

BGP Enhancements for IPv6



ISP Workshops

Adding IPv6 to BGP...

□ RFC4760

- Defines Multi-protocol Extensions for BGP4
- Enables BGP to carry routing information of protocols other than IPv4
 - e.g. MPLS, IPv6, Multicast etc
- Exchange of multiprotocol NLRI must be negotiated at session startup

□ RFC2545

- Use of BGP Multiprotocol Extensions for IPv6 Inter-Domain Routing

RFC4760

- New optional and non-transitive BGP attributes:
 - MP_REACH_NLRI (Attribute code: 14)
 - Carry the set of reachable destinations together with the next-hop information to be used for forwarding to these destinations (RFC2858)
 - MP_UNREACH_NLRI (Attribute code: 15)
 - Carry the set of unreachable destinations
- Attribute contains one or more Triples:
 - AFI Address Family Information
 - Next-Hop Information
(must be of the same address family)
 - NLRI Network Layer Reachability Information

RFC2545

- IPv6 specific extensions
 - Scoped addresses: Next-hop contains a global IPv6 address and/or potentially a link-local address
 - NEXT_HOP and NLRI are expressed as IPv6 addresses and prefix
 - Address Family Information (AFI) = 2 (IPv6)
 - Sub-AFI = 1 (NLRI is used for unicast)
 - Sub-AFI = 2 (NLRI is used for multicast RPF check)
 - Sub-AFI = 3 (NLRI is used for both unicast and multicast RPF check)
 - Sub-AFI = 4 (label)

BGP Considerations

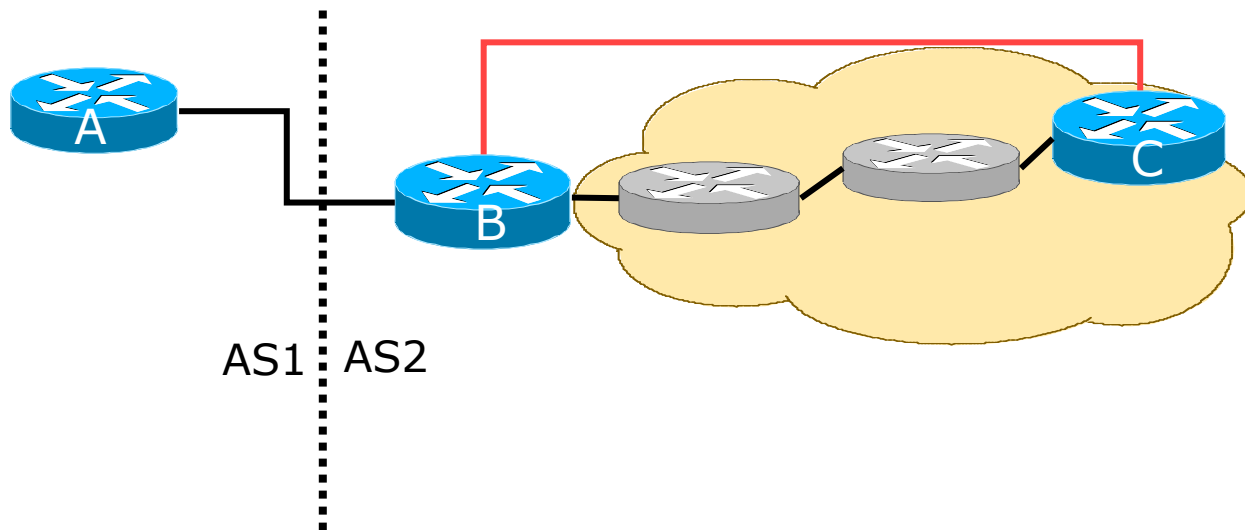
- Rules for constructing the NEXTHOP attribute:
 - When two peers share a common subnet, the NEXTHOP information is formed by a global address and a link local address
 - Redirects in IPv6 are restricted to the usage of link local addresses

Routing Information

- Independent operation
 - One RIB per protocol
 - e.g. IPv6 has its own BGP table
 - Distinct policies per protocol
- Peering sessions can be shared when the topology is congruent

BGP next-hop attribute

- ❑ Next-hop contains a global IPv6 address (or potentially a link local address)
- ❑ Link local address is set as a next-hop only if the BGP peer shares the subnet with both routers (advertising and advertised)



More BGP considerations

- TCP Interaction
 - BGP runs on top of TCP
 - This connection could be set up either over IPv4 or IPv6
- Router ID
 - When no IPv4 is configured, an explicit bgp router-id needs to be configured
 - BGP identifier is a 32 bit integer currently generated from the router identifier – which is generated from an IPv4 address on the router
 - This is needed as a BGP identifier, is used as a tie breaker, and is sent within the OPEN message

BGP Configuration

- Two options for configuring BGP peering
- Using link local addressing
 - ISP uses FE80:: addressing for BGP neighbours
 - **NOT RECOMMENDED**
 - There are plenty of IPv6 addresses
 - Unnecessary configuration complexity
- Using global unicast addresses
 - As with IPv4
 - **RECOMMENDED**

BGP Configuration

- ❑ Cisco IOS assumes that all BGP neighbours will be IPv4 unicast neighbours
 - We need to remove this assumption

```
router bgp 100
  no bgp default ipv4-unicast
```

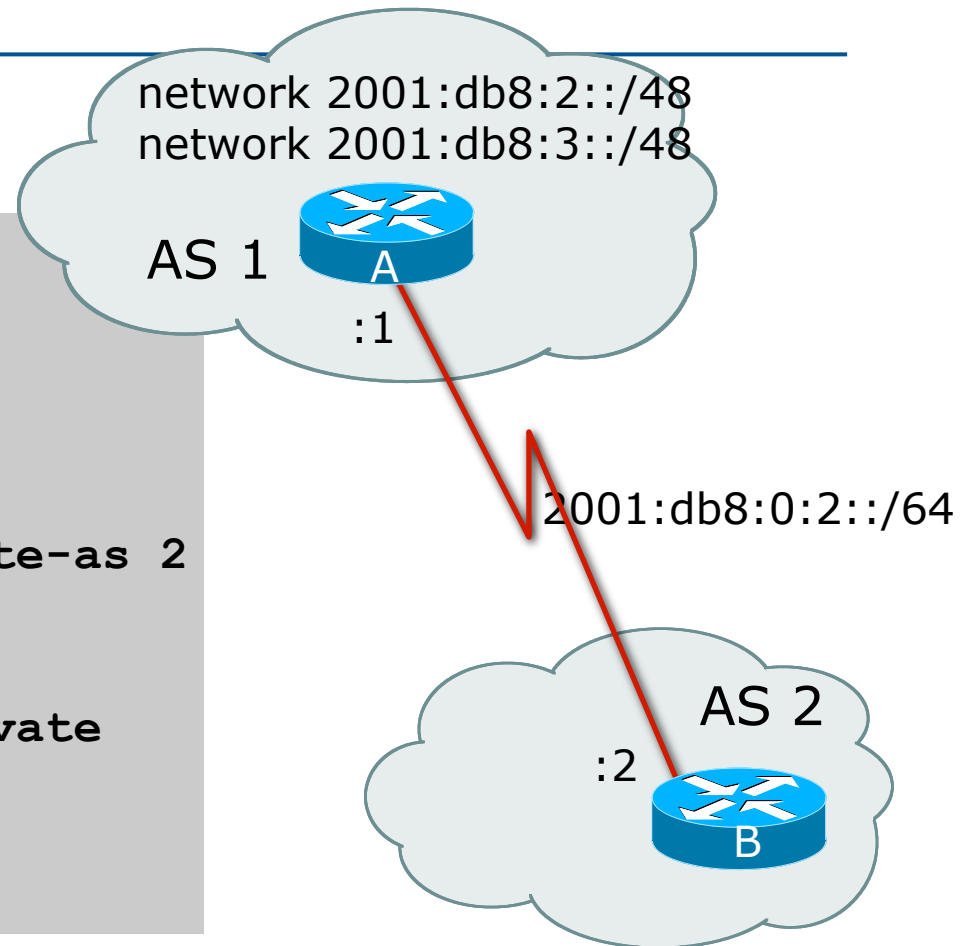
- ❑ Failing to do this will result in all neighbours being defined as IPv4 unicast neighbours
 - Non-IPv4 neighbours will have no specific unicast IPv4 configuration
 - Cluttered configuration, confusing troubleshooting and diagnosis

BGP Configurations

Regular Peering

Router A

```
router bgp 1
  no bgp default ipv4-unicast
  bgp router-id 1.1.1.1
  neighbor 2001:db8:0:2::2 remote-as 2
!
address-family ipv6
  neighbor 2001:db8:0:2::2 activate
  network 2001:db8:2::/48
  network 2001:db8:3::/48
!
```



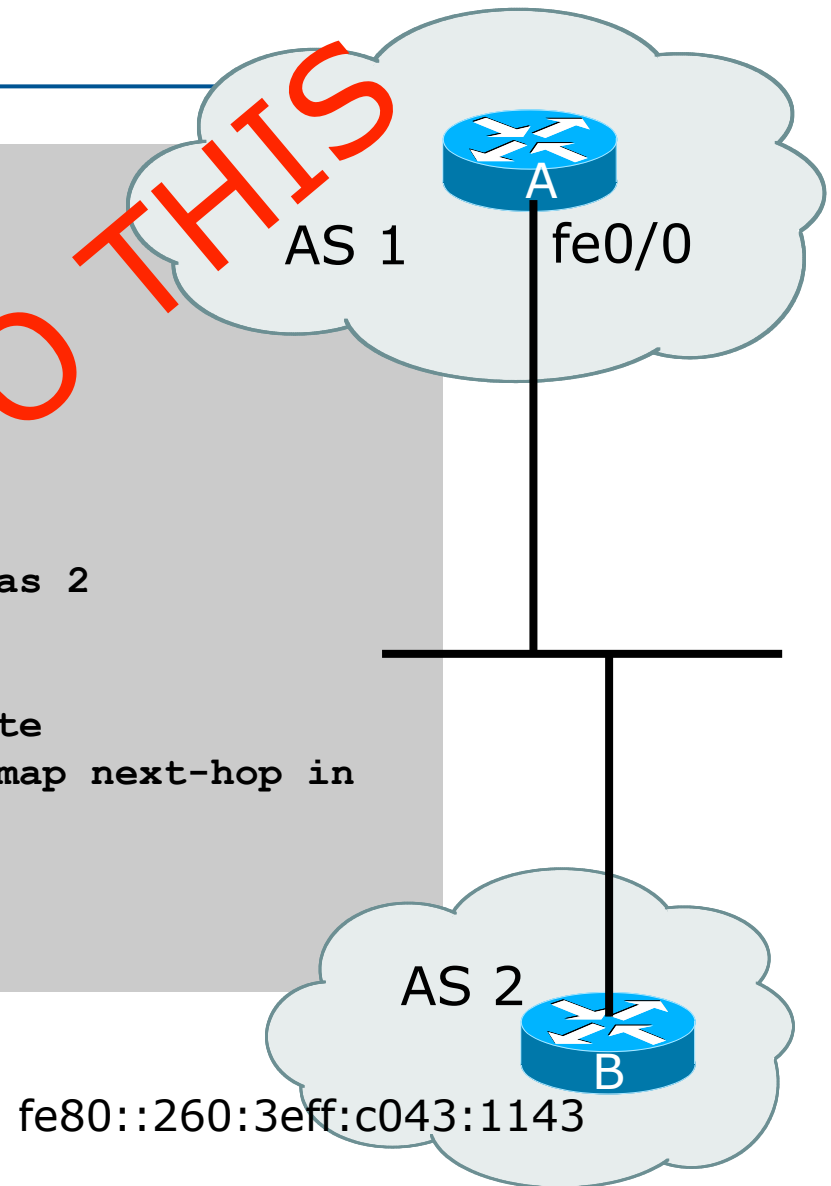
`activate` means that the BGP peering is activated for this particular address family

BGP Configurations

Link Local Peering

Router A

```
interface fastethernet 0/0
  ipv6 address 2001:db8:ffc0:1::1/64
  !
router bgp 1
  no bgp default ipv4-unicast
  bgp router-id 1.1.1.1
  neighbor fe80::260:3eff:c043:1143 remote-as 2
  !
  address-family ipv6
    neighbor fe80::260:3eff:c043:1143 activate
    neighbor fe80::260:3eff:c043:1143 route-map next-hop in
  !
  route-map next-hop permit 5
    set ipv6 next-hop 2001:db8:ffc0:1::1
  !
```



BGP Configuration

IPv4 and IPv6

```
router bgp 10
  no bgp default ipv4-unicast
  neighbor 2001:db8:1:1019::1 remote-as 20
  neighbor 172.16.1.2 remote-as 30
  !
  address-family ipv4
    neighbor 172.16.1.2 activate
    neighbor 172.16.1.2 prefix-list ipv4-ebgp in
    neighbor 172.16.1.2 prefix-list v4out out
    network 172.16.0.0
  exit-address-family
  !
  address-family ipv6
    neighbor 2001:db8:1:1019::1 activate
    neighbor 2001:db8:1:1019::1 prefix-list ipv6-ebgp in
    neighbor 2001:db8:1:1019::1 prefix-list v6out out
    network 2001:db8::/32
  exit-address-family
  !
  ! Continued -->
```

BGP Configuration

IPv4 and IPv6

```
ip prefix-list ipv4-ebgp permit 0.0.0.0/0 le 32
!  
ip prefix-list v4out permit 172.16.0.0/16
!  
ipv6 prefix-list ipv6-ebgp permit ::/0 le 128
!  
ipv6 prefix-list v6out permit 2001:db8::/32
!
```

- Compare IPv4 prefix filters with IPv6 prefix filters

```
ip prefix-list <name> permit|deny <ipv4 address>
```

```
ipv6 prefix-list <name> permit|deny <ipv6 address>
```

BGP Configuration

IPv4 and IPv6

- When configuring the router, recommendation is:
 - Put all IPv6 configuration directly into IPv6 address family
 - Put all IPv4 configuration directly into IPv4 address family
- Router will sort generic from specific address family configuration when the configuration is saved to NVRAM or displayed on the console
- Example follows...
 - Notice how activate is added by the router to indicate that the peering is activated for the particular address family

BGP Address Families

Applied Configuration

```
router bgp 10
  no bgp default ipv4-unicast
  !
  address family ipv4
    neighbor 172.16.1.2 remote-as 30
    neighbor 172.16.1.2 prefix-list ipv4-ebgp in
    neighbor 172.16.1.2 prefix-list v4out out
    network 172.16.0.0
  !
  address-family ipv6
    neighbor 2001:db8:1:1019::1 remote-as 20
    neighbor 2001:db8:1:1019::1 prefix-list ipv6-ebgp in
    neighbor 2001:db8:1:1019::1 prefix-list v6out out
    network 2001:db8::/32
  !
  ip prefix-list ipv4-ebgp permit 0.0.0.0/0 le 32
  ip prefix-list v4out permit 172.16.0.0/16
  ipv6 prefix-list ipv6-ebgp permit ::/0 le 128
  ipv6 prefix-list v6out permit 2001:db8::/32
```

Generic Configuration



Specific Configuration



BGP Address Families

End result

```
router bgp 10
  no bgp default ipv4-unicast
  neighbor 2001:db8:1:1019::1 remote-as 20
  neighbor 172.16.1.2 remote-as 30
!
  address-family ipv4
  neighbor 172.16.1.2 activate
  neighbor 172.16.1.2 prefix-list ipv4-ebgp in
  neighbor 172.16.1.2 prefix-list v4out out
  network 172.16.0.0
  exit-address-family
!
  address-family ipv6
  neighbor 2001:db8:1:1019::1 activate
  neighbor 2001:db8:1:1019::1 prefix-list ipv6-ebgp in
  neighbor 2001:db8:1:1019::1 prefix-list v6out out
  network 2001:db8::/32
  exit-address-family
!
ip prefix-list ipv4-ebgp permit 0.0.0.0/0 le 32
ip prefix-list v4out permit 172.16.0.0/16
ipv6 prefix-list ipv6-ebgp permit ::/0 le 128
ipv6 prefix-list v6out permit 2001:db8::/32
```

Generic Configuration

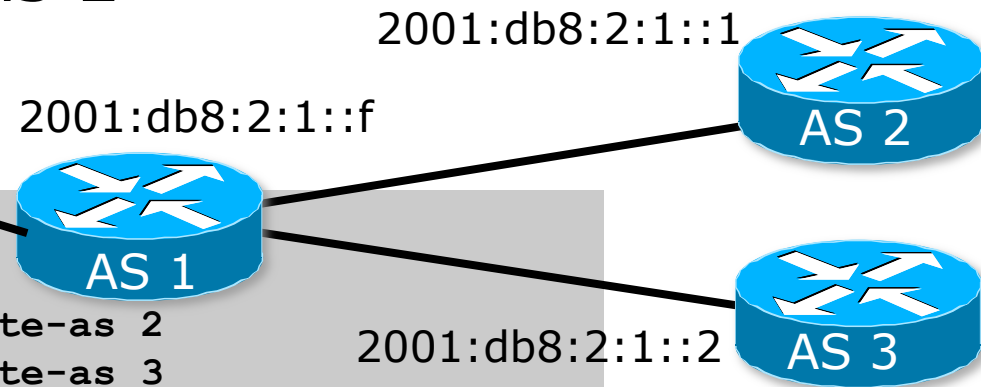
Specific Configuration

BGP Configuration

Manipulating Attributes

- ❑ Prefer routes from AS 2 (local preference)

```
router bgp 1
  no bgp default ipv4-unicast
  neighbor 2001:db8:2:1::1 remote-as 2
  neighbor 2001:db8:2:1::2 remote-as 3
  !
  address-family ipv6
  neighbor 2001:db8:2:1::1 activate
  neighbor 2001:db8:2:1::1 prefix-list in-filter in
  neighbor 2001:db8:2:1::1 route-map fromAS2 in
  neighbor 2001:db8:2:1::2 activate
  neighbor 2001:db8:2:1::2 prefix-list in-filter in
  network 2001:db8::/32
  exit-address-family
  !
  route-map fromAS2 permit 10
  set local-preference 120
```



BGP Configuration

Carrying IPv4 inside IPv6 peering

- IPv4 prefixes can be carried inside an IPv6 peering
 - Note that the next-hop for received prefixes needs to be “fixed”
- Example

```
router bgp 1
  neighbor 2001:db8:0:2::2 remote-as 2
  !
address-family ipv4
  neighbor 2001:db8:0:2::2 activate
  neighbor 2001:db8:0:2::2 route-map ipv4 in
  !
route-map ipv4 permit 10
  set ip next-hop 131.108.1.1
```

BGP Status Commands

- IPv6 BGP show commands take ipv6 as argument

```
show bgp ipv6 unicast <parameter>
```

```
Router5>sh bgp ipv6 uni 2001:DB9:4::/48
BGP routing table entry for 2001:DB9:4::/48, version 20
Paths: (1 available, best #1, table default)
  Advertised to update-groups:
    1
  Local
    2001:DB9::4 (metric 64) from 2001:DB9::4 (10.20.15.227)
      Origin IGP, metric 0, localpref 100, valid, internal, best
```

- IPv4 BGP show commands can also use this format:

```
show bgp ipv4 unicast <parameter>
```

BGP Status Commands

- Display summary information regarding the state of the BGP neighbours

```
show bgp ipv6 unicast summary
```

```
Router1>sh bgp ipv6 uni sum
```

```
BGP router identifier 10.10.15.224, local AS number 10
```

```
BGP table version is 28, main routing table version 28
```

```
18 network entries using 2880 bytes of memory
```

```
38 path entries using 3040 bytes of memory
```

```
9/6 BGP path/bestpath attribute entries using 1152 bytes of memory
```

```
4 BGP AS-PATH entries using 96 bytes of memory
```

```
0 BGP route-map cache entries using 0 bytes of memory
```

```
0 BGP filter-list cache entries using 0 bytes of memory
```

```
BGP using 7168 total bytes of memory
```

```
BGP activity 37/1 prefixes, 95/19 paths, scan interval 60 secs
```

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2001:DB8::2	4	10	185	182	28	0	0	02:36:11	16
2001:DB8::3	4	10	180	181	28	0	0	02:36:08	11
2001:DB8:0:4::1	4	40	153	152	28	0	0	02:05:39	9

↑
Neighbour Information

↑
BGP Messages Activity

Conclusion

- BGP extended to support multiple protocols
 - IPv6 is but one more address family
- Operators experienced with IPv4 BGP should have no trouble adapting
 - Configuration concepts and CLI is familiar format

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