPv6 GUA – FC00::RackID:NodeID



MAC Address – a1:b1:c1:d1:e1:11
IPv6 Link-Local Address – FE80::a1b1:c1d1:e111/64
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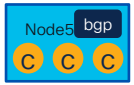

MAC Address – a5:b5:c5:d5:e5:55
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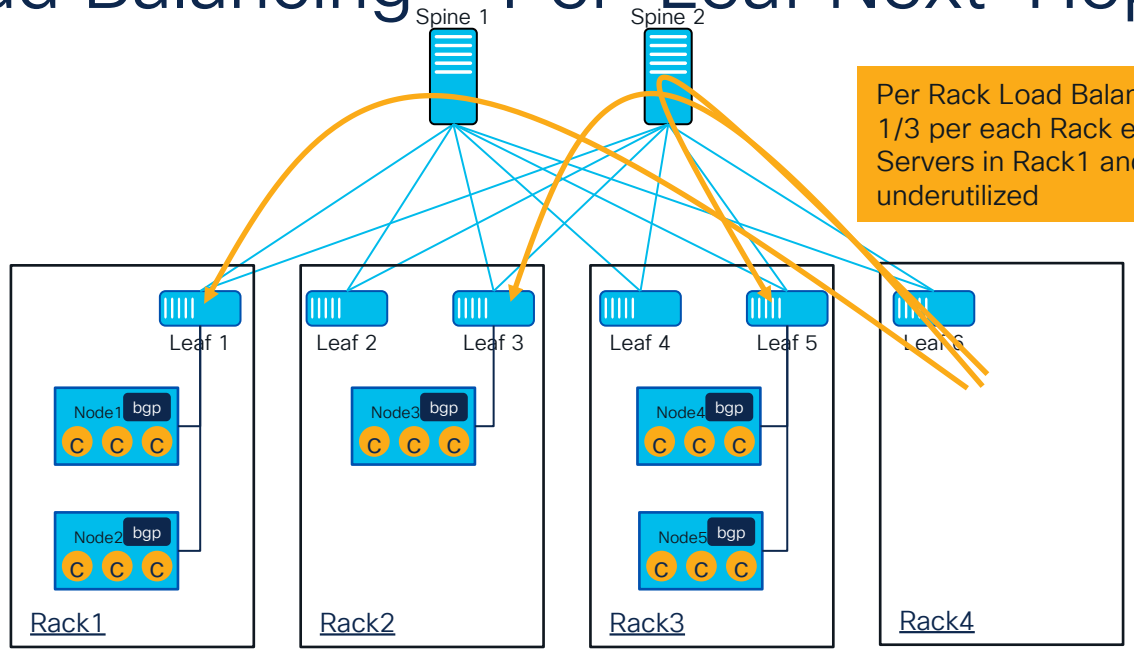
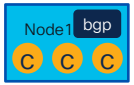
BGP Load Balancing – Per-Leaf Next-Hop



Per Rack Load Balancing
1/3 per each Rack even as 5 Server exists
Servers in Rack1 and Rack3 are probably underutilized

Application #1 – FC00::1/128
Runs on Node1, Node2, Node3, Node4, Node5

Node IP Addressing Example:
IPv6 LLA – FE80::MAC
IPv6 GUA – FC00::RackID:NodeID



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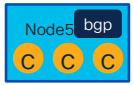

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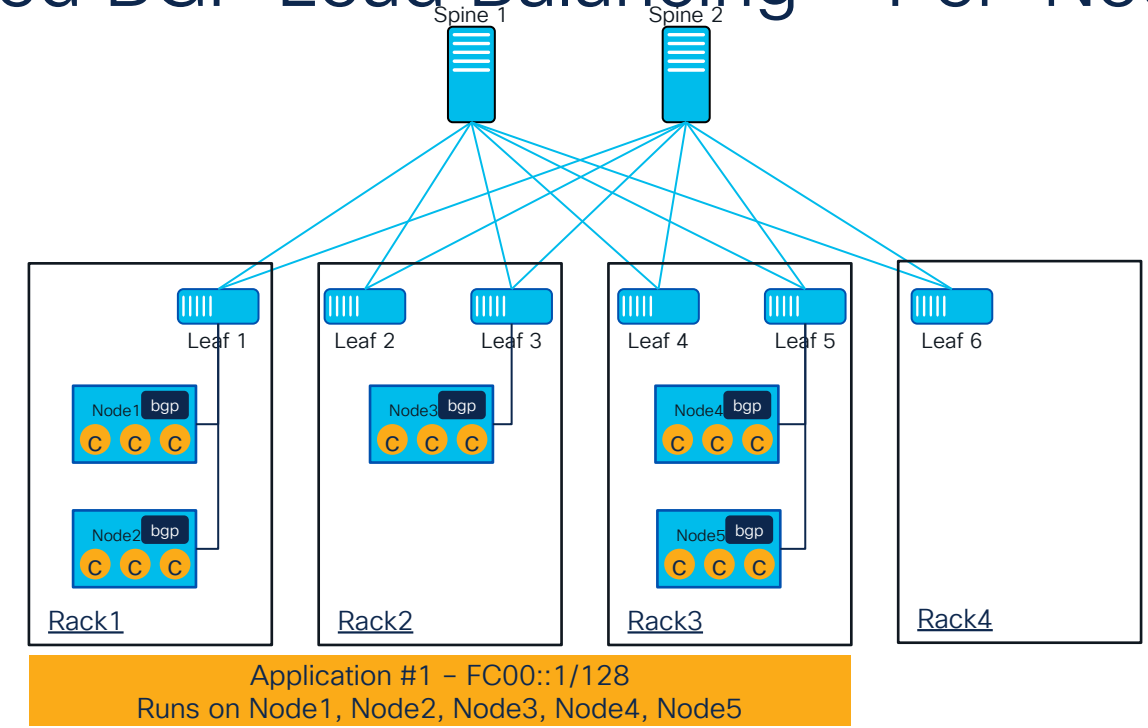
Optimized BGP Load Balancing – Per-Node NH



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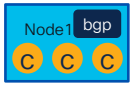

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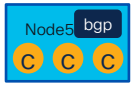

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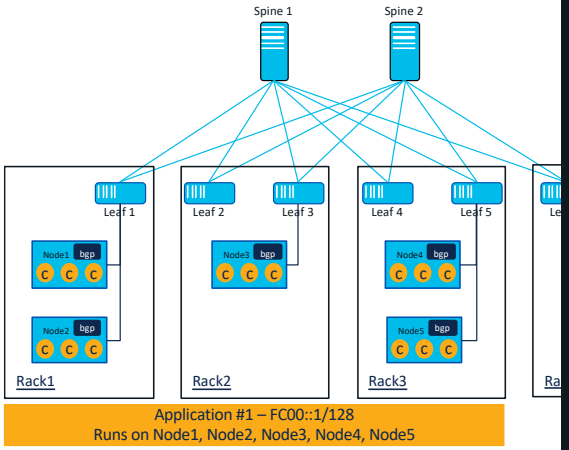
Optimized BGP Load Balancing – Per-Node NH

Per-Node Next-Hop

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    *via fe80::720f:6aff:fe4d:a766, Eth1/5, [20/0], 04:18:47, bgp-auto, external, tag Rack3-4byteASN
```

Load Balancing to where the Application runs (Server)

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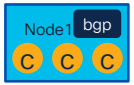

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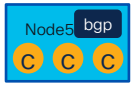

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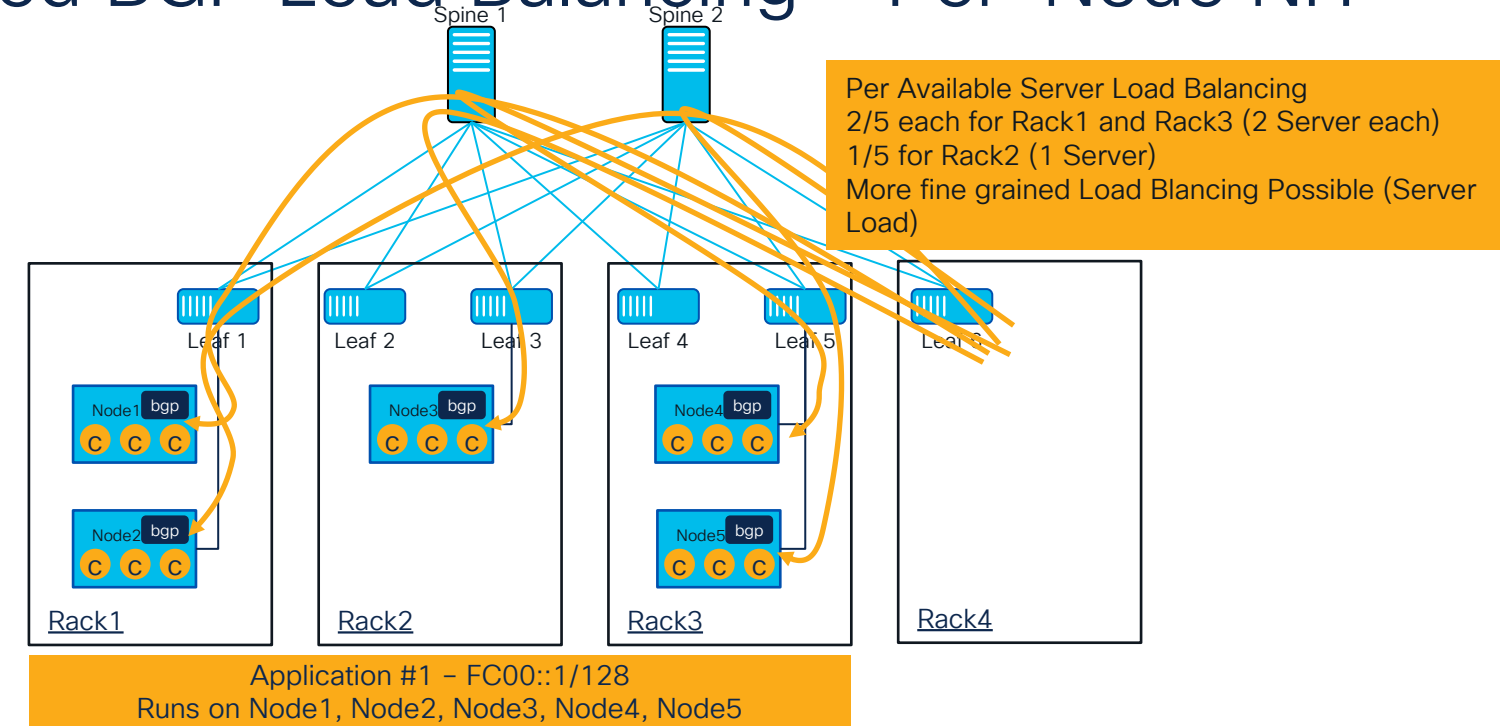

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Node1 bgp

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Node5 bgp

MAC Address – a5:b5:c5:d5:e5:55
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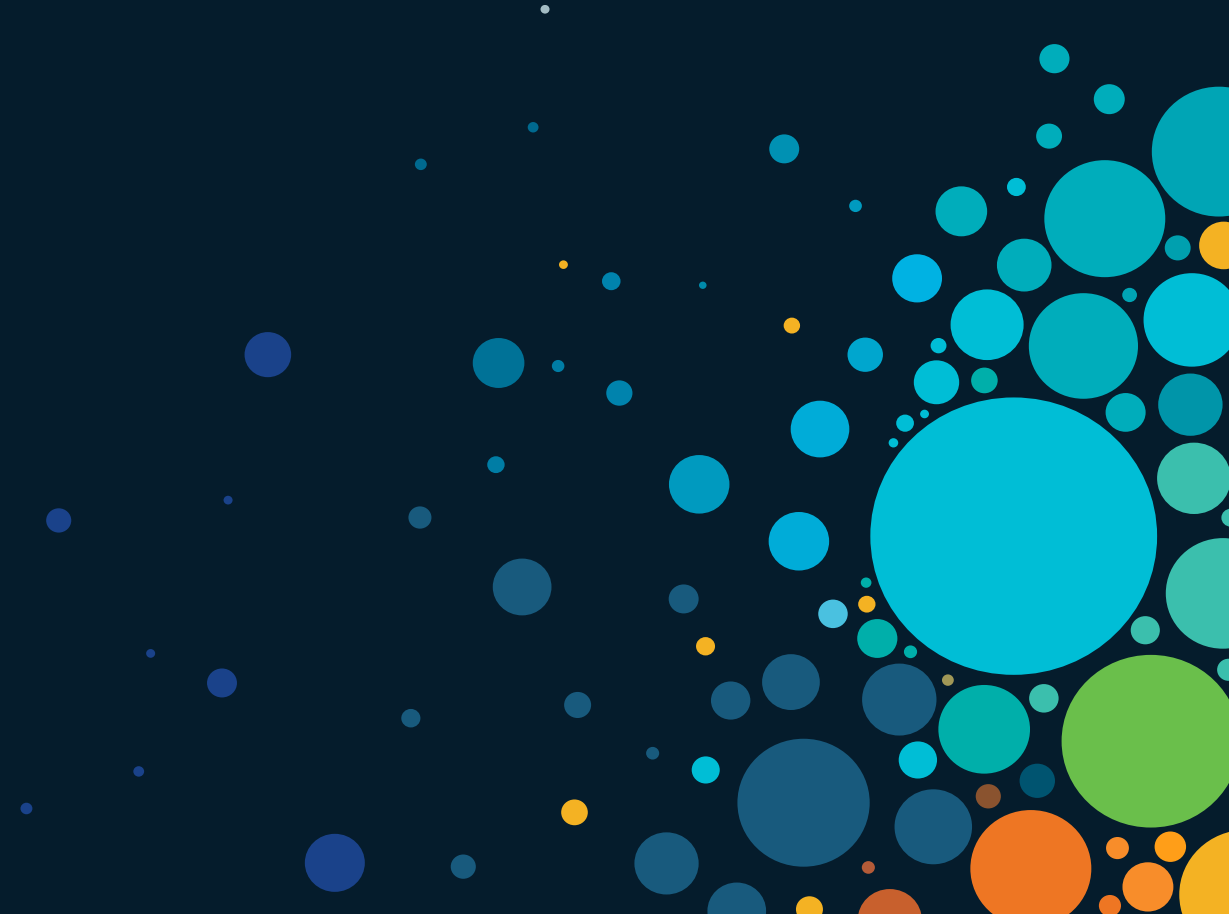
IPv6 Global Unicast Address – FC00::0003:a5b5:c5d5:e55

Conclusion



Conclusion

#1

RFC 5549 or IPv4/IPv6 Prefix via IPv6 Next-Hop

Another tool in your Toolbox
Available for over 10 years (not only in NX-OS)
Active and Updates (RFC 5549 refreshed to RFC 8950)
In production with Service Provider and in the largest Data Center
Facilitates IPv4 and IPv6 Routing without the need for Dual-Stack

#2

BGP Auto-Fabric

Builds on RFC 5549 / RFC 8950 and leverages RFC 7938
Simplifies the Setup and Operation of BGP Fabrics
Simple Layer-3 Fabric for modern Applications
Optimizes Forwarding in a Layer-3 Fabric
Ready for “Cloud Native Application”*
No Overlay Required

*”Cloud Native Applications” are generally defined as Container- or Kubernetes-based Applications

Resources – Cisco NX-OS

- RFC 5549
  - See Unicast Routing Configuration Guide – Advanced BGP
- BGP Auto-Fabric
  - Supported starting NX-OS 10.2(3)F
  - See Unicast Routing Configuration Guide – Advanced BGP

Resources – IETF

- RFC 5549 – Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop
  - https://datatracker.ietf.org/doc/html/rfc5549
- RFC 8950 – Advertising IPv4 Network Layer Reachability Information (NLRI) with an IPv6 Next Hop
  - https://datatracker.ietf.org/doc/html/rfc8950
- RFC 7938 – Use of BGP for Routing in Large-Scale Data Centers
  - https://datatracker.ietf.org/doc/html/rfc7938

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- Attendees who fill out a minimum of four session surveys and the overall event survey will get Cisco Live branded socks!
- Attendees will also earn 100 points in the Cisco Live Game for every survey completed.
- These points help you get on the leaderboard and increase your chances of winning daily and grand prizes.

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