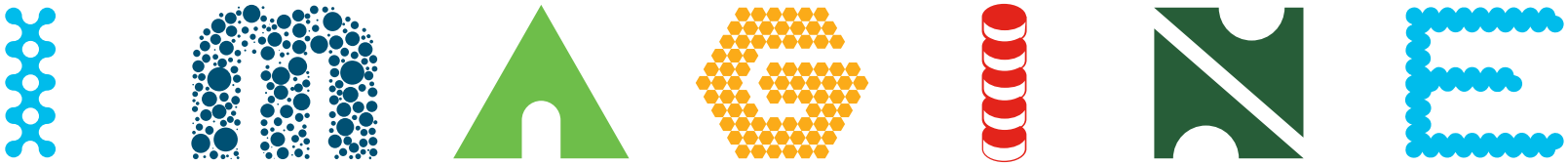

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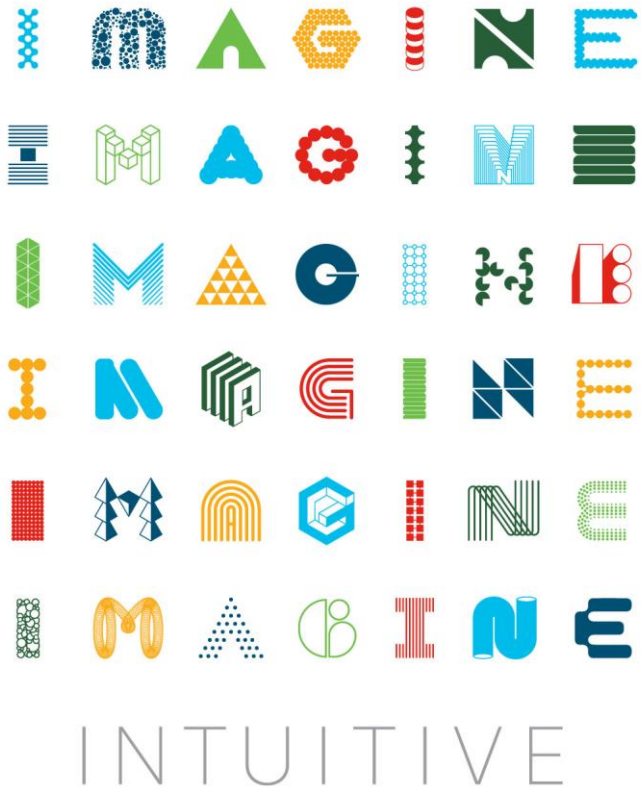
#CLUS

BGP is your Friend – BGP for the CCIE Candidates

BRKCCIE-3000

Johnny Bass – President Bass Consulting Services, Inc.



Agenda

- Introduction
- BGP for the CCIE Candidates
- Basics of BGP: IOS and IOS-XR
- Not so basic BGP
- More advanced BGP features
- Troubleshooting BGP
- Conclusion
- Q&A

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4. Enter messages/questions in the team space

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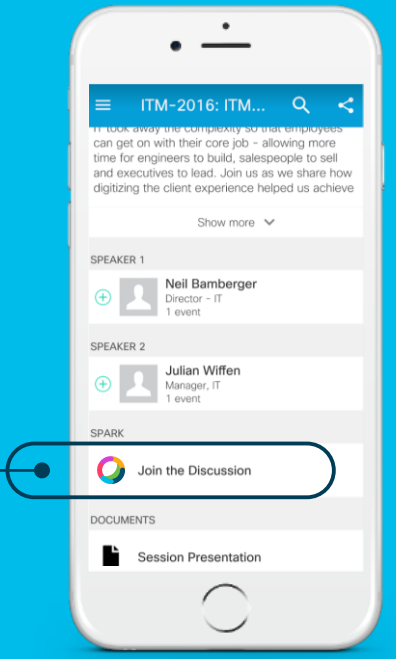

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About the Presenter

- Johnny Bass
- Networking industry since the late 1980s
- CCIE R&S #6458
- CCSI 97168
- Cisco 360 R&S Master Instructor
- Course director for several programs, including Cisco 360 Route Switch, for Global Knowledge

Why Are We Here?

- BGP can be complicated
- BGP is on my blueprint for the lab
- BGP will be worth a LOT of points
- BGP is scary!!!
  - Not really ☺

BGP – Little History

- First RFC – RFC1105 in June 1989 by Kirk Lougheed of Cisco and Jacob Rekhter of IBM
- Replaced EGP for Internet routing
  - NSFNET at the time
- Main claim to fame?
  - Loop detection and prevention!
- BGP 4 – RFC1654 July 1994
  - Add CIDR support
- Multiprotocol BGP – RFC 2283 February 1998

BGP is Complicated!

- Yes, it is…lots of RFCs to add lots of functionality
- Supports the Internet
  - 686,886 IPv4 network entries (Route Views May 2, 2017)
  - 41,213 IPv6 network entries (Route Views May 2, 2017)
- IPv4 and IPv6 unicast and multicast routing
  - For the Internet
  - For corporate core
- Layer 3 VPN
  - MPLS and Dynamic GRE
- Layer 2 VPN
- Segment Routing
- VXLAN EVPN Support
- ????

BGP is Your Friend

- Yes it's complicated, but its also flexible
- BGP doesn't have to be complicated!
  - KISS principle…it will get complicated enough on its own
- BGP scales to BIG numbers
  - As of June 7, 2018: 744,761 IPv4 55,488 IPv6
- BGP is policy driven

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BGP and the CCIE Lab Exams – CCIE Routing & Switching

- 2.7.a Describe, implement and troubleshoot peer relationships
  - 2.7.a [i] Peer-group, template
  - 2.7.a [ii] Active, passive
  - 2.7.a [iii] States, timers
  - 2.7.a [iv] Dynamic neighbors
- 2.7.b Implement and troubleshoot IBGP and EBGP
  - 2.7.b [i] EBGP, IBGP
  - 2.7.b [ii] 4 bytes AS number
  - 2.7.b [iii] Private AS
- 2.7.c Explain attributes and best-path selection
- 2.7.d Implement, optimize and troubleshoot routing policies
  - 2.7.d [i] Attribute manipulation
  - 2.7.d [ii] Conditional advertisement
  - 2.7.d [iii] Outbound route filtering
  - 2.7.d [iv] Communities, extended communities
  - 2.7.d [v] Multi-homing
- 2.7.e Implement and troubleshoot scalability
  - 2.7.e [i] Route-reflector, cluster
  - 2.7.e [ii] Confederations
  - 2.7.e [iii] Aggregation, AS set
- 2.7.f Implement and troubleshoot multi-protocol BGP
  - 2.7.f [i] IPv4, IPv6, VPN address-family
- 2.7.g Implement and troubleshoot AS path manipulations
  - 2.7.g [i] Local AS, allow AS in, remove private AS
  - 2.7.g [ii] Prepend
  - 2.7.g [iii] Regexp
- 2.7.h Implement and Troubleshoot Other Features
  - 2.7.h [i] Multipath
  - 2.7.h [ii] BGP synchronization
  - 2.7.h [iii] Soft reconfiguration, route refresh

BGP and the CCIE Lab Exams - CCIE Service Provider

- 1.2. Border Gateway Protocol
  - 1.2.a. Describe, implement, and troubleshoot IBGP, EBGP, and MP-BGP
  - 1.2.b. Describe, implement, and troubleshoot BGP route policy enforcement
  - 1.2.c. Describe BGP path attribute
  - 1.2.d. Describe and optimize BGP scale and performance
  - 1.2.e. Describe, implement, and troubleshoot advanced BGP features
- 4.3. Routing/fast convergence
  - 4.3.b. Describe, implement, and optimize BGP convergence
- 5.1. Control plane security
  - 5.1.b. Describe, implement, and troubleshoot routing protocol security, for example: BGP-TTL security and protocol authentication
  - 5.1.c. Describe, implement, and troubleshoot BGP prefix suppression
  - 5.1.e. Describe, implement, and troubleshoot BGP prefix based filtering
  - 5.1.f. Describe, implement, and troubleshoot BGPsec
  - 5.3. Infrastructure security
  - 5.3.e. Describe, implement, and troubleshoot BGP Flowspec

BGP and the CCIE Lab Exams - continued

CCIE Routing & Switching and Service Provider

- Don't forget
  - Layer 3 VPN
  - PE to CE routing

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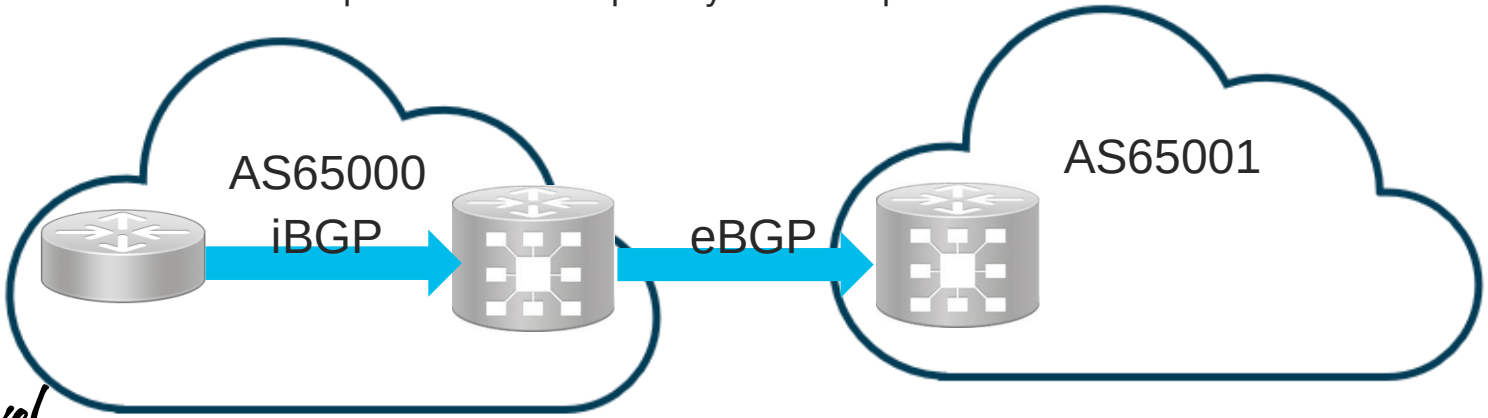
Basics of BGP

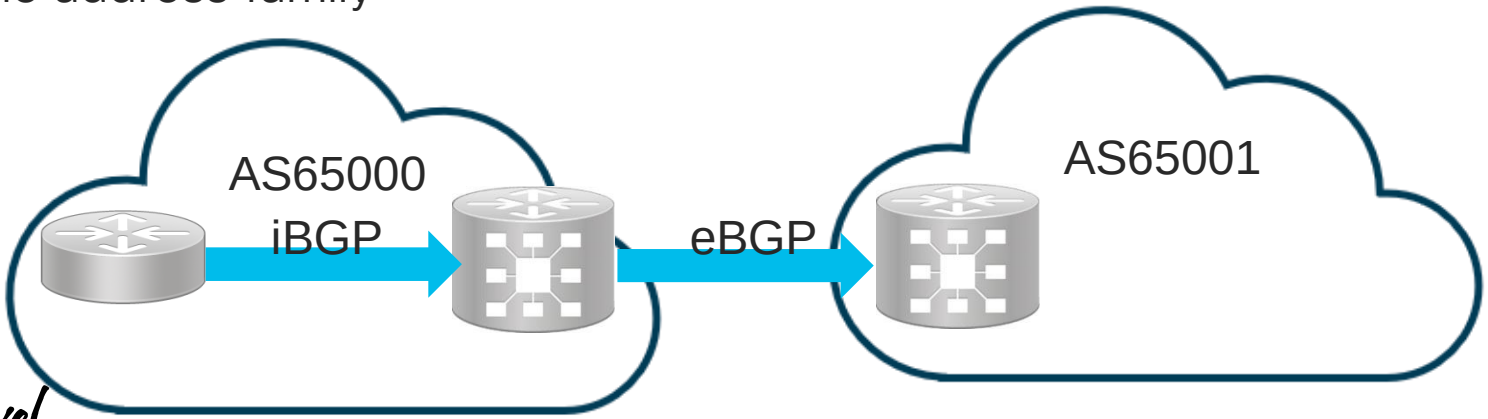
BGP Peering

- iBGP versus eBGP
- iBGP within the same Autonomous System
- eBGP between AS
- iBGP TTL is 255
- eBGP TTL is 1
- eBGP with IOS-XR requires a route policy to accept or advertise routes



BGP Peering – Open

- Open requirements
  - AS
  - Authentication
  - Version
  - Update Source
  - One address family



BGP Peering - iBGP

- IOS/IOS-XE

```
Router bgp 65000
 neighbor 192.168.100.1 remote-as 65000
 neighbor 192.168.100.1 update-source
loopback 0
 neighbor 192.168.100.1 next-hop-self
```

- IOS-XR

```
Router bgp 65000
 address-family ipv4
  exit
 neighbor 192.168.100.2
  remote-as 65000
  update-source loopback 0
  address-family ipv4 unicast
    next-hop-self
```

BGP Peering - eBGP

- IOS/IOS-XE

```
Router bgp 65000
 neighbor 192.168.100.1 remote-as 65001
```

- IOS-XR

```
Route-policy LetRoutesFly
 pass
 end-policy
Router bgp 65001
 address-family ipv4
  exit
 neighbor 192.168.100.2
  remote-as 65000
  address-family ipv4 unicast
    policy LetRoutesFly in
    policy LetRoutesFly out
```

BGP Route Injection

- Routes into BGP?
  - Network statements
  - Redistribution
- Network statement has to match an entry in the IGP table
- Auto Summary impacts both for IPv4
  - IOS-XR does not have the concept of auto summary
  - For network statement, if auto summary is enable, then a match of a subnet wil allow a classful network statement to work, otherwise an exact match
  - For redistribution, auto summary will summarize the routes to their classful boundary, otherwise subnets are injected
  - Auto summary is disabled by default

BGP Route Injection

- IOS/IOS-XE

```
Router bgp 65000
 address-family ipv4
  network 10.1.1.0 mask 255.255.255.0
  redistribute ospf 1
```

- IOS-XR

```
Router bgp 65000
 address-family ipv4 unicast
  network 10.1.1.0/24
  redistribute ospf 1
```

For IPv4 on IOS/IOS-XE, the network and redistribution commands can be done under the routing process

BGP IPv6 Unicast Address Families

- IOS/IOS-XE

```
Router bgp 65000
 neighbor 2005:dead:beef:12::1 remote-as
65001
 address-family ipv6 unicast
  neighbor 2005:dead:beef:12::1 activate
  network 2005:cafe:beef:db8::/64
  redistribute ospfv3 1
```

- IOS-XR

```
Router bgp 65000
 address-family ipv6 unicast
  network 2005:cafe:beef:db8::/64
  redistribute ospf 1
  exit
 neighbor 2005:dead:beef:12::2
  remote-as 65000
  address-family ipv6 unicast
```

Aggregate Prefixes

IOS/IOS-XE

```
PE2(config-router)#aggregate-address 1.1.0.0 255.255.0.0 ?

  advertise-map   Set condition to advertise attribute

  as-confed-set   Generate AS confed set path information

  as-set          Generate AS set path information

  attribute-map   Set attributes of aggregate

  route-map       Set parameters of aggregate

  summary-only    Filter more specific routes from updates

  suppress-map    Conditionally filter more specific routes from updates

  <cr>
```

IOS-XR

```
RP/0/RSP0/CPU0:P1(config-bgp-af)#aggregate-address 1.1.0.0/16 ?

  as-confed-set   Generate AS confed set path information

  as-set          Generate AS set path information

  route-policy    Policy to condition advertisement, suppression,
and attributes

  summary-only    Filter more specific routes from updates

  <cr>
```

Verify BGP Neighbors and Routes

- IOS/IOS-XE
- To see the BGP neighbors
  - Show ip bgp summary
  - Show ip bgp neighbor
  - Show bgp ipv6 unicast summary
  - Show bgp ipv6 unicast neighbor
- To see the BGP table
  - Show ip bgp
  - Show bgp ipv6 unicast

- IOS-XR
- To see the BGP neighbors
  - Show bgp ipv4 unicast summary
  - Show bgp ipv4 unicast neighbor
  - Show bgp ipv6 unicast summary
  - Show bgp ipv6 unicast neighbor
- To see the BGP table
  - Show bgp ipv4 unicast
  - Show bgp ipv6 unicast

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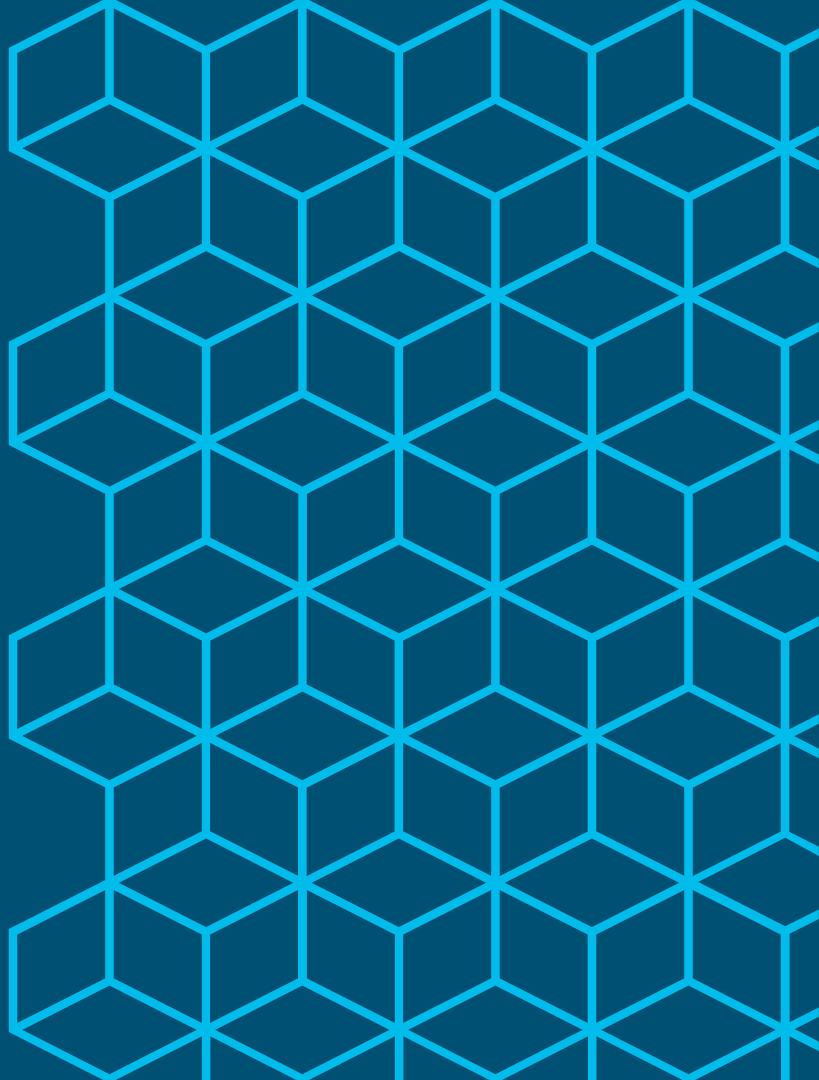
Not so basic BGP



BGP Peering with Peer Groups

- IOS/IOS-XE

```
Router bgp 65000
 neighbor MyGroup peer-group
 neighbor MyGroup remote-as 65001
 neighbor 192.168.100.1 peer-group
MyGroup
 address-family ipv4
  neighbor 192.168.100.1 activate
```

- IOS-XR
  - Nope

BGP Peering with Templates

- IOS/IOS-XE

```
router bgp 65000
 template peer-policy MyPolicy
  send-community both
  exit-peer-policy
 template peer-session MySession
  remote-as 65001
  ttl-security hops 2
 exit-peer-session
 bgp log-neighbor-changes
 neighbor 192.168.100.1 inherit peer-session
MySession
 address-family ipv4
  neighbor 192.168.100.1 activate
  neighbor 192.168.100.1 inherit peer-policy
MyPolicy
 exit-address-family
```

- IOS-XR

```
router bgp 65001
 af-group MyAFgroup ipv4 unicast
 send-community both
session-group MySession
  remote-as 65001
  ttl-security hops 2
 exit
 neighbor 192.168.100.1
  use session-group MySession
  address-family ipv4
   use af-group MyAFgroup
```

Or

```
router bgp 65001
 neighbor-group MyNeighbors
  remote-as 65001
  ttl-security hops 2
  address-family ipv4 unicast
   send-community both
neighbor 192.168.100.1
  use neighbor-group MyNeighbors
```

BGP Timers

Timers by default are:

- Hello 60 seconds
- Hold 180 seconds
- Scan 60 seconds

- IOS/IOS-XE

```
router bgp 65000
 bgp scan-time 45
 timers bgp 30 90
 neighbor 192.168.100.1 timers 45 135
```

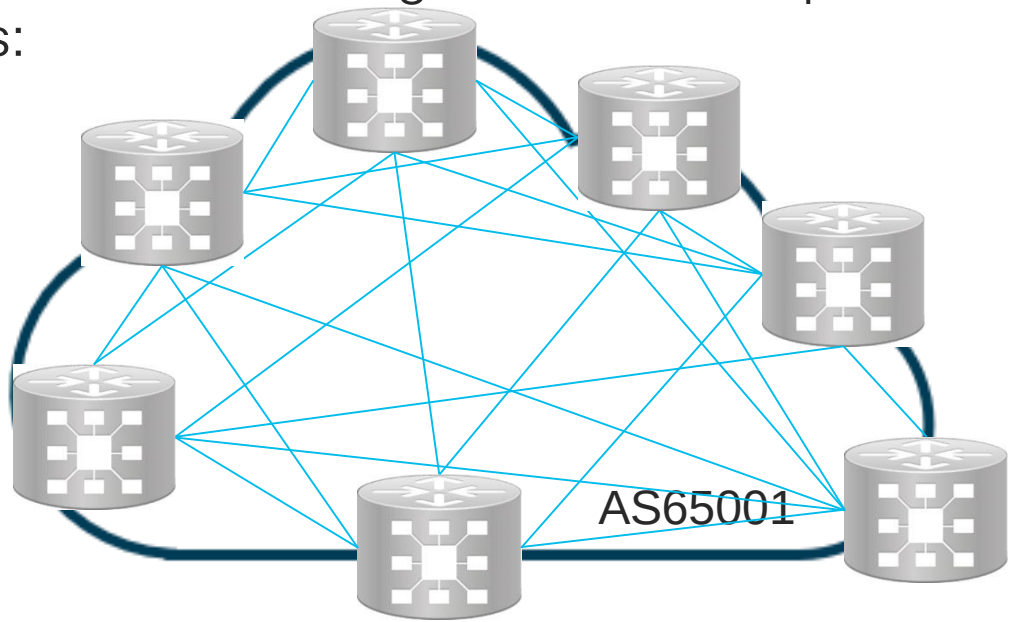
- IOS-XR

```
router bgp 65000
 bgp scan-time 45
 timers bgp 30 90
 neighbor 192.168.100.1
  timers 45 135
```

BGP iBGP Full Mesh Alternatives

- By default iBGP expects a full mesh of neighbor relationships. There are two alternatives:
  - Confederations
  - Route reflection

- Full mesh = (n x (n-1))/2
  - 7 routers = 21 sessions



BGP iBGP Full Mesh Alternatives – Confederations

- IOS/IOS-XE

```
router bgp 65000
 bgp confederation identifier 100
 bgp confederation peer 65001
 neighbor 192.168.100.1 remote-as 65001
 address-family ipv4
  neighbor 192.168.100.1 update-source
loopback 0
  neighbor 192.168.100.1 ebgp-multihop 2
  neighbor 192.168.100.1 next-hop-self
```

- IOS-XR

```
router bgp 65000
 bgp confederation identifier 100
 bgp confederation peer 65001
 neighbor 192.168.100.1
  remote-as 65001
  address-family ipv4 unicast
   update-source loopback 0
   next-hop-self
```

BGP iBGP Full Mesh Alternatives – Route Reflectors

- IOS/IOS-XE

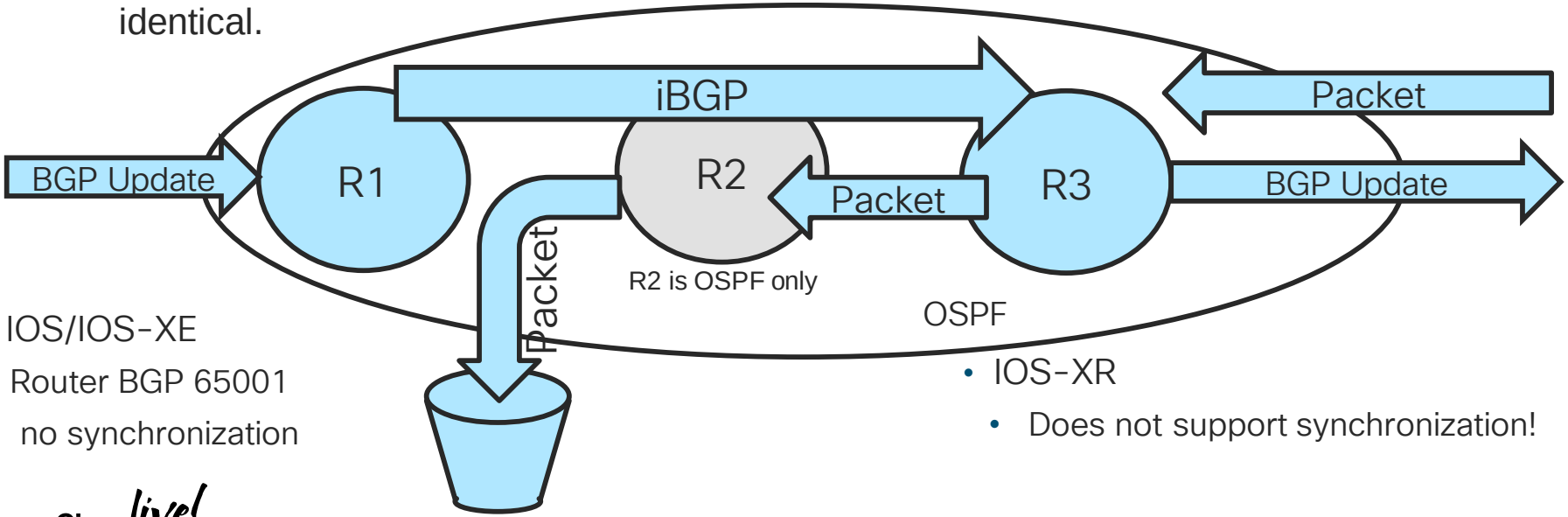
```
router bgp 65000
 neighbor 192.168.100.1 remote-as 65000
 address-family ipv4
  neighbor 192.168.100.1 update-source
loopback 0
  neighbor 192.168.100.1 next-hop-self
  neighbor 192.168.100.1 route-reflector-
client
```

- IOS-XR

```
router bgp 65000
 neighbor 192.168.100.1
  remote-as 65000
  address-family ipv4 unicast
   update-source loopback 0
   next-hop-self
   route-reflector-client
```

BGP iBGP Synchronization

- With synchronization enabled, BGP does not use or advertise a route learned from an IBGP peer unless there is a matching route in the routing table from a source other than BGP.
- RFC 1403 requires that the router ID of the BGP source and the OSPF source be identical.



- IOS/IOS-XE
  Router BGP 65001
  no synchronization

- IOS-XR
  - Does not support synchronization!

Path Attributes

Categories		Examples
Well known	Mandatory	Origin AS path Next hop
	Discretionary	Local preference Atomic aggregate
Optional	Transitive	Community Aggregator
	Nontransitive	Originator ID Cluster list MED

BGP 12 Step Program

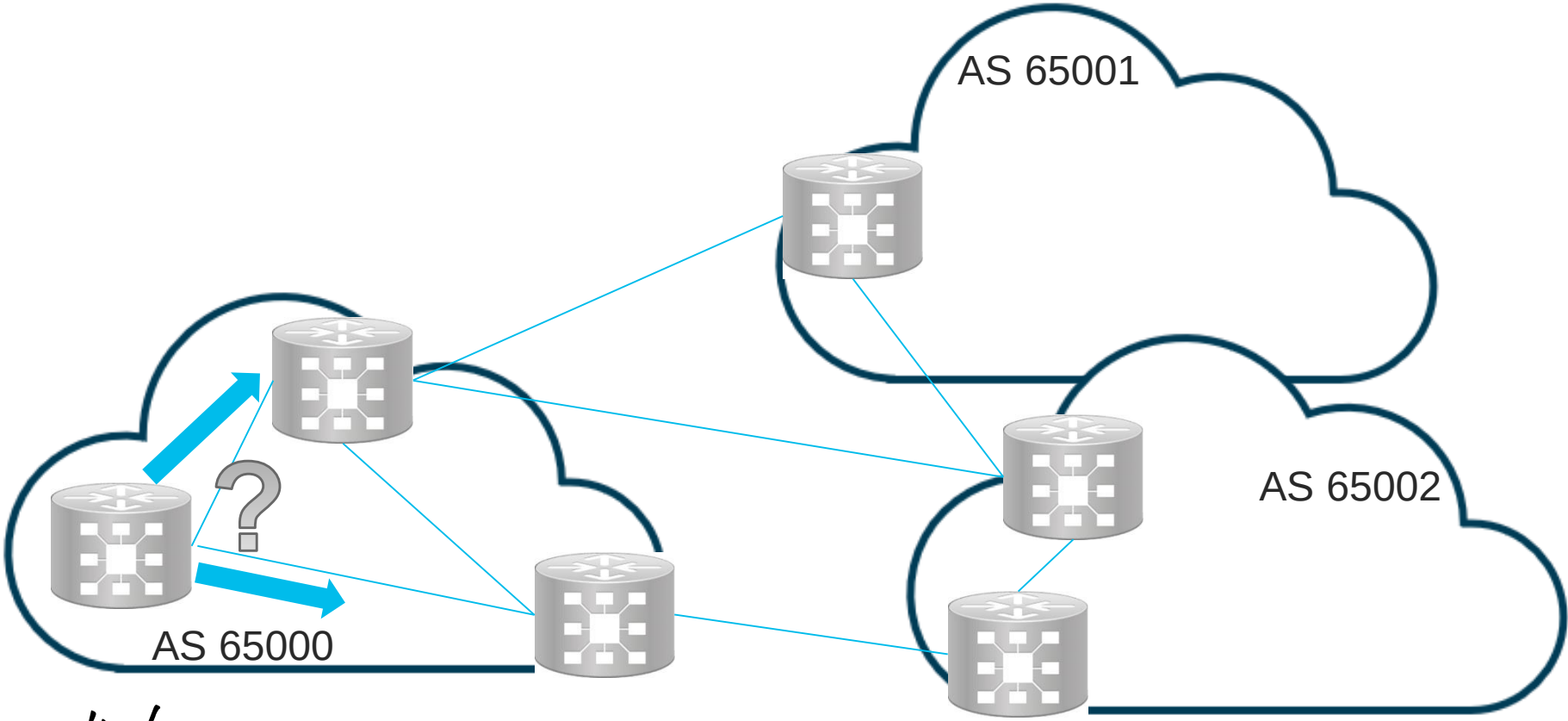
- Prerequisite: no AS loop, good next hop, synchronized if necessary.

1. Highest weight
2. Highest local preference
3. Locally originated
4. Shortest AS path length
5. Origin code
6. Lowest MED
7. EBGP over IBGP
8. If routed to neighbor, prefer the path with lowest IGP metric to next hop

*Consider multipath in RIB

9. If external, prefer older one (> 1 min)
10. Lowest router ID or originator ID
11. Minimum cluster list length
12. Lowest neighbor address

BGP Attribute Manipulations – Weight



BGP Attribute Manipulations – Weight

Locally injected routes have a weight of 32,768. Learned routes have a weight of 0.

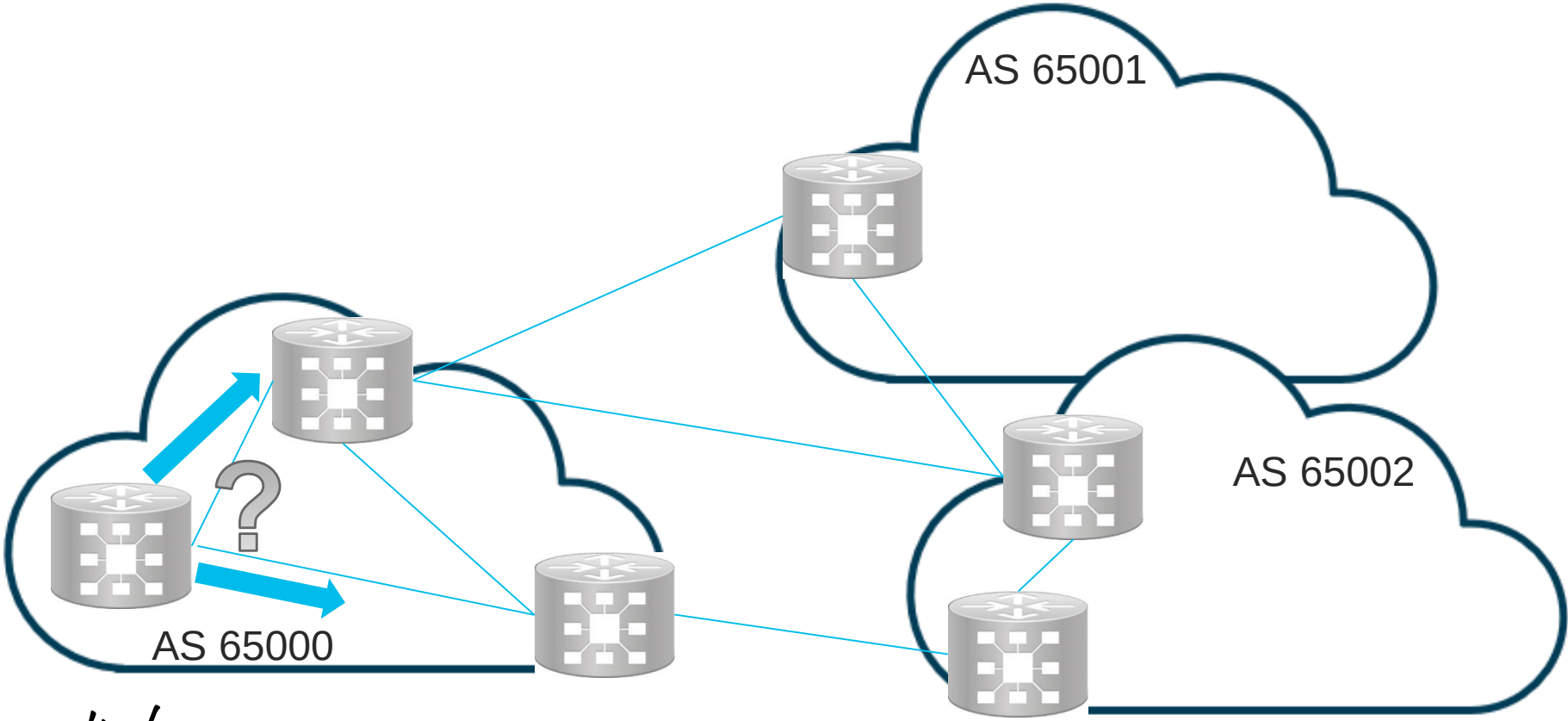
- IOS/IOS-XE

```
router bgp 65000
 address-family ipv4
  neighbor 192.168.100.1 weight 100
  neighbor 192.168.200.1 route-map YourWeight
in
  network 172.16.0.0 route-map MyWeight
!
route-map MyWeight permit 10
 set weight 0
!
route-map YourWeight permit 10
 match ip address prefix-list YourRoutes
 set weight 150
route-map YourWeight permit 20
!
ip prefix-list YourRoutes permit 10.0.0.0/8
```

- IOS-XR

```
router bgp 65000
 address-family ipv4 unicast
  network 172.16.0.0/16 route-policy MyWeight
 neighbor 192.168.100.1
  address-family ipv4 unicast
   weight 100
  neighbor 192.168.200.1
   address-family ipv4 unicast
    route-policy YourWeight in
route-policy YourWeight
 if prefix is (10.0.0.0/8) then
   set weight 150
  else
   pass
  endif
end-policy
route-policy MyWeight
 set weight 100
end-policy
```

BGP Attribute Manipulations – Local Preference



BGP Attribute Manipulations – Local Preference

Default local preference is 100.

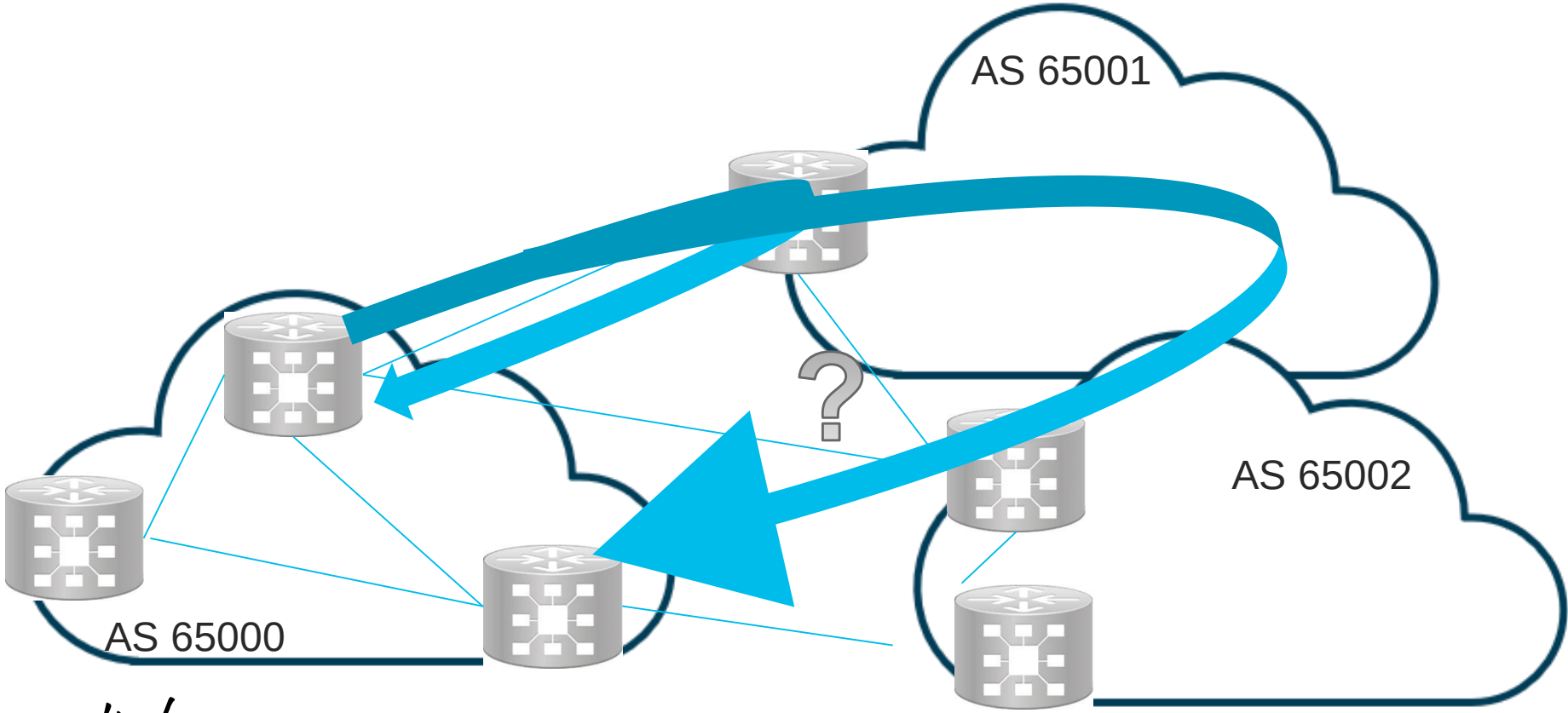
- IOS/IOS-XE

```
router bgp 65000
 bgp default local-preference 150
 address-family ipv4
  neighbor 192.168.200.1 route-map MyPref
in
!
route-map MyPref permit 10
 match ip address prefix-list YourRoutes
 set local-preference 125
route-map MyPref permit 20
!
ip prefix-list YourRoutes permit
10.0.0.0/8
```

- IOS-XR

```
router bgp 65000
 bgp default local-preference 150
 neighbor 192.168.200.1
  address-family ipv4 unicast
   route-policy MyPref in
!
route-policy MyPref
 if prefix is (10.0.0.0/8) then
   set local-preference 125
  else
   pass
  endif
end-policy
```

BGP Attribute Manipulations – AS Path Prepend



BGP Attribute Manipulations – AS Path

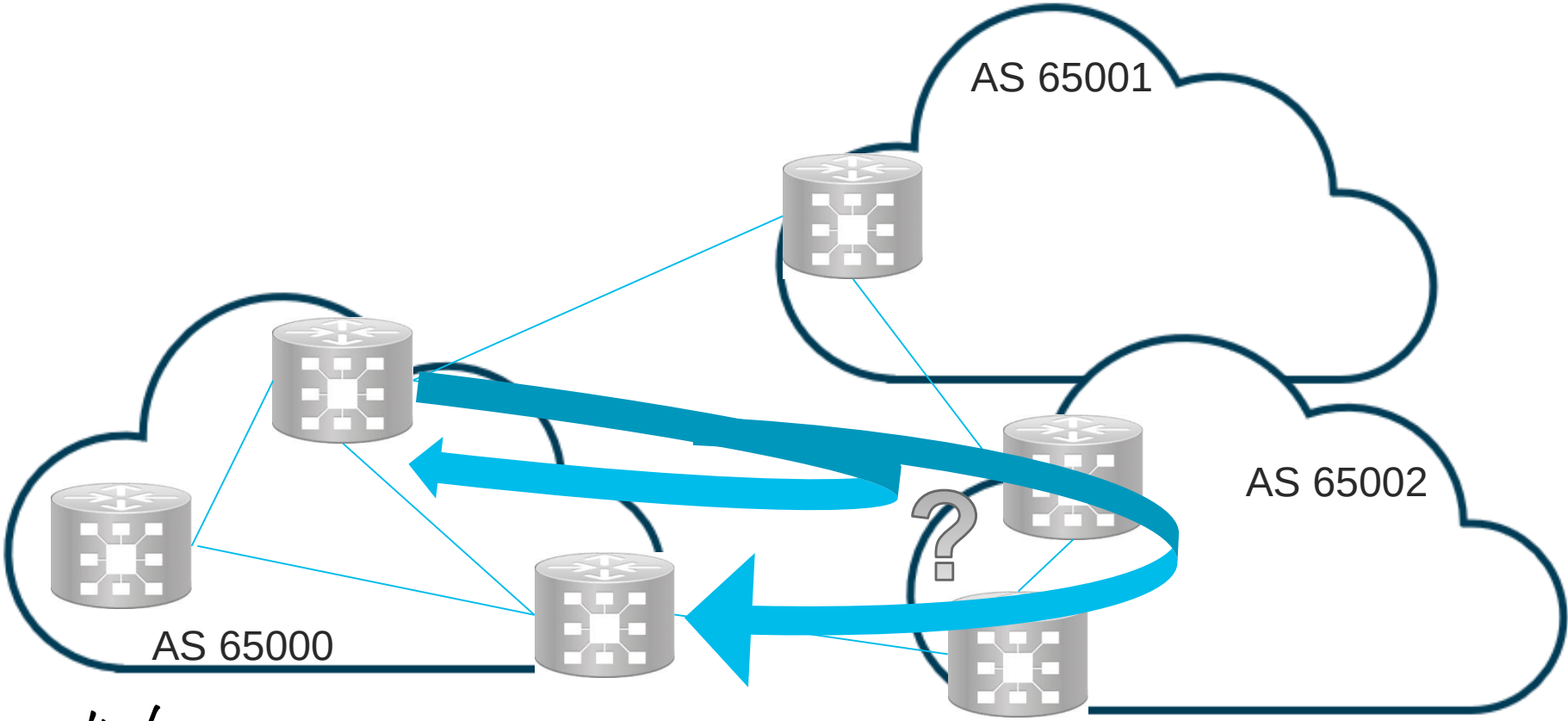
- IOS/IOS-XE

```
router bgp 65000
 address-family ipv4
  neighbor 192.168.200.1 route-map 2nd
out
!
route-map 2nd permit 10
 match as-path 1
 set as-path prepend 65000 65000 65000
route-map 2nd permit 20
!
ip as-path access-list 1 per ^$
```

- IOS-XR

```
router bgp 65000
 neighbor 192.168.100.1
  address-family ipv4 unicast
   route-policy 2nd out
!
route-policy 2nd
 if as-path is-local then
   prepend as-path 65000 3
  else
   pass
  endif
end-policy
```

BGP Attribute Manipulations – MED



BGP Attribute Manipulations – MED

- IOS/IOS-XE

```
router bgp 65000
 default-metric 999
 address-family ipv4
  neighbor 192.168.200.1 route-map 2nd
out
!
route-map 2nd permit 10
 match as-path 1
 set metric 99
route-map 2nd permit 20
!
ip as-path access-list 1 per ^$
```

- IOS-XR

```
router bgp 65000
 default-metric 999
neighbor 192.168.100.1
  address-family ipv4 unicast
   route-policy 2nd out
!
route-policy 2nd
 if as-path is-local then
   set med 99
  else
   pass
  endif
end-policy
```

BGP Private AS, Local AS, Allow AS in, AS Override

- IOS/IOS-XE

```
router bgp 65000
 neighbor 192.168.100.1 remote-as 20
 neighbor 192.168.100.1 local-as 10 no-
prepend replace-as
 address-family ipv4
  neighbor 192.168.100.1 allowas-in
  neighbor 192.168.100.1 as-override
  neighbor 192.168.100.1 remove-private-
as
```

- IOS-XR

```
router bgp 65000
 neighbor 192.168.100.1
  remote-as 20
  local-as 10 no-prepend
  address-family ipv4 unicast
   allowas-in
   as-override
   remove-private-as
```

Route Filtering Tools

- Prefix lists:
  - Used for prefix-based filtering or matching of routes.
  - Can be used to match on the prefix, route source, or next-hop address.
- AS path access lists:
  - Used in BGP for filtering or route matching based on BGP AS Path attribute.
- Route maps:
  - Primarily used to implement complex routing policies.
  - Can also be used as a powerful filtering tool.
- Routing policy language:
  - Replaces route maps in Cisco IOS XR Software.
  - Feature-rich language for complex routing policies.

Configuring Prefix-Lists

- Prefix-lists have names and sequence numbers (like route-maps).
  - IOS/IOS-XE

```
router(config)# ip/ipv6 prefix-list list-name [seq seq]
{permit|deny} network/len [ge value] [le value]
```

  - IOS-XR

```
router(config)# ipv4/ipv6 prefix-list list-name
router(config-ipv4-pfx)# [seq seq] {permit|deny} network/len
[ge value] [le value] [eq value]
```

- An entry with no le or ge (or eq) parameter matches exactly the specified prefix.
- An entry with an le or ge (or eq) parameter matches any route within the address space of address/prefix with prefix longer than or equal to ge value and shorter than or equal to le value or equals to the eq value for IOS-XR platforms.

BGP Prefix Filtering

- IOS/IOS-XE

```
ip prefix-list noRFC1918 deny 10.0.0.0/8
le 32
ip prefix-list noRFC1918 deny
172.16.0.0/12 le 32
ip prefix-list noRFC1918 deny
192.168.0.0/16 le 32
ip prefix-list noRFC1918 permit 0.0.0.0/0
le 32
router bgp 65000
 address-family ipv4
  neighbor 192.168.100.1 prefix-list
noRFC1918 out
```

- IOS-XR

```
prefix-set RFC1918
 10.0.0.0/8 le 32,
 172.16.0.0/12 le 32,
 192.168.0.0/16 le 32
end-set
!
route-policy NoRFC1918
 if prefix in RFC1918 then
   drop
  else
   pass
  endif
end-policy
!
route bgp 65000
 neighbor 192.168.100.1
  address-family ipv4 unicast
   route-policy NoRFC1918 out
```

Commonly Used Characters in Expressions

.	Any single character, including a space
*	Zero or more sequence of pattern
+	One or more sequence of pattern
?	Zero or one occurrence of pattern
^	Beginning of string
$	End of string
_	Match any delimiter (including beginning, end, space, tab, comma)
\	Remove special meaning of character that follows
[ ]	Match one character in a range
( )	Match on a pattern
|	Logical OR

Review of some common RegEx

1. = 10 - 19

^. = any AS path but local

^$ = local AS

.* = any

^200$ = only AS200

_200$ = starts in AS200

^200_ = ends with AS200

_200_ = AS in the path

^200(_200)*$

\1 = repeat of last match 1 time

^[0-9]+$ = match any single AS

^([0-9]+)(_\1)*$ = any AS and it can prepend

RegEx

- IOS/IOS-XE

```
ip as-path access-list 1 permit _10$
ip as-path access-list 1 permit _20$
ip as-path access-list 1 permit _30$
ip as-path access-list 1 permit _40$
router bgp 65000
 address-family ipv4
 neighbor 192.168.100.1 filter 1 in
```

- IOS-XR

```
as-path-set CustomerAS
 ios-regex '_10$',
 ios-regex '_20$',
 ios-regex '_30$',
 ios-regex '_40$'
end-set
route-policy CustomerAS
 if as-path in CustomerAS then
   pass
 else
   drop
 endif
end-policy
router bgp 65000
 neighbor 192.168.100.1
  address-family ipv4 unicast
   route-policy CustomerAS in
```

BGP Communities

- BGP communities are a means of tagging routes to ensure a consistent filtering or route selection policy.
- The community attribute is a transitive optional attribute. Standard community is 32 bit values, extended community are 64 bit value.
- There are several define communities:
  - no-advertise: Do not advertise routes to any peer.
  - no-export: Do not advertise routes to real EBGP peers.
  - local-as: Do not advertise routes to any EBGP peers.
  - internet: Advertise this route to the Internet community.
- A community value is split into two parts:
  - High-order typically contain the AS number of the AS that defines the community meaning.
  - Low-order bits have local significance.

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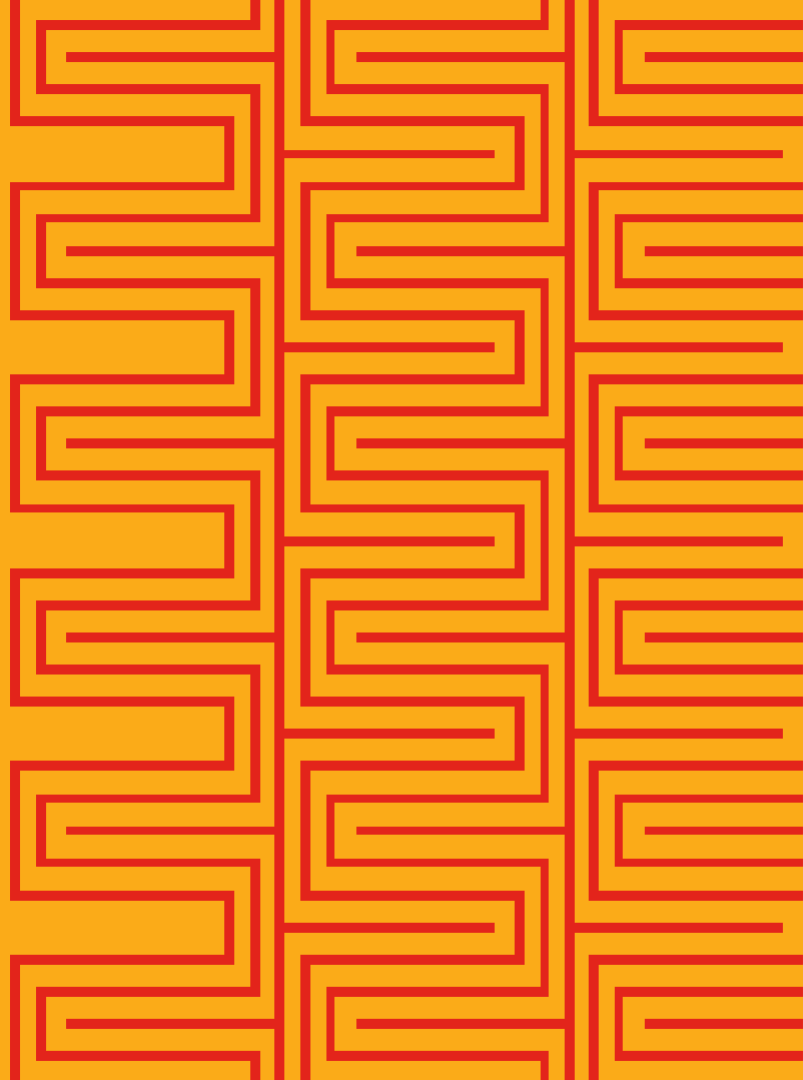
More advanced BGP features



BGP Outbound Route Filtering

Outbound route filtering (RFC 5291) allows one BGP router to send a prefix list to another.

- IOS/IOS-XE

```
Router bgp 65000
 address-family ipv4
  neighbor 192.168.100.1 capability orf prefix-list send
  neighbor 192.168.100.1 prefix-list MyList in

Ip prefix-list MyList permit 10.0.0.0/8 ge 24
```

- IOS-XR

```
route-policy MyORF
 if orf prefix in (10.0.0.0/8 ge 24) then
 pass
 endif
 endpolicy
route-policy PassAll
 pass
 endpolicy
```

```
router bgp 65000
 neighbor 192.168.100.1
  remote-as 65001
  address-family ipv4 unicast
   route-policy PassAll in
   route-policy PassAll out
   capability orf prefix send
   orf route-policy MyORF
```

BGP Dynamic Neighbors

- IOS/IOS-XE

```
router bgp 65000
 bgp log-neighbor-changes
 bgp listen range 192.168.0.0/16 peer-group My192Neighbors
 bgp listen limit 200
 neighbor My192Neighbors peer-group
 neighbor My192Neighbors remote-as 65001 alternate-as 65002 65003 65004
!
 address-family ipv4
  neighbor My192Neighbors activate
 exit-address-family
```

- IOS-XR
  - nope

BGP Prefix Independent Convergence

- IOS/IOS-XE

```
router bgp 65000
 address-family ipv4 unicast
  bgp additional-paths install
```

- IOS-XR

```
route-policy PIC
  set path-selection backup 1 install
 end-policy
router bgp 65000
 address-family ipv4 unicast
  additional-paths selection route-policy PIC
```

BGP Conditional Route Injection

- IOS/IOS-XE

```
router bgp 109
 bgp inject-map NewRoutes exist-map RcvRoutes
!
route-map RcvRoutes permit 10
  match ip address prefix-list RcvRoutes
  match ip route-source prefix-list RouteSource
route-map NewRoutes permit 10
 set ip address prefix-list NewRoutes
ip prefix-list RcvRoutes permit 10.1.1.0/24
ip prefix-list NewRoutes permit 10.1.1.0/25
ip prefix-list NewRoutes permit 10.1.1.128/25
ip prefix-list RouteSource permit 10.2.1.1/32
```

- IOS-XR
  - nope

BGP Security

These are the most common BGP threats:

- BGP routing table manipulation
- BGP route spoofing
- BGP DoS

BGP Countermeasures Overview

Countermeasure	BGP Table Manipulation	BGP Route Spoofing*	BGP DoS
BGP Neighbor Authentication	Yes	No	No
BGP TTL Security Check	Yes	No	Yes
BGP Maximum Prefix	No	No	Yes

- *BGP route spoofing can be prevented using filtering based on prefixes and AS path.

BGP Security

- IOS/IOS-XE

```
router bgp 65000
 neighbor 192.168.100.1 password C1sc0
 neighbor 192.168.100.1 ttl-security hops 1
 address-family ipv4
  neighbor 192.168.100.1 maximum-prefix 1000
```

- IOS-XR

```
router bgp 65000
 neighbor 192.168.100.1
  password C1sc0
  ttl-security
  address-family ipv4
   maximum-prefix 1000
```

- TTL Seuciry:
  - With IOS/IOS-XE the hops value is how many hops away the neighbor can be (the acceptable TTL would be from 255 to 255 minus the number of hops)
  - With IOS-XR, only 255 is an acceptable TTL value
- BGP neighbors can be authenticated before establishing a TCP session:
  - HMAC-MD5 is used.
  - Cisco IOS-XR supports HMAC-SHA1 with key chains.

Dynamic Layer 3 VPN with mGRE

- Dynamic L3 VPNs with mGRE Tunnels feature provides an L3 transport
- L3 tunneling transport can also be used within IP networks to transport VPN traffic across another IPv4 network
- Currently not available on IOS-XR

BGP Dynamic Layer 3 VPN

- IOS/IOS-XE

```
vrf definition MGRE
 rd 1:2
 route-target export 1:2
 route-target import 1:2
 address-family ipv4
exit-address-family
!
interface FastEthernet1/0
 vrf forwarding MGRE
 ip address 172.16.11.18 255.255.255.240
!
l3vpn encapsulation ip MGRE
 transport ipv4 source Loopback0
```

```
router bgp 65000
 neighbor 192.168.100.1 remote-as 65000
 neighbor 192.168.100.1 update-source
Loopback0
 address-family vpnv4
  neighbor 192.168.100.1 activate
  neighbor 192.168.100.1 send-community
extended
  neighbor 192.168.100.1 route-map MGRE-
NEXT-HOP in
 address-family ipv4 vrf MGRE
  redistribute connected
!
route-map MGRE-NEXT-HOP permit 10
 set ip next-hop encapsulate l3vpn MGRE
```

BGP Policy Accounting

Border Gateway Protocol (BGP) policy accounting measures and classifies IP traffic that is sent to, or received from, different peers.

- IOS/IOS-XE

```
ip as-path access-list 1 permit _1234$
route-map BGPAccounting permit 10
 match as-path 1
 set traffic-index 1
router bgp 65000
table-map BGPAccounting
!
interface gigabitethernet0/0
 bgp-policy accounting
```

```
show cef interface gigabitethernet0/0 policy-
statistics
```

- IOS-XR

```
route-policy BGPAccounting
 if as-path originates-from '1234' then
   set traffic-index1
  endif
 end-policy
router bgp 65000
 address-family ipv4 unicast
  table-policy BGPAccounting
!
interface gigabitethernet0/0/0/0
 ipv4 bgp policy accounting input source-
accounting
```

```
show cef interface gigabitethernet 0/0/0/0
bgp-policy-statistics
```

BGP Flowspec

- Flowspec specifies procedures for the distribution of flow specification rules via BGP and defines procedure to encode flow specification rules as Border Gateway Protocol Network Layer Reachability Information (BGP NLRI) which can be used in any application.
- The BGP flow specification (flowspec) feature allows you to rapidly deploy and propagate filtering and policing functionality among a large number of BGP peer routers to mitigate the effects of a distributed denial-of-service (DDoS) attack over your network.
- In Cisco IOS 15.5(S) release, BGP flow specification is supported only on a BGP flow specification client and route reflector.
- ASR9000 can be the flow specification controller

BGP Flowspec - Controller

- IOS-XR

```
class-map type traffic match-all MyFlowSpec
 match protocol tcp
 match packet length 1000-1500
 match destination-port 80 8080
 match destination-address 172.16.199.0
255.255.255.0
 end-class-map
policy-map type pbr MyFlowSpecPolicy
 class type traffic MyFlowSpec
  set dscp 46
  policy rate 50 mbps
  redirect nexthop 192.168.200.1
  end-policy-map
!
flowspec
 local-install interface-all
 address-family ipv4
  service-policy type pbr MyFlowSpecPolicy
```

```
router bgp 65000
 address-family ipv4 flowspec
  exit
  neighbor 192.168.100.2
   address-family ipv4 flowspec
```

BGP Flowspec - Client

- IOS/IOS-XE

```
router bgp 65000
 address-family ipv4 flowspec
  neighbor 192.168.100.1 activate
!
flowspec
 address-family ipv4
  local-install interface-all
 vrf customerA
  local-install interface-all
```

- IOS-XR

```
router bgp 65000
 address-family ipv4 flowspec
  exit
  neighbor 192.168.100.1
   address-family ipv4 flowspec
!
flowspec
  local-install interface-all
```

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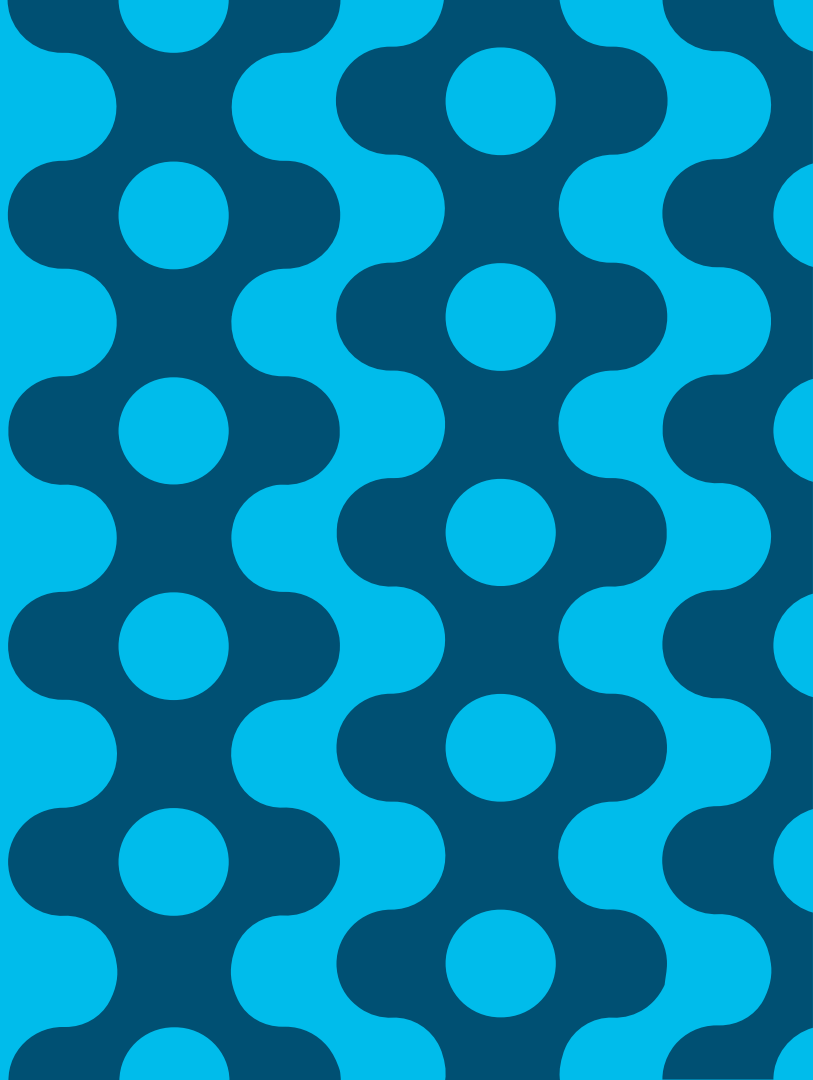
Troubleshooting BGP



Troubleshooting BGP Peering

- IOS/IOS-XE
  - Show ip bgp neighbor
  - Show bgp ipv6 unicast neighbor
  - Show ip bgp summary
  - Show bgp ipv6 unicast summary
- IOS-XR
  - Show bgp neighbor
  - Show bgp ipv6 unicast neighbor
  - Show bgp summary
  - Show bgp ipv6 unicast summary

BGP Neighbor States

When establishing a BGP session, BGP goes through the following states:

Idle: The router is searching the routing table to see whether a route exists to reach the neighbor.

Connect: The router found a route to the neighbor and is waiting to completed the three-way TCP handshake.

Active: BGP will try another TCP three-way handshake to establish a connection with the remote BGP neighbor. If it is successful, it will move to the OpenSent state. If the ConnectRetry timer expires then we move back to the Connect state.

OpenSent: The open message is sent, with the parameters for the BGP session.

OpenConfirm: The router received an agreement on the parameters for establishing a session.

Established: Peering is established; routing begins.

Troubleshooting BGP Updates (Routes)

- IOS/IOS-XE
  - Show bgp
    - Or show ip bgp
    - Or show bgp ipv4 unicast
  - Show bgp ipv6 unicast
- IOS-XR
  - Show bgp
  - Show bgp ipv6 unicast

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Conclusion

- BGP is complicated, but it is manageable. The more you play with it, the more comfortable you'll get...the more BGP will be your friend!

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Q&A

If you have questions later, email me @ Johnny@Bassconsulting.com
Or find me on LinkedIn www.linkedin.com/in/johnny-bass-ccie6458

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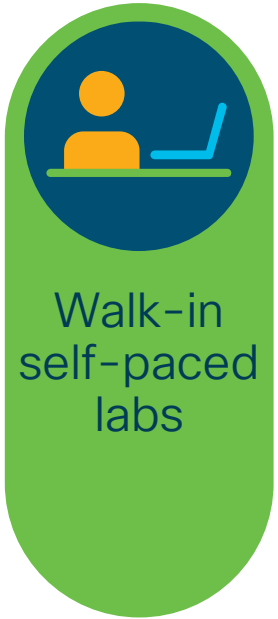

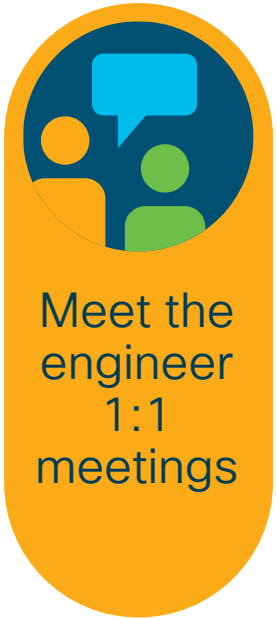

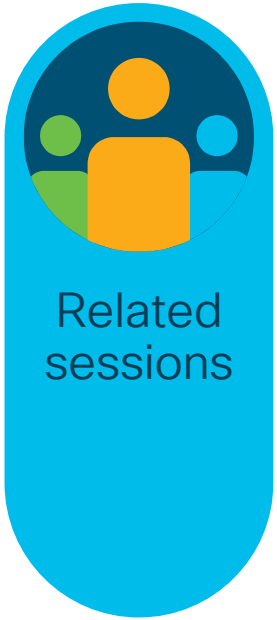

Thank you

INTUITIVE

R&S related Cisco education offerings

Course	Description	Cisco Certification
CCIE R&S Advanced Workshops (CIERS-1 & CIERS-2) plus Self Assessments, Workbooks & Labs	Expert level trainings including: instructor led workshops, self assessments, practice labs and CCIE Lab Builder to prepare candidates for the CCIE R&S practical exam.	CCIE® Routing & Switching
• Implementing Cisco IP Routing v2.0 • Implementing Cisco IP Switched Networks V2.0 • Troubleshooting and Maintaining Cisco IP Networks v2.0	Professional level instructor led trainings to prepare candidates for the CCNP R&S exams (ROUTE, SWITCH and TSHOOT). Also available in self study eLearning formats with Cisco Learning Labs.	CCNP® Routing & Switching
Interconnecting Cisco Networking Devices: Part 2 (or combined)	Builds on ICND1 to provide capabilities needed to configure, implement and troubleshoot a small enterprise network. Including: understanding of Quality of Service (QoS), how virtualized and cloud services interact and impact enterprise networks, along with an overview of network programmability and the related controller types and tools that are available to support software-defined network architectures. Also available in self study eLearning format with Cisco Learning Lab.	CCNA® Routing & Switching
Interconnecting Cisco Networking Devices: Part 1	Understand layer 2 and layer 3 networking fundamentals needed to install, configure, and provide basic support of small/branch networks. Covers network device security and IPv6 basics. Also available in self study eLearning format with Cisco Learning Lab.	CCENT® Routing & Switching

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Design Cisco education offerings

Course	Description	Cisco Certification
Designing Cisco Network Service Architectures (ARCH) Version 3.0	Provides learner with the ability to perform conceptual, intermediate, and detailed design of a network infrastructure that supports desired capacity, performance, availability required for converged Enterprise network services and applications.	CCDP® (Design Professional) (Available Now)
Designing for Cisco Internetwork Solutions (DESGN) Version 3.0	Instructor led training focused on fundamental design methodologies used to determine requirements for network performance, security, voice, and wireless solutions. Prepares candidates for the CCDA certification exam.	CCDA® (Design Associate) (Available Now)

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Wireless Cisco education offerings

Course	Description	Cisco Certification
• Designing Cisco Wireless Enterprise Networks • Deploying Cisco Wireless Enterprise Networks • Troubleshooting Cisco Wireless Enterprise Networks • Securing Cisco Wireless Enterprise Networks	Professional level instructor led trainings to prepare candidates to conduct site surveys, implement, configure and support APs and controllers in converged Enterprise networks. Focused on 802.11 and related technologies to design, deploy, troubleshoot as well as secure Wireless infrastructure. Course also provide details around Cisco mobility services Engine, Prime Infrastructure and wireless security.	CCNP® Wireless
Implementing Cisco Unified Wireless Network Essential	Prepares candidates to design, install, configure, monitor and conduct basic troubleshooting tasks of a Cisco WLAN in Enterprise installations.	CCNA® Wireless
Deploying Basic Cisco Wireless LANs (WDBWL)	Understanding of the Cisco Unified Wireless Networking for enterprise deployment scenarios. In this course, you will learn the basics of how to install, configure, operate, and maintain a wireless network, both as an add-on to an existing wireless LAN (WLAN) and as a new Cisco Unified Wireless Networking solution.	1.2
Deploying Advanced Cisco Wireless LANs (WDAWL)	The WDAWL advanced course is designed with the goal of providing learners with the knowledge and skills to successfully plan, install, configure, troubleshoot, monitor, and maintain advanced Cisco wireless LAN solutions such as QoS, “salt and pepper” mobility, high density deployments, and outdoor mesh deployments in an enterprise customer environment.	1.2
Deploying Cisco Connected Mobile Experiences (WCMX)	WCMX will prepare professionals to use the Cisco Unified Wireless Network to configure, administer, manage, troubleshoot, and optimize utilization of mobile content while gaining meaningful client analytics.	2.0

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Cybersecurity Cisco education offerings

Course	Description	Cisco Certification
Understanding Cisco Cybersecurity Fundamentals (SFUND)	The SECFND course provides understanding of cybersecurity's basic principles, foundational knowledge, and core skills needed to build a foundation for understanding more advanced cybersecurity material & skills.	CCNA® Cyber Ops
Implementing Cisco Cybersecurity Operations (SECOPS)	This course prepares candidates to begin a career within a Security Operations Center (SOC), working with Cybersecurity Analysts at the associate level.	CCNA® Cyber Ops
Cisco Security Product Training Courses	Official deep-dive, hands-on product training on Cisco's latest security products, including NGFW, ASA, NGIPS, AMP, Identity Services Engine, Email and Web Security Appliances, and much more.	

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Cybersecurity Cisco education offerings

Course	Description	Cisco Certification
CCIE Security 5.0		CCIE® Security
Implementing Cisco Edge Network Security Solutions (SENSS) Implementing Cisco Threat Control Solutions (SITCS) v1.5 Implementing Cisco Secure Access Solutions (SISAS) Implementing Cisco Secure Mobility Solutions (SIMOS)	Configure Cisco perimeter edge security solutions utilizing Cisco Switches, Cisco Routers, and Cisco Adaptive Security Appliance (ASA) Firewalls Implement Cisco's Next Generation Firewall (NGFW), FirePOWER NGIPS (Next Generation IPS), Cisco AMP (Advanced Malware Protection), as well as Web Security, Email Security and Cloud Web Security Deploy Cisco's Identity Services Engine and 802.1X secure network access Protect data traversing a public or shared infrastructure such as the Internet by implementing and maintaining Cisco VPN solutions	CCNP® Security
Implementing Cisco Network Security (IINS 3.0)	Focuses on the design, implementation, and monitoring of a comprehensive security policy, using Cisco IOS security features	CCNA® Security

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Data Center / Virtualization Cisco education offerings

Course	Description	Cisco Certification
Introducing Cisco Data Center Networking (DCICN) Introducing Cisco Data Center Technologies (DCICT)	Get job-ready foundational-level certification and skills in installing, configuring, and maintaining next generation data centers.	CCNA® Data Center
Implementing Cisco Data Center Unified Computing (DCUCI) Implementing Cisco Data Center Infrastructure (DCII) Implementing Cisco Data Center Virtualization and Automation (DCVAI) Designing Cisco Data Center Infrastructure (DCID) Troubleshooting Cisco Data Center Infrastructure (DCIT)	Obtain professional level skills to design, configure, implement, troubleshoot next generation data center infrastructure.	CCNP® Data Center
Product Training Portfolio:DCAC9K, DCINX9K, DCMDS, DCUCS, DCNX1K, DCNX5K, DCNX7K, CACND, DSACI, HFLEX UCSDF, UCSDACI, DCUCCEN	Gain hands-on skills using Cisco solutions to configure, deploy, manage and troubleshoot unified computing, policy-driven and virtualized data center infrastructure.	
Designing the FlexPod® Solution (FPDESIGN) Implementing and Administering the FlexPod® Solution (FPIMPADM)	Learn how to design, implement and administer FlexPod® solutions	Cisco and NetApp Certified FlexPod® Specialist
Designing the VersaStack Solution (VSDESIGN) Implementing and Administering the VersaStack Solution (VSIMP)	Learn how to design, implement and administer VersaStack solutions	

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Network Programmability Cisco education offerings

Course	Description	Cisco Certification
Developing with Cisco Network Programmability (NPDEV)	Provides Application Developers with comprehensive curriculum to develop infrastructure programming skills; Addresses needs of software engineers who automate network infrastructure and/or utilize APIs and toolkits to interface with SDN controllers and individual devices	Cisco Network Programmability Developer (NPDEV) Specialist Certification
Designing and Implementing Cisco Network Programmability (NPDESI)	Provides network engineers with comprehensive soup-to-nuts curriculum to develop and validate automation and programming skills; Directly addresses the evolving role of network engineers towards more programmability, automation and orchestration	Cisco Network Programmability Design and Implementation (NPDESI) Specialist Certification
Programming for Network Engineers (PRNE)	Learn the fundamentals of Python programming – within the context of performing functions relevant to network engineers. Use Network Programming to simplify or automate tasks	Recommended pre-requisite for NPDESI and NPDEV Specialist Certifications
Cisco Digital Network Architecture Implementation Essentials (DNAIE)	This training provides students with the guiding principles and core elements of Cisco's Digital Network Architecture (DNA) architecture and its solution components including; APIC-EM, NFV, Analytics, Security and Fabric.	

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Course	Description	Cisco Certification
Understanding Cloud Fundamentals (CLDFND) Introducing Cloud Administration (CLDADM)	Learn how to perform foundational tasks related to Cloud computing, and the essentials of Cloud infrastructure, administration and operations	CCNA® Cloud
Implementing and Troubleshooting the Cisco Cloud Infrastructure (CLDINF) Designing the Cisco Cloud (CLDDES) Automating the Cisco Enterprise Cloud (CLDAUT) Building the Cisco Cloud with Application Centric Infrastructure (CLDACI)	Obtain professional level skills to design, automate, secure, provision and manage private and hybrid Clouds	CCNP® Cloud
Product Training Portfolio: CloudCenter: CLDCTR* UCS Director: UCSDF, UCSDACI Prime Service Catalog: PSCF, PSCI, PSCD MetaPod: MPODF20	Gain in-depth hands-on skills using Cisco solutions to configure, deploy, manage and troubleshoot Cloud deployments	

*Available Q3FY18

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Collaboration Cisco education offerings

Course	Description	Cisco Certification
CCIE Collaboration Advanced Workshop (CIEC)	Gain expert-level skills to integrate, configure, and troubleshoot complex collaboration networks	CCIE® Collaboration
Implementing Cisco Collaboration Applications (CAPPS)	Understand how to implement the full suite of Cisco collaboration applications including Jabber, Cisco Unified IM and Presence, and Cisco Unity Connection.	CCNP® Collaboration
Implementing Cisco IP Telephony and Video Part 1 (CIPTV1) Implementing Cisco IP Telephony and Video Part 2 (CIPTV2) Troubleshooting Cisco IP Telephony and Video (CTCOLLAB)	Learn how to implement Cisco Unified Communications Manager, CUBE, and audio and videoconferences in a single-site voice and video network. Obtain the skills to implement Cisco Unified Communications Manager in a modern, multisite collaboration environment. Troubleshoot complex integrated voice and video infrastructures	CCNP® Collaboration
Implementing Cisco Collaboration Devices (CICD) Implementing Cisco Video Network Devices (CIVND)	Acquire a basic understanding of collaboration technologies like Cisco Call Manager and Cisco Unified Communications Manager. Learn how to evaluate requirements for video deployments, and implement Cisco Collaboration endpoints in converged Cisco infrastructures.	CCNA® Collaboration

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Service Provider Cisco education offerings

Course	Description	Cisco Certification
Deploying Cisco Service Provider Network Routing (SPROUTE) & Advanced (SPADVROUTE) Implementing Cisco Service Provider Next-Generation Core Network Services (SPCORE) Edge Network Services (SPEDGE)	SPROUTE covers the implementation of routing protocols (OSPF, IS-IS, BGP), route manipulations, and HA routing features; SPADVROUTE covers advanced routing topics in BGP, multicast services including PIM-SM, and IPv6; SPCORE covers network services, including MPLS-LDP, MPLS traffic engineering, QoS mechanisms, and transport technologies; SPEDGE covers network services, including MPLS Layer 3 VPNs, Layer 2 VPNs, and Carrier Ethernet services; all within SP IP NGN environments.	CCNP Service Provider®
Building Cisco Service Provider Next-Generation Networks, Part 1&2 (SPNGN1), (SPNGN2)	The two courses introduce networking technologies and solutions, including OSI and TCP/IP models, IPv4/v6, switching, routing, transport types, security, network management, and Cisco OS (IOS and IOS XR).	CCNA Service Provider®
Implementing Cisco Service Provider Mobility UMTS Networks (SPUMTS); Implementing Cisco Service Provider Mobility CDMA Networks (SPCDMA); Implementing Cisco Service Provider Mobility LTE Networks (SPLTE)	The three courses (SPUMTS, SPCDMA, SPLTE) cover knowledge and skills required to understand products, technologies, and architectures that are found in Universal Mobile Telecommunications Systems (UMTS) and Code Division Multiple Access (CDMA) packet core networks, plus their migration to Long-Term Evolution (LTE) Evolved Packet Systems (EPS), including Evolved Packet Core (EPC) and Radio Access Networks (RANs).	Cisco Service Provider Mobility CDMA to LTE Specialist; Cisco Service Provider Mobility UMTS to LTE Specialist
Implementing and Maintaining Cisco Technologies Using IOS XR (IMTXR)	Service Provider/Enterprise engineers to implement, verification-test, and optimize core/edge technologies in a Cisco IOS XR environment.	Cisco IOS XR Specialist

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Internet of Things (IoT) Cisco education offerings

Course	Description	Cisco Certification
Managing Industrial Networks for Manufacturing (IMINS2)	An associate level instructor led lab based training focuses on common industrial application protocols, security, wireless and troubleshooting designed to prepare you for the CCNA Industrial certification	CCNA® Industrial
Managing Industrial Networks with Cisco Networking Technologies (IMINS)	This instructor led lab based training addresses foundational skills needed to manage and administer networked industrial control systems for today's connected plants and enterprises. It helps prepare plant administrators, control system engineers and traditional network engineers for the Cisco Industrial Networking Specialist certification.	Cisco Industrial Networking Specialist
Control Systems Fundamentals for Industrial Networking (ICINS)	For IT and Network Engineers, provides an introduction to industry IoT verticals, automation environment and an overview of industrial control networks (E-Learning)	Pre-learning for IMINS, IMINS2 training & certifications
Networking Fundamentals for Industrial Control Systems (INICS)	For Industrial Engineers and Control System Technicians, covers basic IP and networking concepts, and introductory overview of Automation industry Protocols.	Pre-learning for IMINS, IMINS2 training & certifications

For more details, please visit: http://learningnetwork.cisco.com
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Data and Analytics Cisco education offerings

Course	Description
ANDMB – Data Management, Architecture and Applications	Provides hands on training with a technical mix of application, compute, storage and networking topics concerning the deployment of Big Data clusters.
ANDMA – Advanced Data Management, Architecture and Applications	Covers major architecture design to cater to different needs of the application, data center or deployment requirements. It provides architectural designs and advanced hands-on training on topics covering Scaling of cluster to thousands of nodes and management, Data Life Cycle management with HDFS tiered storage, and different approaches for Multi-tenant Hadoop cluster deployments with Openstack

Data and Analytics training page: http://www.cisco.com/c/en/us/training-events/resources/learning-services/technology/data-analytics.html
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Digital Business Transformation Cisco education offerings

Course	Description	Cisco Certification
For Technology Sellers:		
Adopting the Cisco Business Architecture Approach	Builds skills to discover and address technology needs using a business-focused, consultative sales approach, broadly applicable and targeted to prepare for the digital transformation journey that is demanded across the business world.	Cisco Business Architecture Analyst
Applying Cisco Business Architecture Techniques	Provides tools and skills training to prepare the learner to use a business led approach to technology solutions sales and deployments. This continues the journey begun with the Adopting the Cisco Business Architecture Approach above	Cisco Business Architecture Specialist
Mastering the Cisco Business Architecture Discipline	Builds skills, and proven, real-world techniques to prepare for a Business architect leadership role in the sales and deployment of transformative technology solutions.	Cisco Business Architecture Practitioner
Cisco Customer Success Manager Specialist	Prepares for the crucial role that drives adoption and enablement, ensuring that customers achieve their expected business outcomes, and reduces churn/increases renewal for services and subscription based products.	Cisco Certified Customer Success Manager

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