



BGP Enhancements for IPv6

ISP/IXP 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

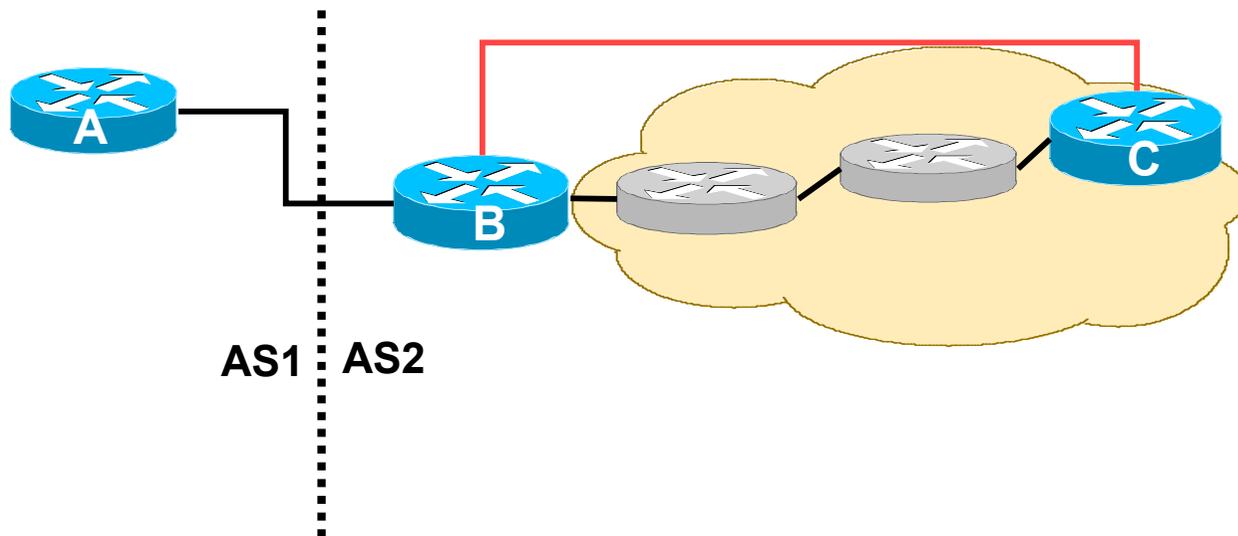
 - e.g. IPv6 has its own BGP table

 - 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 as a next-hop is only set 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, this 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

- IOS assumes by default that all BGP neighbours will be IPv4 unicast neighbours

We need to remote 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

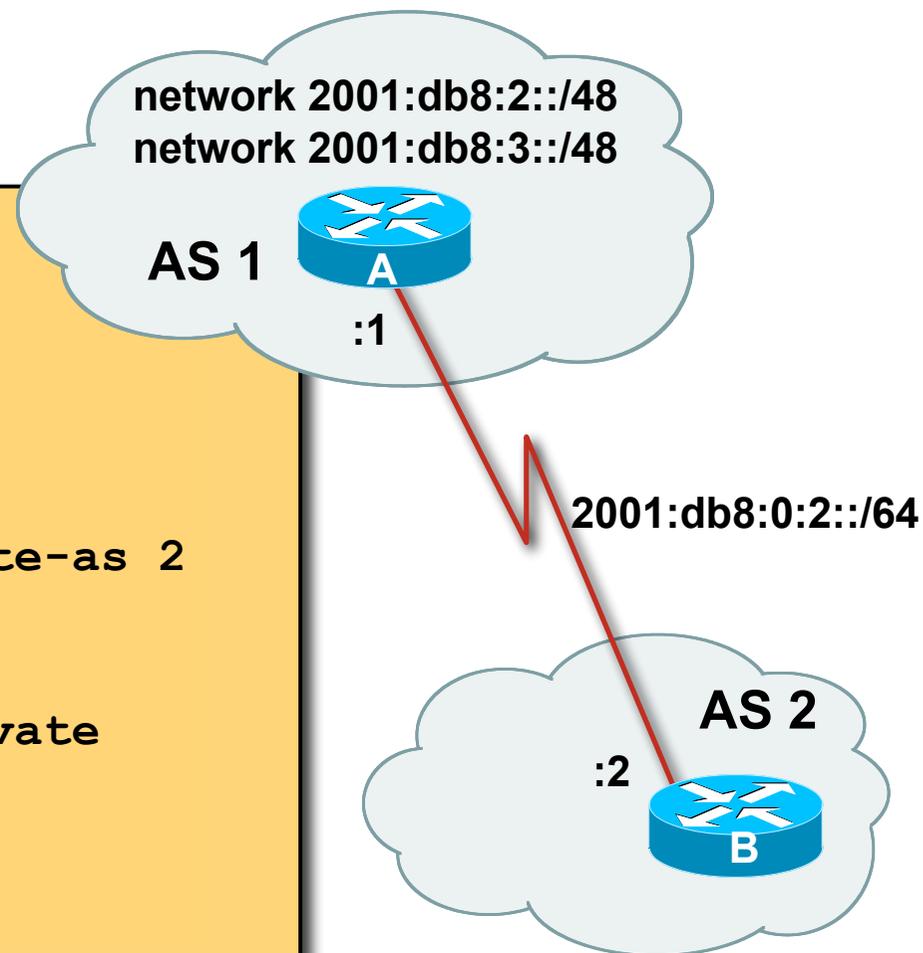
Cluttered configuration, confusing troubleshooting and diagnosis

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
  !
```



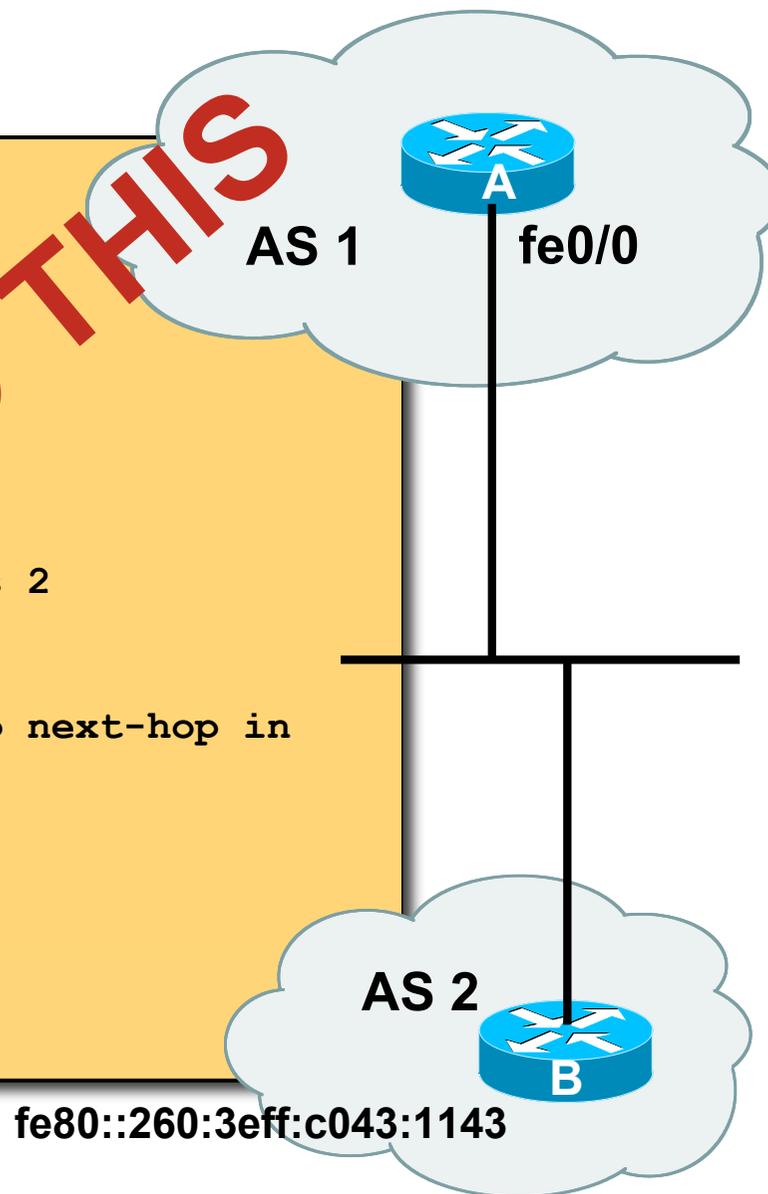
`activate` means that the BGP peering is activated for this particular address family

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
```

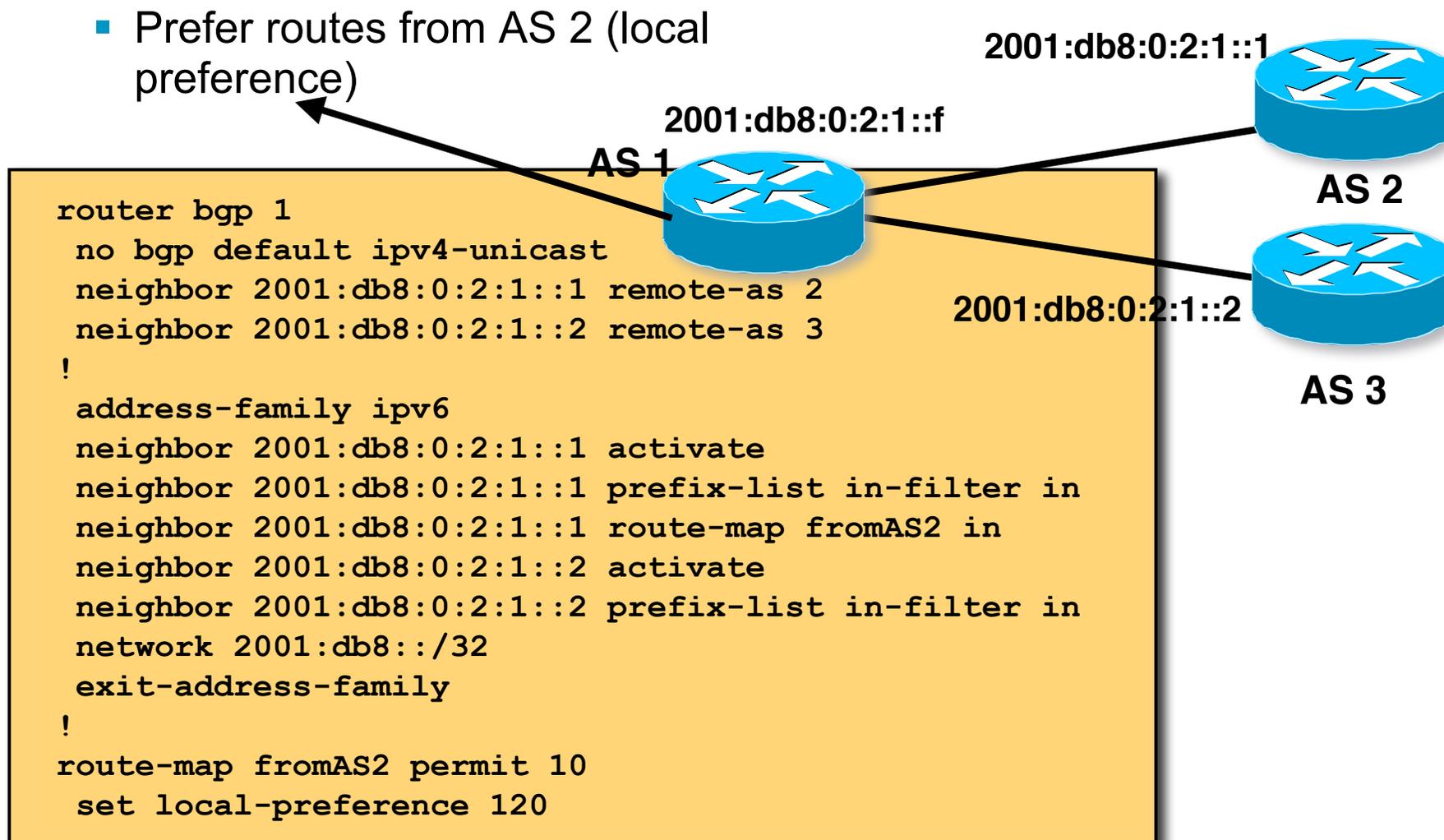
Generic Configuration

Specific Configuration

BGP Configuration

Manipulating Attributes

- Prefer routes from AS 2 (local preference)



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>
```

```
Router1#show bgp ipv6 unicast 2017::/32
BGP routing table entry for 2017::/32, version 11
Paths: (1 available, best #1)
Local
2001:db8:c18:2:1::1 from 2001:db8:c18:2:1::1 (10.10.20.2)
Origin incomplete, 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

```
BGP router identifier 128.107.240.254, local AS number 109
BGP table version is 400386, main routing table version 400386
585 network entries using 78390 bytes of memory
9365 path entries using 674280 bytes of memory
16604 BGP path attribute entries using 930384 bytes of memory
8238 BGP AS-PATH entries using 228072 bytes of memory
42 BGP community entries using 1008 bytes of memory
9451 BGP route-map cache entries using 302432 bytes of memory
584 BGP filter-list cache entries using 7008 bytes of memory
BGP using 2221574 total bytes of memory
2 received paths for inbound soft reconfiguration
BGP activity 63094/62437 prefixes, 1887496/1878059 paths, scan interval 60secs
```

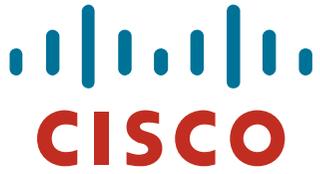
Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2001:1458:C000::64B:4:1									
	4	513	1294728	460213	400386	0	0	3d11h	498

↑
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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