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BRKRST-3320

Troubleshooting BGP

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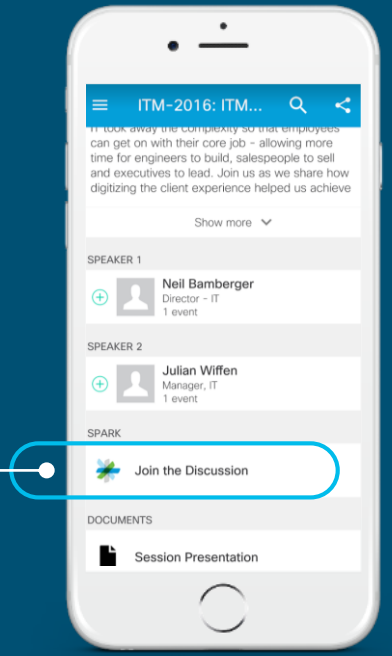

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Agenda

- Introduction
- Generic Troubleshooting Methodology
- BGP Peering Issues
- Best Path calculation, Convergence
- Missing Routes, Unexpected Routes, Filtering and Stale Routes
- Troubleshooting with BGP Table Version , Route Churn
- Troubleshooting with NX-OS
- BGP and Automation
- Conclusion

Generic Troubleshooting Methodology (Techniques)

Generic Troubleshooting Advice

Few Basic Things

- Define the problem
- Narrow down the problem
  - Can you reproduce it?
  - Which device(s) are the cause of the problem?
  - Verify relevant configuration pieces
- Troubleshoot one thing at a time
  - 20k routes flapping? Pick one route and focus on that one route
- Have a co-worker take a look
  - Forces you to talk through the problem
  - Different set of eyes may spot something
- Packet capture tools
  - Platform based / SPAN

Generic Troubleshooting Advice

NTP, Syslog, Tacacs

- Use NTP to sync timestamps on your routers
  - `clock timezone EST -5 0`
  - `clock summer-time EDT recurring`
  - `ntp server x.x.x.x`
- Use a Syslog Server
  - `logging buffered {informational | debugging}`
  - `logging host x.x.x.x`
  - `service timestamps log datetime msec localtime`
- Tacacs Logs
  - `Viewing Commands executed during / before the problem`
  - `Use show accounting logs (on NX-OS)`

Generic Troubleshooting Advice

Define the baseline…

- "The CPU on this router is high"
  - High compared to what?
  - What is the CPU load normally at this time of day?
- Things to keep track of
  - CPU load
  - Free Memory
  - Largest block of memory
  - Input/Output load for interfaces
  - Rate of BGP bestpath changes
  - Etc., etc.

Generic Troubleshooting Advice

Packet Capture Tools

- IOS / IOS XE
  - ✓ Embedded Packet Capture
- 6500 / 7600
  - ✓ ELAM
  - ✓ NETDR Capture
  - ✓ MPA (Mini Protocol Analyzer)
- ASR9000
  - ✓ Network Processor Capture
- Nexus (9k, 7k, 5k, 3k)
  - ✓ Ethanalyzer
  - ✓ Elam

Generic Troubleshooting Advice

Sniffer Captures – Last Resort

- Use SPAN to get traffic to your sniffer
  - monitor session 1 source interface Te2/4 rx
  - monitor session 1 destination interface Te2/2
- IOS-XR
  - Only supported on ASR-9000
  - Use ACLs to control what packets to SPAN
- RSPAN
  - *"RSPAN has all the features of SPAN, plus support for source ports and destination ports that are distributed across multiple switches, allowing one to monitor any destination port located on the RSPAN VLAN. Hence, one can monitor the traffic on one switch using a device on another switch."*

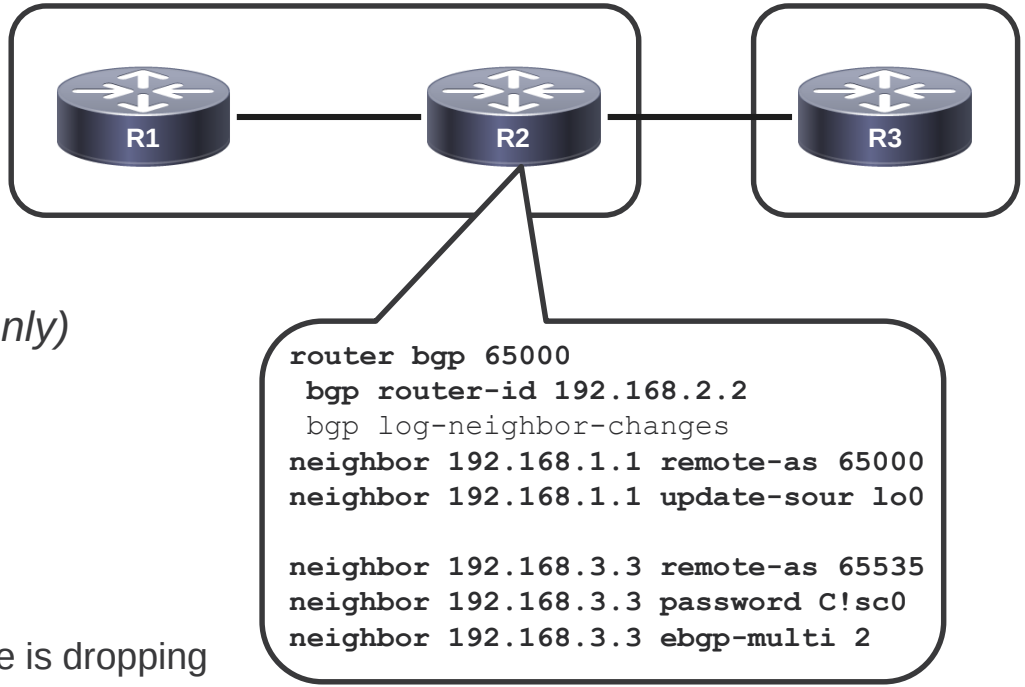
Troubleshooting BGP Peering Issues, Session Flaps

BGP Peering Issues

Preliminary checks

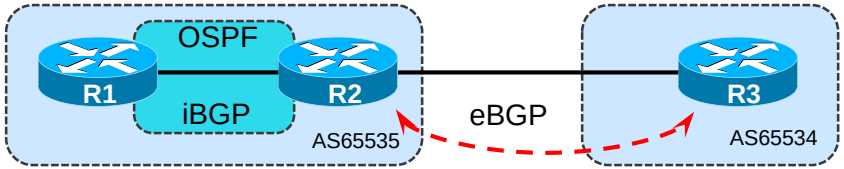
- Verify Configuration
  - ✓ Peering IP Address
  - ✓ AS Number
  - ✓ MD5 Authentication (Optional)
  - ✓ **ebgp-multihop** *hop-count (eBGP only)*

- Verify Reachability
  - ✓ **ping** *remote-ip* **source** *source-ip*
  - If reachability issues found:
    - ✓ Use **traceroute** to verify where the trace is dropping



BGP Peering Issues

ebgp-multihop and disable-connected-check

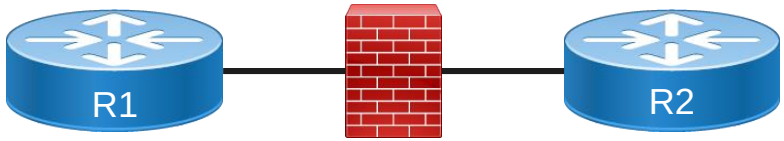


- BGP uses a TTL of 1 for eBGP peers
  - Also verifies if NEXTHOP is directly connected
- For eBGP peers that are more than 1 hop away a larger TTL must be used
  - No longer verifies if NEXTHOP is directly connected
- Use **`neighbor disable-connected-check`**
- Disables the “is the NEXTHOP on a connected subnet” check

```
router bgp 65534
 neighbor 192.168.3.3 remote-as 65535
 neighbor 192.168.3.3 disable-connected-check
```

BGP Peering Issues

Blocking ACLs



- Verify any Firewall / ACLs in the path for TCP port 179

```
R1#telnet 2.2.2.2 179 /source-interface loopback 0
Trying 2.2.2.2 ...
% Destination unreachable; gateway or host down
```

- Ensure BGP Pass-Through configured
  - ASA / PIX offsets TCP sequence number with a random number for every TCP session
    - Causes MD5 authentication to fail
    - ASA strips off TCP option 19

1. Create ACL to permit BGP traffic
2. Create TCP Map to allow TCP option 19
3. Create class-map to match BGP traffic
4. Disable sequence number randomization and Enable TCP option 19 in global policy

BGP Peering Issues

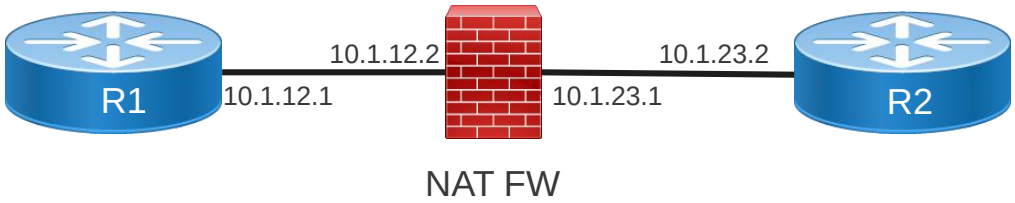
BGP Pass-Through – ASA FW Configuration

```
access-list OUT extended permit tcp host 10.1.12.1 host 10.1.12.2 eq bgp
access-list OUT extended permit tcp host 10.1.12.2 eq bgp host 10.1.12.2
!
access-list BGP-TRAFFIC extended permit tcp host 10.1.110.2 host 10.1.110.10 eq bgp
access-list BGP-TRAFFIC extended permit tcp host 10.1.110.2 eq bgp host 10.1.110.10
!
tcp-map TCP-OPTION-19
tcp-options range 19 19 allow
!
access-group OUT in interface Outside
!
class-map BGP_TRAFFIC
match access-list BGP-TRAFFIC
!
policy-map global_policy
  class BGP_TRAFFIC
    set connection random-sequence-number disable
    set connection advanced-options TCP-OPTION-19
```

BGP Peering Issues

BGP Across NAT

- NAT Translation – 10.1.12.1 translated to 10.1.23.3
- BGP Peering between R1 and R2
- What will be the neighbor IP configured-
  - On R1?
  - On R2?

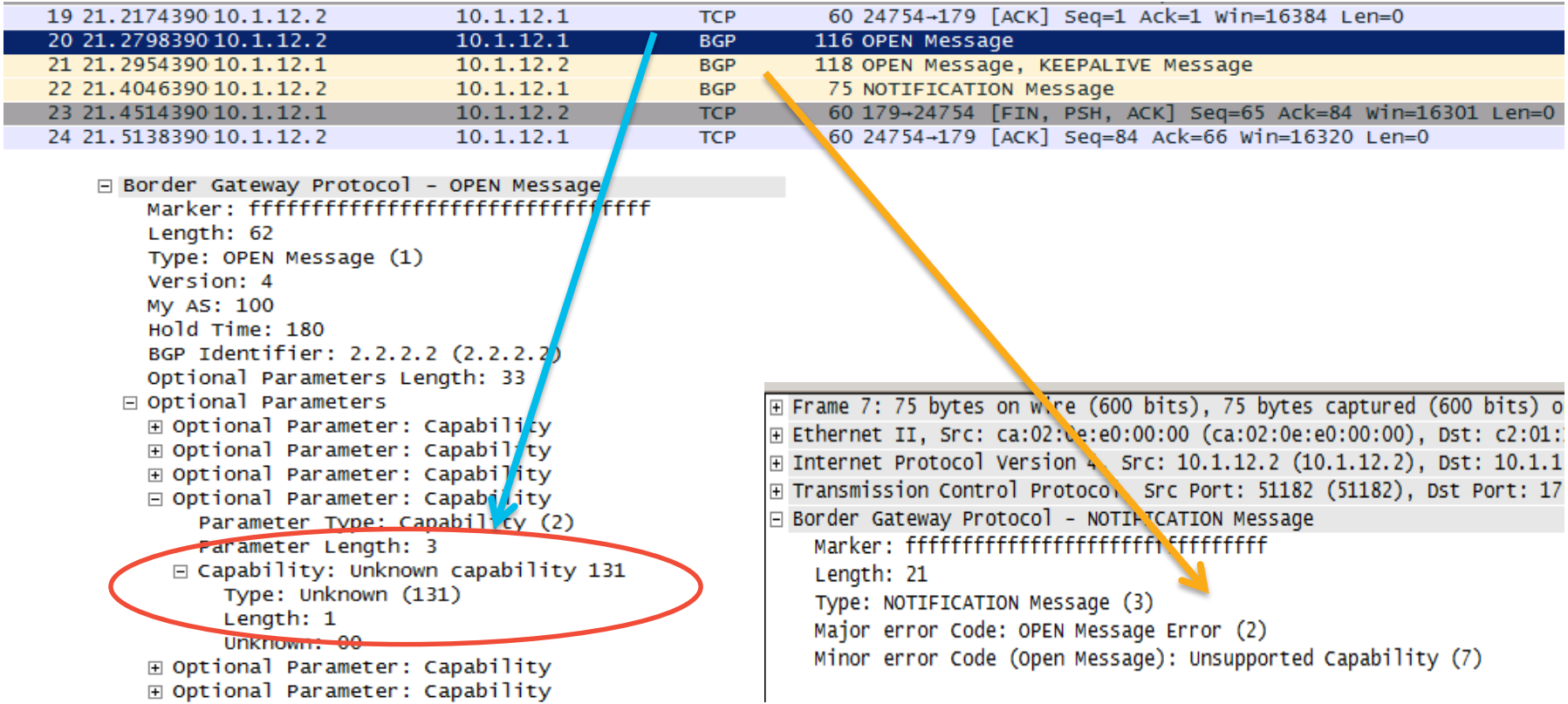


BGP Peering Issues

Notifications

```
R2#
*Mar 24 20:25:47.262: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Down BGP
Notification sent
*Mar 24 20:25:47.262: %BGP-3-NOTIFICATION: sent to neighbor 1.1.1.1 4/0
(hold time expired) 0 bytes
```

- BGP NOTIFICATIONs consist of an error code, sub-code and data
  - All Error Codes and Sub-codes can be found here
    - http://www.iana.org/assignments/bgp-parameters/bgp-parameters.xml
    - http://tinyurl.com/bgp-notification-codes
  - Data portion may contain what triggered the notification
    - Example: corrupt part of the UPDATE



Notifications Contd…

```
%BGP-3-NOTIFICATION: sent to neighbor 2.2.2.2 2/2 (peer in wrong AS) 2 bytes 00C8
FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF 002D 0104 00C8 00B4 0202 0202 1002 0601 0400
0100 0102 0280 0002 0202 00
```

Value	Name	Reference
1	Message Header Error	RFC 4271
2	OPEN Message Error	RFC 4271
3	UPDATE Message Error	RFC 4271
4	Hold Timer Expired	RFC 4271
5	Finite State Machine Error	RFC 4271
6	Cease	RFC 4271

The first 2 in “2/2” is the Error Code….so “OPEN Message Error”

Notifications Contd…

Subcode #	Subcode Name	Subcode Description
1	Unsupported BGP version	The version of BGP the peer is running isn't compatible with the local version of BGP
2	Bad Peer AS	The AS this peer is locally configured for doesn't match the AS the peer is advertising
3	Bad BGP Identifier	The BGP router ID is the same as the local BGP router ID
4	Unsupported Optional Parameter	There is an option in the packet which the local BGP speaker doesn't recognize
6	Unacceptable Hold Time	The remote BGP peer has requested a BGP hold time which is not allowed (too low)
7	Unsupported Capability	The peer has asked for support for a feature which the local router does not support

OPEN Message Subcodes shown above
The second 2 in "2/2" is the Error Subcode….so "Bad Peer AS"

BGP Peering Issues

Problem with TCP Process (show tcp brief)

PCB	Recv-Q	Send-Q	Local Address	Foreign Address	State
0x48277ea4	**0**	**0**	**:::179**	**:::0**	**LISTEN**
0x48276c50	0	0	0.0.0.0:23	0.0.0.0:0	LISTEN
0x48290da8	0	0	12.26.28.152:23	223.255.254.249:48877	ESTAB
0x4827755c	**0**	**0**	**0.0.0.0:179**	**0.0.0.0:0**	**LISTEN**

- PCB is the internal identifier used by TCP. It can be used as input to other show commands.
- Recv-Q shows how much received data is waiting to be “read” from TCP by application.
- Send-Q shows how much application data is waiting to be “sent” by TCP.
- Local-address and foreign address identify the two end points of the connection.
- State identifies the current state of the connection.

BGP Peering Issues

Most Common TCP States

- LISTEN
  - A listen socket on which incoming connections will be accepted.
- ESTAB
  - An established connection
- CLOSED
  - Socket not fully programmed – most often seen on standby RP by applications that are warm or hot standby.

Connections that are getting established:

- SYNSENT
  - A SYN message was sent to peer.
- SYNRCVD
  - A SYN message was received from peer – socket will move into ESTAB state.

Connections that are getting terminated:

- CLOSEWAIT, CLOSING, LASTACK, TIMEWAIT, FINWAIT1, FINWAIT2

BGP Peering Issues

Detailed info about a TCP Socket

```
XR# show tcp detail pcb 0x48277a58

  Connection state is ESTAB, I/O status: 0, socket status: 0
  PCB 0x48277a58, vrfid 0x60000000, Pak Prio: Unspecified, TOS: 16, TTL: 255
  Local host: 12.26.28.152, Local port: 179 (Local App PID: 180393)
  Foreign host: 223.255.254.249, Foreign port: 49017
  Current send queue size in bytes: 0 (max 16384)
  Current receive queue size in bytes: 0 (max 16384)  mis-ordered: 0 bytes
  Current receive queue size in packets: 0 (max 50)
```

- **Pak Prio**: Did the application mark the packet with correct priority? Determines the queuing within the router before it goes out on the wire.
- **TOS**: Type of service, goes out on the wire.
- **TTL**: Important for eBGP for the TTL security check
- **Mis-ordered**: How much of the received data is out-of-order?
- **Receive queue in packets**: how many packets are sitting in receive buffers?

BGP Peering Issues

Malformed Update

- What if a peer sends you a message that causes us to send a NOTIFICATION?
  - Corrupt UPDATE
  - Bad OPEN message, etc.
- View the message that triggered the NOTIFICATION

```
show ip bgp neighbor 1.1.1.1 | begin Last reset

  Last reset 5d12h, due to BGP Notification sent, invalid or corrupt AS path
  Message received that caused BGP to send a Notification:
  FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFF
  005C0200 00004140 01010040 0206065D
  1CFC059F 400304D5 8C20F480 04040000
  05054005 04000000 55C0081C 329C4844
  329C6E28 329C6E29 58F50082 58F5EACE
  58F5FA02 58F5FA6E 18D14E70
```

http://bgpaste.convergence.cx/

BGP Peering Issues

Unsupported Capability

```
*Jan  5 18:18:04.667: %BGP-3-NOTIFICATION: sent to neighbor
10.1.12.1 active 2/7 (unsupported/disjoint capability) 0 bytes

R2#

*Jan  5 18:18:04.671: %BGP-4-MSGDUMP: unsupported or mal-
formatted message received from 10.1.12.1:

FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF 002D 0104 0064 00B4
0101 0101 1002 0601 0400 0100 0102 0280 0002 0202 00
```

- Disable capability negotiation during session establishment process using the below hidden command

`neighbor x.x.x.x dont-capability-negotiate`

Peering Issues

Stable BGP peers going into Idle State

- BGP Peering has been up for months, but all of a sudden, BGP session goes down and never comes back up
- IGP goes down as well? Yes
- Debug shows keepalives are getting generated
- Check for the Interface Queue on both sides
  - Interface Queue (both input and output queue) getting wedge can cause this symptom
    - Temporary workarounds – Increase the Queue size, RP Switchover
    - If its input queue wedge, check the **`show buffer input-interface`** *`x/y`* **`packet`** to analyze what packets are stuck in queue. Also checking for incoming traffic rate
    - If its output queue, check for outgoing traffic rate. Check the transmission side

```
R2#show interface gi0/1 | in queue
 Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Output queue: 1001/1000 (size/max)
```

BGP Peering Issues

Notifications – Hold Time Expired


```
%BGP-5-ADJCHANGE: neighbor 2.2.2.2 Down BGP Notification sent
%BGP-3-NOTIFICATION: sent to neighbor 2.2.2.2 4/0 (hold time expired)

R1#show ip bgp neighbor 2.2.2.2 | include last reset
Last reset 00:01:02, due to BGP Notification sent, hold time expired
```

- R1 sends hold time expired NOTIFICATION to R2
  - R1 did not receive a KA from R2 for *holdtime* seconds
- One of two issues
  - R2 is not generating keepalives
  - R2 is generating keepalives but R1 is not receiving them

BGP Peering Issues

Notifications - Hold Time Expired

- Check if R2 is building keepalives (KA)
  - Check for output drops on R2 outgoing interface
  - When did R2 last build a BGP message for R1. (Should be within “keepalive interval” seconds

```
R2#show ip bgp neighbors 1.1.1.1
   Last read 00:00:15, last write 00:00:44, hold time is 180,
     keepalive interval is 60 seconds
```

- R2 is building messages for R1 but possibly R2 is unable to send them
  - Check OutQ and MsgSent Counters – **`show bgp afi safi summary`**
  - OutQ is the number of packets waiting for TCP to Tx to a peer
  - MsgSent is the number of packets TCP has removed from OutQ and transmitted for a peer

BGP Peering Issues

Notifications – Hold Time Expired

```
R2#show ip bgp sum | begin Neighbor
Neighbor …  MsgRcvd MsgSent    TblVer  InQ OutQ  Up/Down  State/PfxRcd
1.1.1.1  …       53      284    10167    0   97 00:01:20        0
```

The number of packets transmitted is not increasing ☹

The number of packets generated is increasing

At least one BGP keepalive interval apart

```
R2#show ip bgp sum | begin Neighbor
Neighbor …  MsgRcvd MsgSent    TblVer  InQ OutQ  Up/Down  State/PfxRcd
1.1.1.1  …       53      284    10167    0   98 00:02:24        0
```

OutQ is incrementing due to keepalive generation
MsgSent is not incrementing
Something is “stuck” on the OutQ
The keepalives are not leaving R2!!

Randomly Flapping Peers

Flapping continuously but not at regular intervals…

- What if the BGP peer is flapping continuously, but not at regular intervals.
  - Sometimes it flaps every 2 minutes and sometimes it flaps after 5 minutes

```
R2#show ip bgp sum | begin Neighbor
Neighbor    …   MsgRcvd MsgSent    TblVer  InQ OutQ  Up/Down    State/PfxRcd
10.1.13.3   …       160     284     10167    0    0    00:01:20          10
```

```
R2#show ip bgp sum | begin Neighbor
Neighbor    …   MsgRcvd MsgSent    TblVer  InQ OutQ  Up/Down    State/PfxRcd
10.1.13.3   …       165     296     10167    0    0    00:00:39          10
```

  - Most probable cause could be keepalives are not getting generated in timely manner
  - Or, they are not being forwarded out in a timely manner

Randomly Flapping Peers

ASR1k – EPC Capture and Debugs

```
ASR1k(config)#ip access-list extended MYACL
ASR1k(config-acl)#permit tcp host 10.1.13.1 eq bgp host 10.1.13.3
ASR1k(config-acl)#permit tcp host 10.1.13.1 host 10.1.13.3 eq bgp
ASR1k#monitor capture CAP1 buffer circular packets 1000
ASR1k#monitor capture CAP1 buffer size 10
ASR1k#monitor capture CAP1 interface GigabitEthernet0/0/0 in
ASR1k#monitor capture CAP1 access-list MYACL
ASR1k#monitor capture CAP1 start
ASR1k#monitor capture CAP1 stop
ASR1k#monitor capture CAP1 export bootflash:cap1.pcap
```

```
ASR1k#debug ip bgp keepalives
```

Randomly Flapping Peers

ASR1k – EPC Capture

```
ASR1k#show monitor capture buffer CAP1 dump
16:25:44.938 JST Aug 21 2015 : IPv4 LES CEF    : Gig0/0 None

F19495B0:                     AABBCC00 0800AABB          *;L...*;
F19495C0: CC000700 08004540 003B1C5D 4000FE06  L.....E@.;.]@.~.
F19495D0: 42020707 07070808 08084A07 00B39372  B.........J..3.r
F19495E0: FFE37CDC E3D35018 3D671161 0000FFFF  .c|\cSP.=g.a....
F19495F0: FFFFFFFF FFFFFFFF FFFFFFFF FD        ............}
```

Flapping BGP Peers

Regular Interval Flaps

```
*Jun 22 15:16:23.033: %BGP-3-NOTIFICATION: received from neighbor
192.168.2.2 4/0 (hold time expired) 0 bytes
```

```
*Jun 22 15:16:23.033: %BGP-5-ADJCHANGE: neighbor 192.168.2.2 Down
BGP Notification received
```

```
*Jun 22 15:16:55.621: %BGP-5-ADJCHANGE: neighbor 192.168.2.2 Up
```

```
*Jun 22 15:19:56.409: %BGP-3-NOTIFICATION: received from neighbor
192.168.2.2 4/0 (hold time expired) 0 bytes
```

```
*Jun 22 15:19:56.409: %BGP-5-ADJCHANGE: neighbor 192.168.2.2 Down
BGP Notification received
```

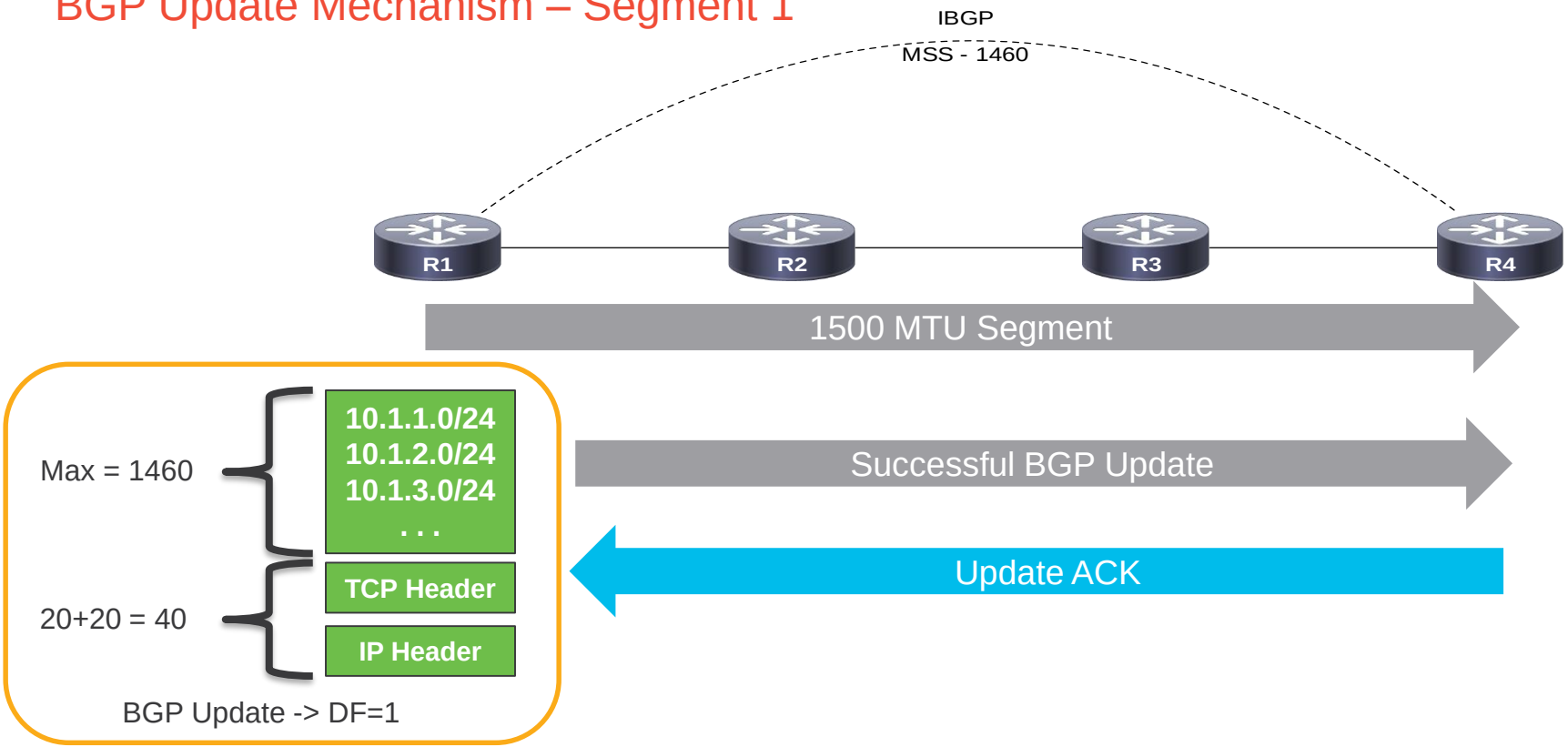
```
*Jun 22 15:20:13.361: %BGP-5-ADJCHANGE: neighbor 192.168.2.2 Up
```

Flapping BGP Peers

BGP Update Mechanism – Segment 1

MSS Calculation

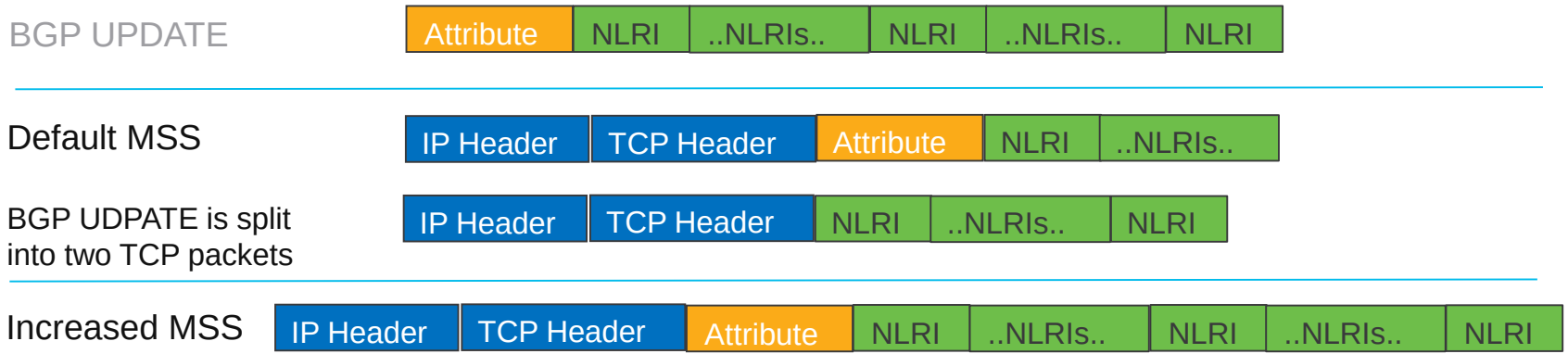
MSS = MTU – IP Header (20) – TCP header (20)



BGP Update

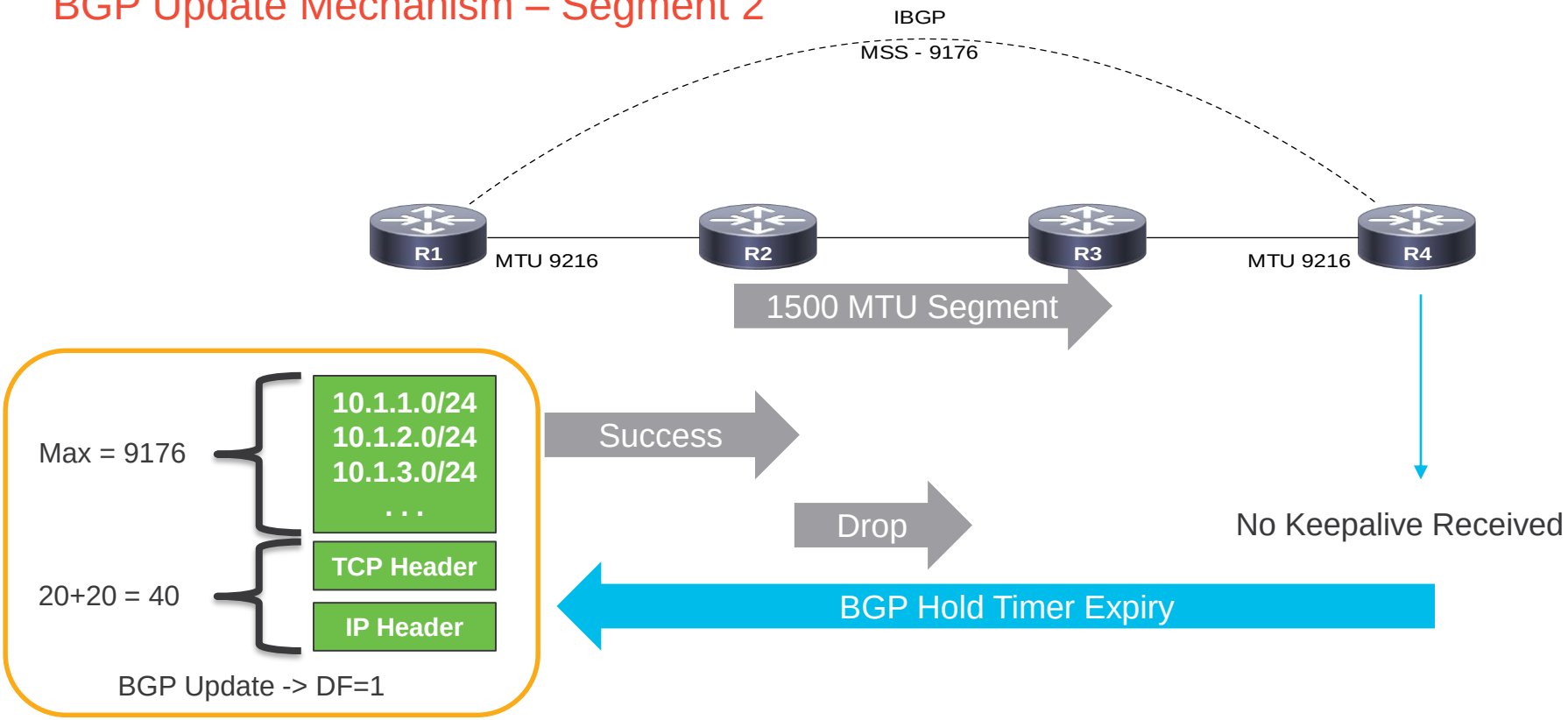
Role of TCP MSS

TCP MSS (max segment size) is also a factor in convergence times. The larger the MSS the fewer TCP packets it takes to transport the BGP updates. Fewer packets means less overhead and faster convergence.



Flapping BGP Peers

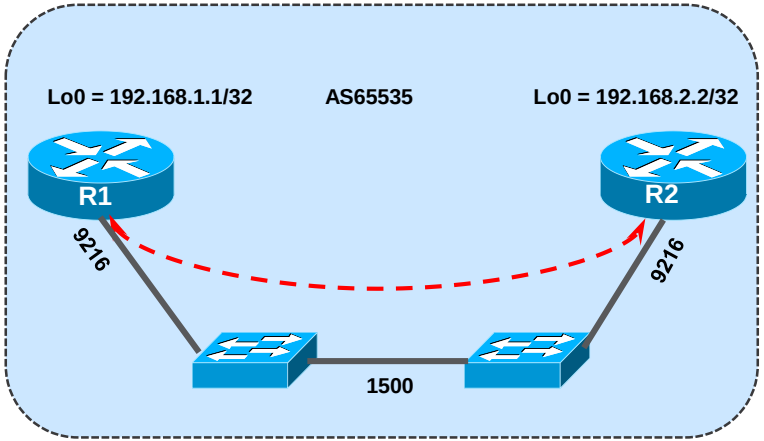
BGP Update Mechanism – Segment 2



Flapping BGP Peers

Path MTU Discovery

- R1 sends a packet with packet size of outgoing interface MTU and DF-bit set
- Intermittent device who has lower MTU has two options
  - Fragment and send the packets (if DF-bit not set)
  - Drop the packet and send ICMP error message Type 3 Code 4
- ICMP error message also have the MTU details in the Next-Hop MTU field
- Source on receiving the message, sends the packet with mentioned MTU.



Type 3 – Destination Unreachable
Code 4 – Fragmentation needed and DF-bit set

Flapping BGP Peers

Notifications – Hold Time Expired

- MSS ping
  - BGP OPENs and Keepalives are small
  - UPDATEs can be much larger
  - Maybe small packets work but larger packets do not?

```
R1#ping 192.168.2.2 source loop0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/21/24 ms

R1#ping 192.168.2.2 source loop0 size 1500 df-bit

Type escape sequence to abort.
Sending 5, 1500-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
Packet sent with the DF bit set
. . . . .
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

BGP BestPath and BGP Convergence

BGP Best Path

Path Selection Algorithm

- Quick bestpath review
- Remember
  - BGP only advertises one path per prefix…the bestpath
  - Cannot advertise path from one iBGP peer to another
- Bestpath selection process is a little lengthy
  - First eliminate paths that are ineligible for bestpath

1	Not synchronized	Only happens if “sync” is configured AND the route isn’t in your IGP
2	Inaccessible NEXTHOP	IGP does not have a route to the BGP NEXTHOP
3	Received-only paths	Happens if “soft-reconfig inbound” is applied. A path will be received-only if it was denied/modified by inbound policy.

BGP Best Path

Inaccessible Next-Hop

- If a BGP route does not have a valid next hop, then it will not be installed in the RIB
- Use **`show bgp`** *`afi safi <prefix>`* to verify the prefix and the NH

```
BGP routing table entry for 192.168.1.0/24
  Versions:
    Process              bRIB/RIB  SendTblVer
    Speaker                  2929        2929
  Paths: (1 available, no best path)
    Not advertised to any peer
    Received by speaker 0
    Local
      10.0.200.1 (inaccessible) from 10.0.101.2 (10.0.101.2)
        Origin IGP, localpref 100, valid, confed-internal
```

BGP Best Path

Path Selection Algorithm

1	Weight	Highest wins	Scope is router only
2	LOCAL_PREFERENCE	Highest wins	Scope is AS only
3	Locally Originated		Redistribution or network statement favored over aggregate-address
4	AS_PATH	Shortest wins	Skipped if “bgp bestpath as-path ignore” configured AS_SET counts as 1 CONFED parts do not count
5	ORIGIN	Lowest wins	IGP < EGP < Incomplete
6	MED	Lowest wins	MEDs are compared only if the first AS in the AS_SEQUENCE is the same
7	eBGP over iBGP		
8	Metric to Next Hop	Lowest wins	IGP cost to the BGP NEXTHOP
9	Multiple Paths in RIB		Flag path as “multipath” is max-paths is configured
10	Oldest External Wins		Unless BGP best path compare router-id configured
11	BGP Router ID	Lowest	
12	CLUSTER_LIST	Smallest	Shorter CLUSTER_LIST wins
13	Neighbor Address	Lowest	Lowest neighbor address

BGP Best Path

Viewing Best Path

```
R1#show bgp ipv4 unicast 192.168.200.200/32
BGP routing table entry for 192.168.200.200/32, version 2
Paths: (2 available, best #2, table default)
Advertised to update-groups:
     1
Refresh Epoch 1  200, (Received from a RR-client)
    192.168.3.3 (metric 2) from 192.168.3.3 (192.168.3.3)
      Origin IGP, metric 0, localpref 100, valid, internal,
      rx pathid: 0, tx pathid: 0
  Refresh Epoch 1
  200, (Received from a RR-client)
    192.168.2.2 (metric 2) from 192.168.2.2 (192.168.2.2)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      rx pathid: 0, tx pathid: 0x0
```

show bgp ipv4 unicast 192.168.200.200/32 bestpath

BGP Best Path

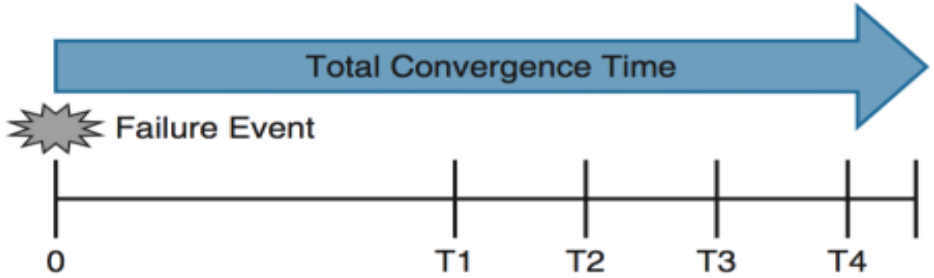
Viewing Best Path

```
IOS-XR-1#show bgp ipv4 unicast 192.168.200.200/32 bestpath-compare
BGP routing table entry for 192.168.200.200/32, version 2
. . .
 Path #1: Received by speaker 0
 200, (Received from a RR-client)
    192.168.2.2 (metric 2) from 192.168.2.2 (192.168.2.2)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 5
      best of AS 200, Overall best
  Path #2: Received by speaker 0
 200, (Received from a RR-client)
    192.168.3.3 (metric 2) from 192.168.3.3 (192.168.3.3)
      Origin IGP, metric 0, localpref 100, valid, internal
      Received Path ID 0, Local Path ID 0, version 0
      Higher router ID than best path (path #1)
```

Convergence

Symptoms

- BGP Table is getting updated slowly
- Traffic loss (Traffic Black-Hole) is experienced
- High CPU



- Two general convergence situations
  - Initial startup
  - Periodic route changes

Convergence

Initial Startup

- Initial convergence happens when:
  - A router boots
  - RP failover
  - clear ip bgp *
- How long initial convergence takes is a factor of the amount of work to be done and the router/network's ability to do this fast and efficiently

Convergence

Initial Startup

Initial convergence can be stressful…if you are approaching BGP scalability limits this is when you will see issues.

Convergence

Initial Startup

What work needs to be done?

1) Accept routes from all peers
   - Not too difficult
2) Calculate bestpaths
   - This is easy
3) Install bestpaths in the RIB
   - Also fairly easy
4) Advertise bestpaths to all peers
   - This can be difficult and may take several minutes depending on the following variables…

Convergence

Dimensional Factors

- Number of peers
- Number of address-families
- Number of path/prefix per address-family
- Link speed of individual interface, individual peer
- Different update group settings and topology
- Complexity of attribute creation / parsing for each address-family

Convergence

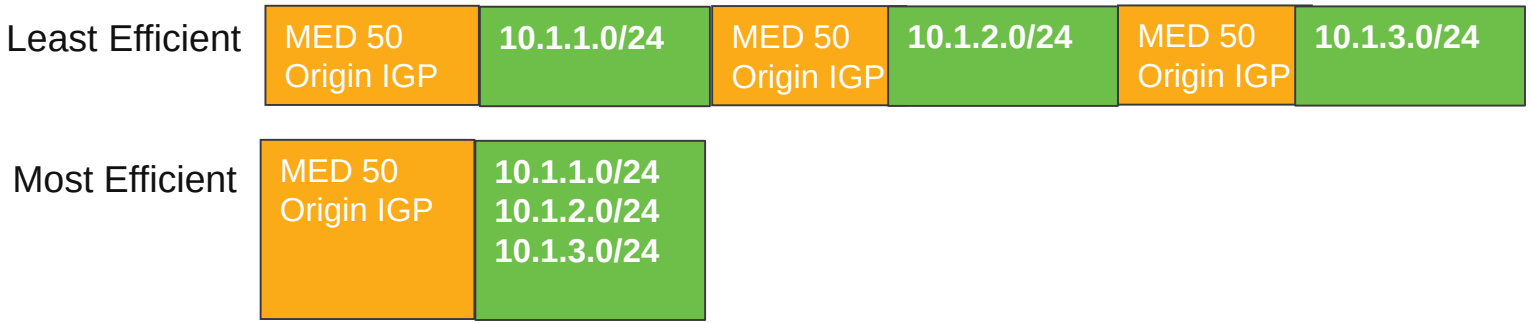
UPDATE Packing

- An UPDATE contains a set of Attributes and a list of prefixes (NLRI)
  - BGP starts an UPDATE by building an attribute set
  - BGP then packs as many destinations (NLRIs) as it can into the UPDATE

    NLRI = Network Layer Reachability Information

    Only NLRI with a matching attribute set can be placed in the UPDATE

    NLRI are added to the UPDATE until it is full (4096 bytes max)



Convergence

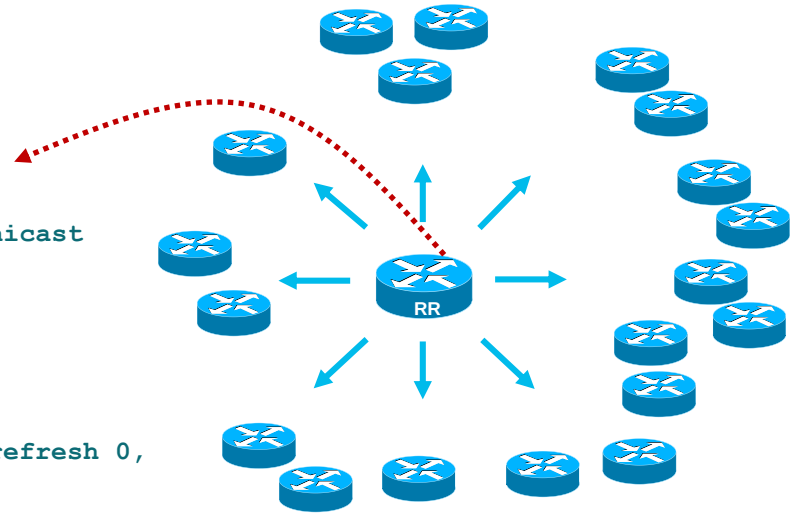
UPDATE Packing

- The fewer attribute sets you have the better
  - More NLRI will share an attribute set
  - Fewer UPDATEs to converge
- Things you can do to reduce attribute sets
  - next-hop-self for all iBGP sessions
  - Don’t accept/send communities you don’t need
  - Use cluster-id to put RRs in the same POP in a cluster
- To see how many attribute sets you have

```
show ip bgp summary
190844 network entries using 21565372 bytes of memory
302705 path entries using 15740660 bytes of memory
57469/31045 BGP path/bestpath attribute entries using 6206652 bytes of memory
```

Update Group on RR

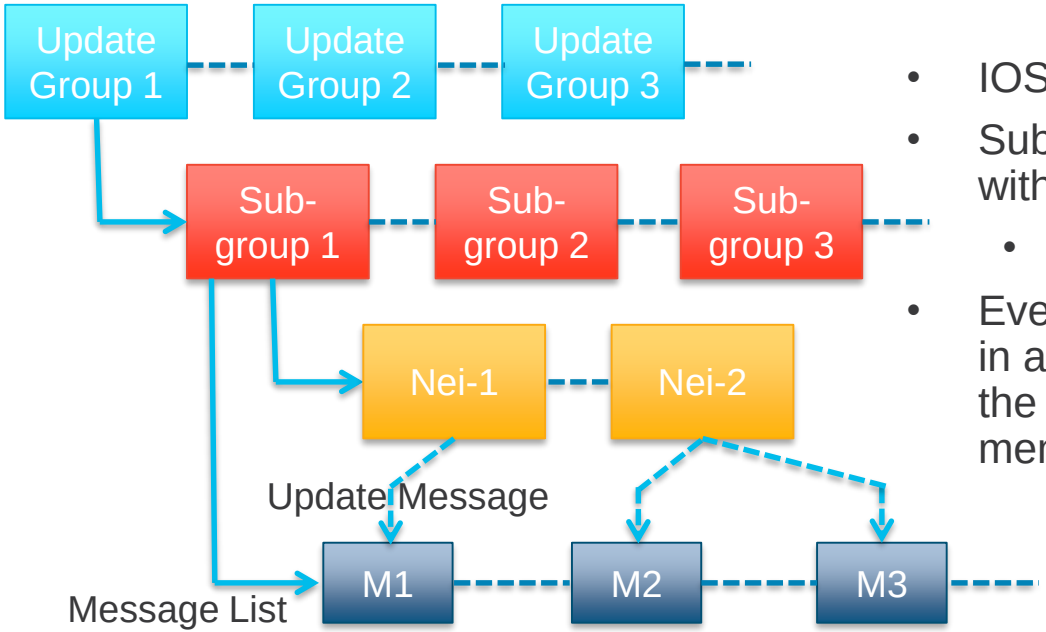
- Update groups are very usefull on all BGP speakers
  - but mostly on RR due to
    - Number of peers
    - Same outbound policy
      - IBGP peers typically do not have any outbound policies




```
RR#show bgp ipv4 unicast update-group 10
BGP version 4 update-group 2, internal, Address Family: IPv4 Unicast
  BGP Update version : 300/0, messages 0
  Route-Reflector Client
  Topology: global, highest version: 300, tail marker: 300
  Format state: Current working (OK, last not in list)
                Refresh blocked (not in list, last not in list)
  Update messages formatted 239, replicated 24210, current 0, refresh 0,
                                    limit 2000

  Number of NLRIs in the update sent: max 812, min 0
  Minimum time between advertisement runs is 0 seconds
  Has 101 members:
   10.1.1.2       10.2.1.1       10.2.1.10      10.2.1.100
   10.2.1.11      10.2.1.12      10.2.1.13      10.2.1.14
   ...
```

Troubleshooting BGP Convergence

Update Groups on IOS XR

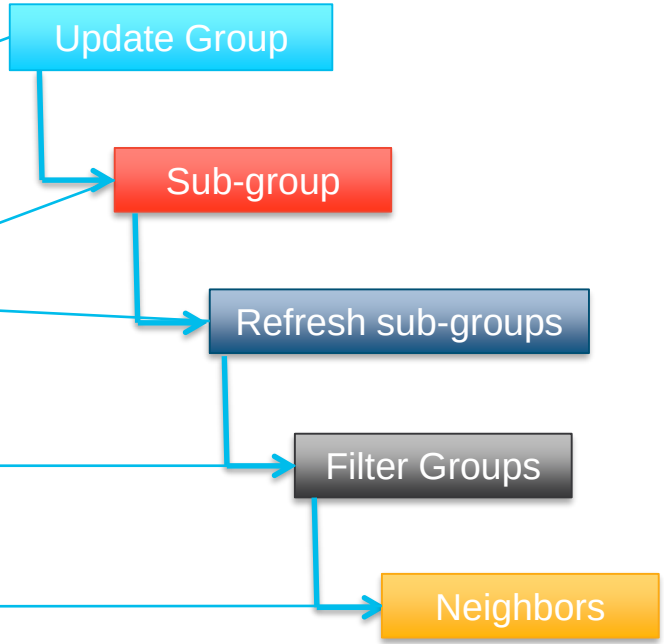


- IOS XR have hierarchical update groups
- Sub-Groups are subset of neighbors within an update Group
  - Neighbors running at same pace
- Even a newly configured neighbor is put in a separate sub-group till it reaches the same table version as other members

Troubleshooting BGP Convergence

Update Groups on IOS XR

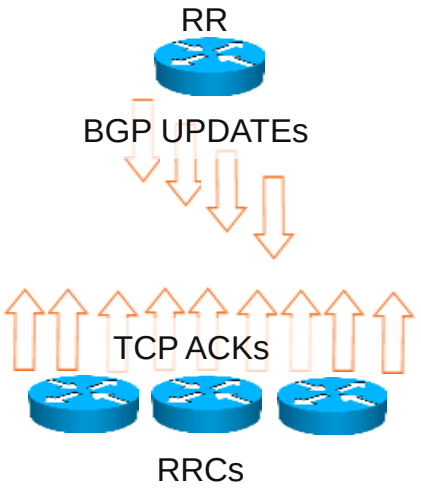
```
RP/0/0/CPU0:R10#show bgp update-group
Update group for IPv4 Unicast, index 0.2:
<snip>
Sub-groups merged: 5
Number of refresh subgroups: 0
Messages formatted: 36, replicated: 68
All neighbors are assigned to sub-group(s)
    Neighbors in sub-group: 0.2, Filter-Groups num:3
    Neighbors in filter-group: 0.3(RT num: 3)
        10.1.100.1
    Neighbors in filter-group: 0.1(RT num: 3)
        10.1.100.2
    Neighbors in filter-group: 0.2(RT num: 3)
        10.1.100.8
```



Convergence

Dropping TCP Acks

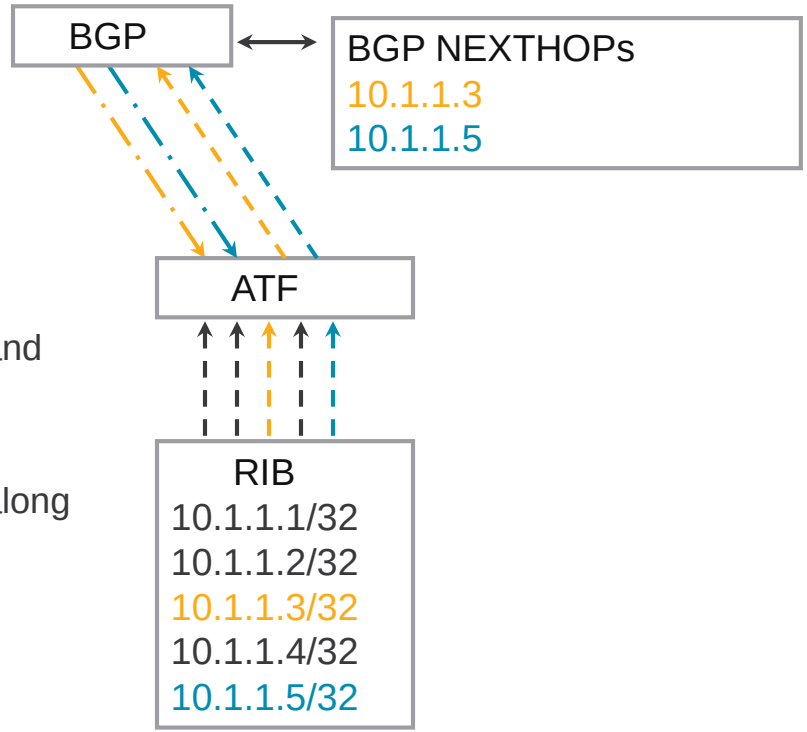
- Primarily an issue on RRs (Route Reflectors) with
  - One or two interfaces connecting to the core
  - Hundreds of RRCs (Route Reflector Clients)
- RR sends out tons of UPDATES to RRCs
- RRCs send TCP ACKs
- RR core facing interface(s) receive huge wave of TCP ACKs



Convergence

Nexthop Tracking – NHT

- BGP nexthop tracking
  - Relies on ATF
  - Event driven convergence model
- Register NEXTHOPs with ATF
  - 10.1.1.3
  - 10.1.1.5
- ATF filters out changes for 10.1.1.1/32, 10.1.1.2/32, and 10.1.1.4/32
  - BGP has not registered for these
- Changes to 10.1.1.3/32 and 10.1.1.5/32 are passed along to BGP
  - Recompute bestpath for prefixes that use these NEXTHOPs
  - No need to wait for BGP Scanner



Convergence

Nexthop Tracking

- Enabled by default
  - `[no] bgp nexthop trigger enable`
- BGP registers all nexthops with ATF
  - `show ip bgp attr next-hop ribfilter`
- Trigger delay is configurable
  - `bgp nexthop trigger delay <0-100>`
  - 5 seconds by default
- Debugs
  - `debug ip bgp events nexthop`
  - `debug ip bgp rib-filter`

Convergence

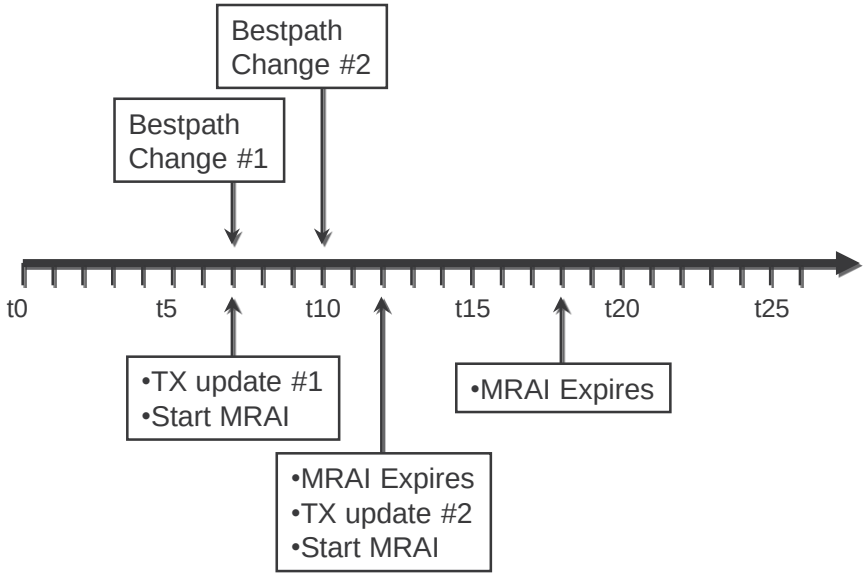
MRAI (Minimum Route Advertisement Interval)

- How is the timer enforced for peer X?
  - Timer starts when all routes have been advertised to X
  - For the next MRAI (seconds) we will not propagate any bestpath changes to peer X
  - Once X's MRAI timer expires, send him updates and withdraws
  - Restart the timer and the process repeats…
- User may see a wave of updates and withdraws to peer X every MRAI seconds
- User will NOT see a delay of MRAI between each individual update and/or withdraw
  - BGP would never converge if this were the case

Convergence

MRAI

- MRAI timeline for BGP peer w/ MRAI of 5 seconds
- T0
  - The big bang ☺
- T7
  - Bestpath Change #1
  - UPDATE sent immediately
  - MRAI timer starts, will expire at T12
- T10
  - Bestpath Change #2
  - Must wait until T12 for MRAI to expire
- T12
  - MRAI expires
  - Bestpath Change #2 is Txed
  - MRAI timer starts, will expire at T17
- T17
  - MRAI expires
  - No pending UPDATEs



Convergence

MRAI

- BGP is not a link state protocol, it is path vector
- May take several “rounds/cycles” of exchanging updates and withdraws for the network to converge
- MRAI must expire between each round!
- The more fully meshed the network and the more tiers of ASes, the more rounds required for convergence
- Think about
  - How many tiers of ASes there are in the Internet
  - How meshy peering can be in the Internet

Convergence

MRAI

- Internet churn means we are constantly setting and waiting on MRAI timers
  - One flapping prefix slows convergence for all prefixes
  - Internet table sees roughly 6 bestpath changes per second
- For iBGP and PE-CE eBGP peers
  - **`neighbor`** `x.x.x.x` **`advertisement-interval`** `0`
  - Has been the default since 12.0(32)S
- For regular eBGP peers
  - Default is 30 seconds
  - Lowering to 0 may get you dampened
  - OK to lower for eBGP peers if they are not using dampening

Troubleshooting BGP Convergence – IOS XR

Show bgp all all convergence

```
RP/0/0/CPU0:R10# show bgp all all convergence
Address Family: IPv4 Unicast
====================================
Converged.
All received routes in RIB, all neighbors updated.
All neighbors have empty write queues.

Address Family: VPNv4 Unicast
============================
Not converged.
Received routes may not be entered in RIB.
One or more neighbors may need updating.
```

Not converged – implies that there are BGP neighbors that for which the replication has not completed yet

Troubleshooting BGP Convergence – IOS XR

Verifying Performance Statistics

```
0/0/CPU0:R10#sh bgp ipv4 uni update-gr 0.2 performance-statistics
Update group for IPv4 Unicast, index 0.2:
  <snip>
  Messages formatted: 0, replicated: 0
  All neighbors are assigned to sub-group(s)
    Neighbors in sub-group: 0.1, Filter-Groups             1
     Neighbors in filter-group: 0.1(RT num: 0
      10.1.102.2    10.1.103.2    10.1.104      10.1.105.2
  Updates generated for 0 prefixes in 10 calls(best-external:0)
              (time spent: 10.000 secs)
 <snip>
```

Verify the time spent in generating and replicated the updates

Troubleshooting Route Filtering

- Troubleshooting Missing Routes
- Troubleshooting Unexpected Routes
- Troubleshooting using Regex
- Troubleshooting Stale Routes

Missing Routes / Stale Routes

What does it mean?

- Missing Routes
  - The remote peer has not received the route
  - Possible Problem
    - Either speaker didn’t advertise the routes or the remote peer didn’t receive or process the BGP update
    - Inbound / Outbound Route-maps (Filtering)
- Stale Routes
  - A route present in the BGP table learnt from remote peer but not present on the remote peer BGP table
  - Possible Problem
    - Either remote speaker didn’t advertise the withdraw or the local device didn’t process the withdraw
    - EOR received

Missing Routes

RPL in IOS XR

- IOS and NX-OS by default install routes in the BGP table for prefixes learnt from eBGP peers
- IOS XR requires a mandatory RPL policy to have them installed in BGP table.
  - The RPL can permit all routes or conditional routes

```
route-policy Inbound-ROUTES
 if destination in A1-Prefix-Set then
    pass
 else
    drop
 endif
end-policy
router bgp 65530
neighbor-group IGW
  remote-as 65530
address-family ipv4 unicast
route-policy Inbound-ROUTES in
```

Missing Routes

BGP not in read-write mode

- May not see the routes in BGP table, incase BGP remains in read-only mode
  - To have the BGP routes installed, BGP should be in read-write mode
- On XR, use the below commands to verify BGP in read-write mode
  - **Show bgp**
  - **Show bgp process performance-statistics detail**
    - At the very bottom of this output, you will see the below lines, if the device entered the read-write mode

```
First neighbor established:  Jan 23 20:15:45
Entered DO_BESTPATH mode:    Jan 23 20:15:49
Entered DO_IMPORT mode:      Jan 23 20:15:49
Entered DO_RIBUPD mode:      Jan 23 20:15:49
Entered Normal mode:         Jan 23 20:15:49
Latest UPDATE sent:          Jan 23 20:18:39
```

Unexpected Routes

Route-Map Problem

```
route-map OSPF2BGP permit 10
 match ip prefix-list FILTERv4
!
router bgp 100
 address-family ipv4 unicast
   redistribute ospf 1 route-map OSPF2BGP
```

- What is the outcome of the above redistribution ?

Unexpected Routes

Route-Map Problem

```
route-map OSPF2BGP permit 10
 match ip prefix-list FILTERv4
route-map OSPF2BGP permit 20
 match ipv6 prefix-list FILTERv6
!
router bgp 100
 address-family ipv4 unicast
   redistribute ospf 1 route-map OSPF2BGP
 address-family ipv6 unicast
   redistribute ospfv3 1 route-map OSPF2BGP
```

- What is the outcome of the above redistribution ?

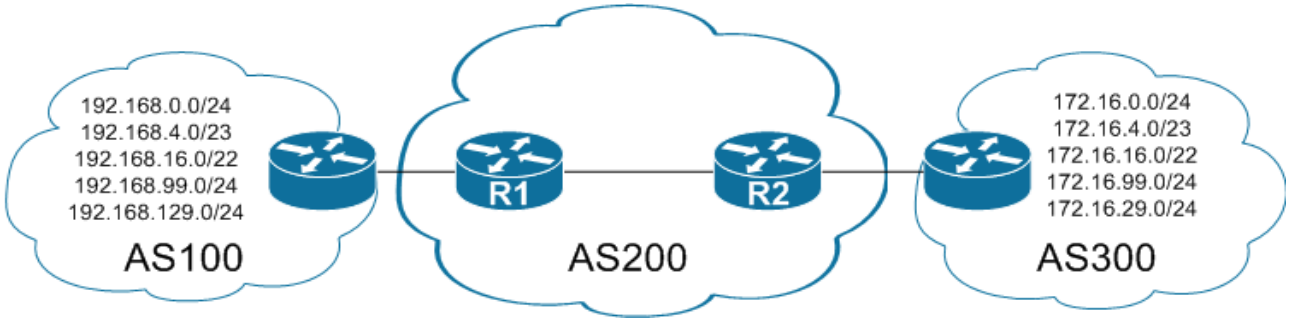
Unexpected Routes

Route-Map Behavior

- A route map processes routes or IP packets in a linear fashion, that is, starting from the lowest sequence number.
- If referred policies (for example, prefix lists) within a match statement of a route-map entry return either a no-match or a deny-match, Device fails the match statement and processes the next route-map entry.
- Without any match statement in a route-map entry, the permission (permit or deny) of the route-map entry decides the result for all the routes or packets.

Troubleshooting Filtering

Topology




```
R2#show bgp ipv4 unicast
Network          Next Hop       Metric LocPrf Weight Path
*> 172.16.0.0/24    192.168.200.3       0             0 300 80 90 21003 2100 i
*> 172.16.4.0/23    192.168.200.3       0             0 300 1080 1090 1100 1110 i
*> 172.16.16.0/22   192.168.200.3       0             0 300 11234 21234 31234 i
*> 172.16.99.0/24   192.168.200.3       0             0 300 40 i
*> 172.16.129.0/24  192.168.200.3       0             0 300 10010 300 30010 30050 i
*>i192.168.0.0      10.12.1.1           0    100      0 100 80 90 21003 2100 i
*>i192.168.4.0/23   10.12.1.1           0    100      0 100 1080 1090 1100 1110 i
*>i192.168.16.0/22  10.12.1.1           0    100      0 100 11234 21234 31234 i
*>i192.168.99.0     10.12.1.1           0    100      0 100 40 i
*>i192.168.129.0    10.12.1.1           0    100      0 100 10010 300 30010 30050 i
```

Troubleshooting Filtering

Regex Query Modifiers

Modifier	Description
_ (Underscore)	Matches a space
^ (Caret)	Indicates the start of the string
$ (Dollar Sign)	Indicates the end of the string
[] (Brackets)	Matches a single character or nesting within a range
- (Hyphen)	Indicates a range of numbers in brackets
[^] (Caret in Brackets)	Excludes the characters listed in brackets
() (Parentheses)	Used for nesting of search patterns
| (Pipe)	Provides ‘or’ functionality to the query
. (Period)	Matches a single character, including a space
* (Asterisk)	Matches zero or more characters or patterns
+ (Plus Sign)	One or more instances of the character or pattern
? (Question Mark)	Matches one or no instances of the character or pattern.

Troubleshooting Filtering

Regex

```
R2#show bgp ipv4 unicast regexp _300_
! Output omitted for brevity
     Network          Next Hop      Metric LocPrf Weight Path
*> 172.16.0.0/24    192.168.200.3         0             0 300 80 90 21003 455 i
*> 172.16.4.0/23    192.168.200.3         0             0 300 878 1190 1100 1010 i
*> 172.16.16.0/22   192.168.200.3         0             0 300 779 21234 45 i
*> 172.16.99.0/24   192.168.200.3         0             0 300 145 40 i
*> 172.16.129.0/24  192.168.200.3         0             0 300 10010 300 1010 40 50 i
*>i192.168.129.0    10.12.1.1             0    100      0 100 10010 300 1010 40 50 i
```

```
R2#show bgp ipv4 unicast regexp ^300_
! Output omitted for brevity
     Network          Next Hop      Metric LocPrf Weight Path
*> 172.16.0.0/24    192.168.200.3         0             0 300 80 90 21003 455 i
*> 172.16.4.0/23    192.168.200.3         0             0 300 878 1190 1100 1010 i
*> 172.16.16.0/22   192.168.200.3         0             0 300 779 21234 45 i
*> 172.16.99.0/24   192.168.200.3         0             0 300 145 40 i
*> 172.16.129.0/24  192.168.200.3         0             0 300 10010 300 1010 40 50 i
```

Troubleshooting Filtering

Regex

```
R2#show bgp ipv4 unicast regexp [4-8]0_
! Output omitted for brevity
     Network          Next Hop    Metric LocPrf Weight Path
*> 172.16.0.0/24    192.168.200.3      0             0 300 80 90 21003 455 i
*> 172.16.99.0/24   192.168.200.3      0             0 300 145 40 i
*> 172.16.129.0/24  192.168.200.3      0             0 300 10010 300 1010 40 50 i
*>i192.168.0.0      10.12.1.1          0    100      0 100 80 90 21003 455 i
*>i192.168.99.0     10.12.1.1          0    100      0 100 145 40 i
*>i192.168.129.0    10.12.1.1          0    100      0 100 10010 300 1010 40 50 i
```

```
R2#show bgp ipv4 unicast regexp ^[13]00_[^3-8]
! Output omitted for brevity
     Network          Next Hop    Metric LocPrf Weight Path
*> 172.16.99.0/24   192.168.200.3      0             0 300 145 40 i
*> 172.16.129.0/24  192.168.200.3      0             0 300 10010 300 1010 40 50 i
*>i192.168.99.0     10.12.1.1          0    100      0 100 145 40 i
*>i192.168.129.0    10.12.1.1          0    100      0 100 10010 300 1010 40 50 i
```

Troubleshooting Filtering

Prefix-List Blocking Prefixes

```
RTR#debug bgp ipv4 unicast updates in
BGP updates debugging is on (inbound) for address family: IPv4 Unicast

RTR#clear bgp ipv4 unicast 10.1.45.4 soft in
! Output omitted for brevity
* 18:59:42.515: BGP(0): process 10.1.12.0/24, next hop 10.1.45.4, metric 0 from 10.1.45.4
* 18:59:42.515: BGP(0): Prefix 10.1.12.0/24 rejected by inbound filter-list.
* 18:59:42.515: BGP(0): update denied
```

```
NXOS5# debug bgp updates
NXOS5# clear bgp ipv4 unicast 10.1.45.4 soft in
! Output omitted for brevity
19:02:54 bgp: 300 [8449] UPD: [IPv4 Unicast] 10.1.45.4 Inbound as-path-list 1, action permit
 19:02:54 bgp: 300 [8449] UPD: [IPv4 Unicast] 10.1.45.4 Inbound as-path-list 1, action deny
 19:02:54 bgp: 300 [8449]  UPD: [IPv4 Unicast] Dropping prefix 10.1.12.0/24 from peer 10.1.45.4,
due to attribute policy rejected
```

Troubleshooting Filtering

IOS XR BGP RPL Debugging

```
route-policy R4-IN
  if destination in (10.0.0.0/8 le 32) then
    pass
  endif
  if destination in (172.16.0.0/12 le 32) then
    set med 20
  endif
end-policy
```

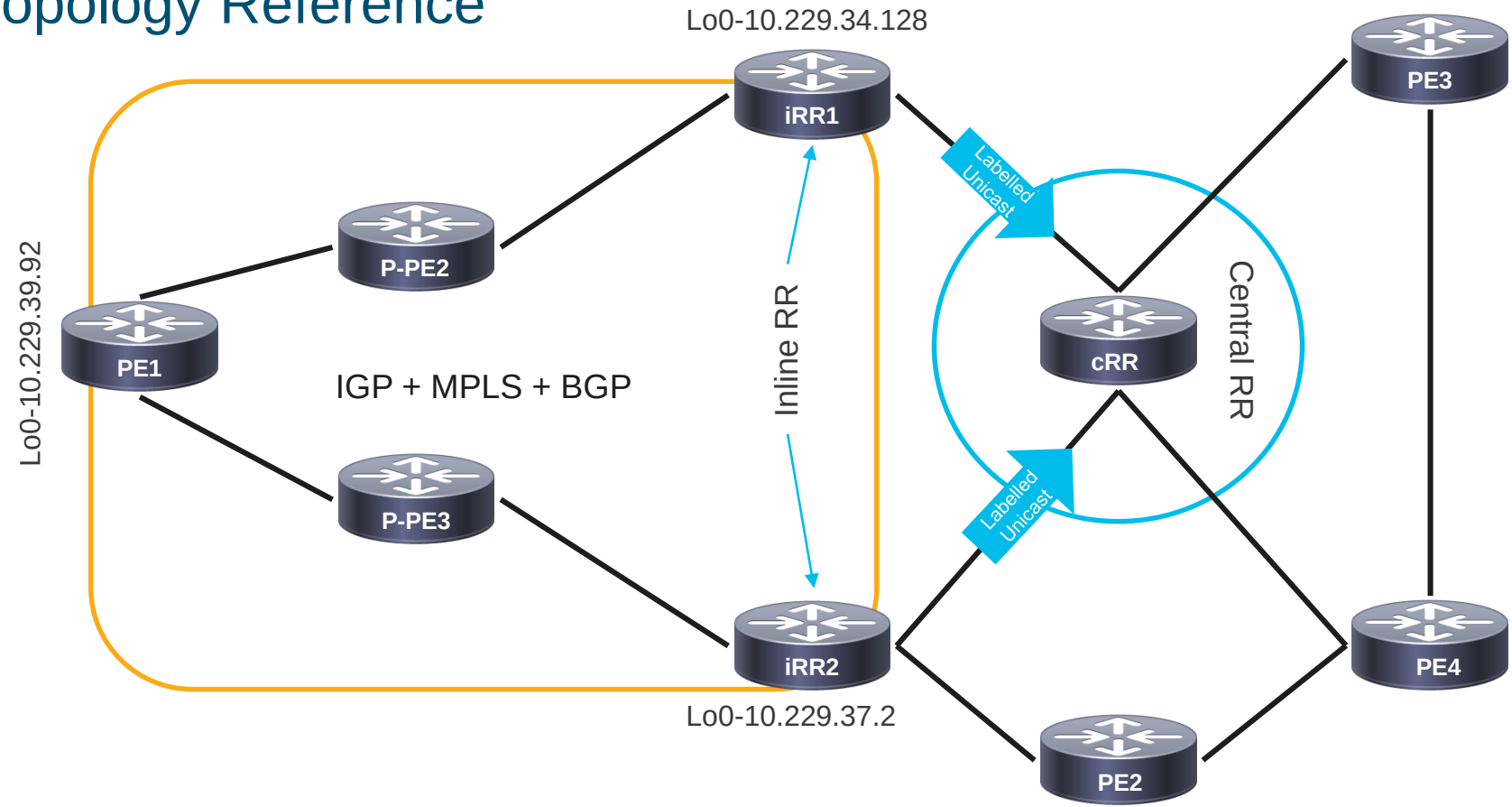
```
RP/0/0/CPU0:XR#debug bgp policy-execution events
RP/0/0/CPU0:XR#clear bgp ipv4 unicast 10.1.45.4 soft
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]: --Running policy 'R4-IN':---
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   Attach pt='neighbor-in-dflt'
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   Attach pt inst='default-IPv4-Uni-10.1.45.4'
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]: Input route attributes:
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   as-path: 200 100 600
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   as-path-length: 3
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   as-path-unique-length: 3
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   community: No Community Information
. . .
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   path-type: ebgp
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   aigp-metric: 0
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   validation-state: not-found
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]: Policy execution trace:
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   Condition: destination in (10.0.0.0/8 ...)
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   Condition evaluated to FALSE
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   Condition: destination in (172.16.0.0/12 ...)
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   Condition evaluated to FALSE
RP/0/0/CPU0: 06:19:10.000 : bgp[1053]:   End policy: result=DROP
```

Stale Routes

Symptoms and Possible Causes

- Symptoms
  - Stale Entry to BGP Peer
  - Traffic Black-Hole
  - Outage
- Possible Causes
  - BGP Slow Peer
  - Sender didn't process the updates
  - Receiver didn't process the update

Topology Reference



Stale Routes

Example – Route on BGP Speaker

```
RP/0/RSP0/CPU0:RR2#show bgp ipv4 labeled-unicast 10.229.37.92
BGP routing table entry for 10.229.37.92/32
  Local Label: 25528
Last Modified: Jan 13 10:20:52.424 for 11:45:15
Paths: (1 available, best #1)
   Path #1: Received by speaker 0
 Advertised to update-groups (with more than one peer):
   0.1 0.2 0.3 0.7
 Local
   10.229.34.128 (metric 5) from 192.168.53.9 (10.229.37.92)
     Received Label 26596
     Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
     Received Path ID 1, Local Path ID 0, version 301642
     Community: 65080:109
     Originator: 10.229.37.92, Cluster list: 0.0.254.56, 10.229.34.128
```

Stale Routes

Example – Stale Entry on Receiving Router

```
Central-RR#show bgp ipv4 unicast 10.229.37.92
BGP routing table entry for 10.229.37.92/32, version 290518
BGP Bestpath: deterministic-med
Paths: (3 available, best #2, table default)
  Refresh Epoch 1
  Local, (Received from a RR-client)
    10.229.34.128 (metric 116) from 10.229.34.128 (10.229.34.128)
      Origin IGP, metric 0, localpref 100, valid, internal, best2
      Community: 65080:109
      Originator: 10.229.37.92, Cluster list: 10.229.34.128
      mpls labels in/out nolabel/26596
      rx pathid: 0x1A, tx pathid: 0x1
  Local, (Received from a RR-client)
    10.229.37.2 (metric 113) from 10.229.37.2 (10.229.37.2)
      Origin IGP, metric 0, localpref 100, valid, internal, best
      Community: 65080:109
      Originator: 10.229.37.92, Cluster list: 10.229.37.2
      mpls labels in/out nolabel/27183
      rx pathid: 0x7, tx pathid: 0x0
```

Stale Routes

How to Troubleshoot?

- On IOS, its difficult to get to the root cause after the problem has occurred.
  - Enable conditional debugs and wait for the issue to happen again
  - Reproduce the problem in lab environment (hard but not impossible)
- On IOS XR, use **show bgp trace** and **bgp debugs** to understand if the advertisement has been sent/received or not
  - Debug
- On NX-OS, use **show bgp event-history events | errors** to figure out if the prefix has been received / advertised or not

Stale Routes or Missing Routes / Advertisements

Conditional Debugs

```
IOS-1#show access-list 99
Standard IP access list 99
    permit 10.1.1.0 0.0.0.255

IOS-1#debug ip bgp 2.2.2.2 update 99
```

```
IOS-XR
route-policy DEBUG_BGP
 if destination in BGP_PREFIX then
  pass
 else
  drop
 endif
end-policy
 prefix-set BGP_PREFIX
  100.1.1.0/24
 end-set
debug bgp update ipv4 unicast [in | out] route-policy DEBUG_BGP
```

BGP Route Churn and Troubleshooting with BGP Table Version

Route Churn

Symptom - High CPU?

```
Router#show process cpu
  CPU utilization for five seconds: 100%/0%; one minute: 99%; five minutes: 81%
....
139     6795740   1020252       6660 88.34% 91.63% 74.01%    0 BGP Router
```

- Define “High”
  - Know what normal CPU utilization is for the router in question
  - Is the CPU spiking due to “BGP Scanner” or is it constant?
- Look at the scenario
  - Is BGP going through “Initial Convergence”?
- If not then route churn is the usual culprit
  - Illegal recursive lookup or some other factor causes bestpath changes for the entire table

Route Churn

High CPU due to BGP Router

- How to identify route churn?
  - Do “sh ip bgp summary”, note the table version
  - Wait 60 seconds
  - Do “sh ip bgp summary”, compare the table version from 60 seconds ago
- You have 150k routes and see the table version increase by 300
  - This is probably normal route churn
  - Know how many bestpath changes you normally see per minute
- You have 150k routes and see the table version fluctuating by 20K - 50k
  - This is bad and is the cause of your high CPU

Route Churn

```
Router#Show ip bgp all sum | in tab
BGP table version is 936574954, main routing table version 936574954
BGP table version is 429591477, main routing table version 429591477
Router#


Router#Show ip bgp all sum | in tab
BGP table version is 936576768, main routing table version 936575068
BGP table version is 429591526, main routing table version 429591526
Router#

Router#show ip route | in 00:00:0
B       187.164.0.0 [200/0] via 218.185.80.140, 00:00:00
B       187.52.0.0 [200/0] via 218.185.80.140, 00:00:00
B       187.24.0.0 [200/0] via 218.185.80.140, 00:00:00
B       187.68.0.0 [200/0] via 218.185.80.140, 00:00:00
B       186.136.0.0 [200/0] via 218.185.80.140, 00:00:00
. . . .
```

Over 1800 prefixes flapped

< 4 seconds later

Route Churn

Table Version Changes?

- What causes massive table version changes?
- Flapping peers
  - Hold-timer expiring?
  - Corrupt UPDATE?
- Route churn
  - Don’t try to troubleshoot the entire BGP table at once
  - Identify one prefix that is churning and troubleshoot that one prefix
  - Will likely fix the problem with the rest of the BGP table churn

Route Churn

Flapping Routes in BGP

- Figuring out flapping routes from routing table is easy (even in vrf)
  - **`Show ip route vrf * | in 00:00:0|VRF`**
- How about identifying flapping routes on the VPNv4 Route Reflector?
  - **`Show bgp vpnv4 unicast all summary | in table`**
  - Use the table version as the marker in the below command to see the routes which flapped after the last command that was executed
  - **`Show bgp vpnv4 unicast all version`** [*`version-num`* | **`recent`** *`version-num`*]
  - Use the next-hop of the prefixes from the above command, to see why the prefixes are flapping

Route Churn

Flapping Routes in BGP

```
R1#show bgp ipv4 unicast version recent 6
BGP table version is 12, local router ID is 192.168.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
     Network          Next Hop            Metric LocPrf Weight Path
r>i 192.168.2.2/32   192.168.2.2              0    100      0 i
r>i 192.168.3.3/32   192.168.3.3              0    100      0 i
*mi 192.168.200.200/32
                     192.168.3.3              0    100      0 200 i
*>i                  192.168.2.2              0    100      0 200 i
```

Route Churn

Flapping Routes in BGP on IOS XR

- IOS XR has more interesting command for table version updates
  - **Show bgp** *afi safi* **version** *<start-version> <end-version>*

```
RP/0/0/CPU0:XR1#show bgp ipv4 unicast version 5 7
VRF: default
------------
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf    Version Path
*>i192.168.2.2/32     192.168.2.2              0    100         6
i*>i192.168.3.3/32     192.168.3.3             0    100         7
i*>i192.168.200.200/32 192.168.2.2             0    100         5 200 i
i                      192.168.3.3             0    100         5 200 i

Processed 3 prefixes, 4 paths
```

Route Churn

Which AFI?

- If there are too many updates coming onto the router, one way to identify it would be
  - **`Show ip traffic | section TCP`**
- Symptom – TCP traffic increasing rapidly, but table version for IPv4 and VPNv4 AFI is only increasing by 200 or 300 or a smaller value
- Check for different AFI's enabled on the router and checking for the table version changes in those AFI's
  - Especially IPv6 or VPNv6 as those can have more impact with fewer prefixes flapping

Embedded Event Manager (EEM)

- Serves as a powerful tool for high CPU troubleshooting
- Triggered based on event and thresholds
- Multiple actions can be set based on events

```
event manager applet HIGHCPU
event snmp oid "1.3.6.1.4.1.9.9.109.1.1.1.1.3.1" get-type exact entry-op gt entry-val "90"
exit-op lt exit-val "70" poll-interval 5 maxrun 200
action 1.0 syslog msg "START of TAC-EEM: High CPU"
action 1.1 cli command ”show clock"
action 1.3 cli command ”show ip bgp all summary | append disk0:proc_CPU"
action 2.0 cli command "sh clock | append disk0:proc_CPU"
action 2.1 cli command "show process cpu sorted | append disk0:proc_CPU“
action 2.2 cli command "show proc cpu history | append disk0:proc_CPU"
action 2.3 cli command " show ip bgp all summary | append disk0:proc_CPU"
action 3.1 cli command "show log | append disk0:proc_CPU"
action 4.0 syslog msg "END of TAC-EEM: High CPU"
```

Troubleshooting with NX-OS

- BGP process
- Debugging
- BGP Event-History
- RPM

Troubleshooting with NX-OS

Verifying BGP Configuration Parameters

- Sometimes we may require to verify some configuration parameters for BGP
- To verify the config / process wide parameters, use the command "**`show bgp process`**"
- Includes the following:
  - BGP Router-ID
  - Confed ID or Cluster ID
  - Process and Memory state
  - # of configured peers and established peers
  - AFI information
    - Redistribution (if any)
      - Route-map
    - NHT Information

Show bgp process

```
N7K1# show bgp process
BGP Process Information
BGP Process ID : 5128
BGP Protocol Started, reason: : configuration
BGP Protocol Tag : 1
BGP Protocol State : Running
BGP Memory State : OK
BGP asformat : asplain

BGP attributes information
Number of attribute entries : 15
HWM of attribute entries : 49
Bytes used by entries : 1380
Entries pending delete : 0
HWM of entries pending delete : 0
BGP paths per attribute HWM : 11
BGP AS path entries : 0
Bytes used by AS path entries : 0

Information regarding configured VRFs:
BGP Information for VRF default VRF Id : 1
VRF state : UP
Router-ID : 192.168.1.1
Configured Router-ID : 192.168.1.1
Confed-ID : 0 Cluster-ID : 0.0.0.0
No. of configured peers : 10
No. of pending config peers : 0
No. of established peers : 0
VRF RD : Not configured
. . .
```

Show bgp process

```
N7K1# show bgp process
contd. . .

Information for address family IPv4 Unicast in VRF default
Table Id                : 1
Table state             : UP
Peers Active-peers Routes Paths Networks Aggregates
5           0        19     20     10        0

Redistribution
   static, route-map static-bgp
   direct, route-map rm-permit-all
   eigrp, route-map rm-permit-all


Default-Information originate enabled

 Nexthop trigger-delay
       critical 3000 ms
       non-critical 10000 ms
```

Troubleshooting with NX-OS

BGP Event-History

- NX-OS event-history capability is alternate to running debugs
- Event-History Buffer Sizes:
  - Large
  - Medium
  - Small
- Event-History maintained for:
  - Events
  - Errors
  - Detail
  - Msgs
  - CLI

Troubleshooting with NX-OS

Processing an Incoming Update – show bgp event-history detail

- Manually enable Detail Event-History using the command "**event-history detail size [large | medium | small]**"

```
05:28:12.515623: (default) UPD: Received UPDATE message from 10.1.23.2
05:28:12.515616: (default) BRIB: [IPv4 Unicast] (192.168.1.1/32 (10.1.23.2)): returning from
bgp_brib_add, new_path: 0, change: 0, undelete: 0, history: 0, force: 0, (pflags=0x28), reeval=0
05:28:12.515608: (default) BRIB: [IPv4 Unicast] 192.168.1.1/32 from 10.1.23.2 was already in BRIB
with same attributes
05:28:12.515600: (default) BRIB: [IPv4 Unicast] (192.168.1.1/32 (10.1.23.2)): bgp_brib_add:
handling nexthop
05:28:12.515593: (default) BRIB: [IPv4 Unicast] Path to 192.168.1.1/32 via 192.168.2.2 already
exists, dflags=0x8001a
05:28:12.515580: (default) BRIB: [IPv4 Unicast] Installing prefix 192.168.1.1/32 (10.1.23.2) via
10.1.23.2  into BRIB with extcomm
05:28:12.515557: (default) UPD: [IPv4 Unicast] Received prefix 192.168.1.1/32 from peer
10.1.23.2, origin 0, next hop 10.1.23.2, localpref 0, med
005:28:12.515524: (default) UPD: 10.1.23.2 Received attr code 2, length 10, AS-Path: <200 100 >
05:28:12.515503: (default) UPD: Attr code 3, length 4, Next-hop: 10.1.23.2
05:28:12.515454: (default) UPD: Attr code 1, length 1, Origin: IGP
05:28:12.515446: (default) UPD: 10.1.23.2 parsed UPDATE message from peer, len 52 , withdraw len
0, attr len 24, nlri len 5
```

Troubleshooting with NX-OS

Update Generation – show bgp event-history detail

```
05:28:11.478903: (default) UPD: [IPv4 Unicast] 10.1.23.2 Created UPD msg (len 52) with prefix
192.168.1.1/32 ( Installed in HW) path-id 1 for peer
05:28:11.478886: (default) UPD: 10.1.23.2 Sending attr code 3, length 4, Next-hop: 10.1.23.3
05:28:11.478880: (default) UPD: 10.1.23.2 Sending attr code 2, length 10, AS-Path: <300 100 >
05:28:11.478870: (default) UPD: 10.1.23.2 Sending attr code 1, length 1, Origin: IGP
05:28:11.478856: (default) UPD: [IPv4 Unicast] consider sending 192.168.1.1/32 to peer 10.1.23.2,
path-id 1, best-ext is off
. . .
05:28:11.478717: (default) EVT: [IPv4 Unicast] soft refresh out completed for 1 peers
05:28:11.478690: (default) EVT: [IPv4 Unicast] Adding peer 10.1.23.2 for update gen
05:28:11.478686: (default) BRIB: [IPv4 Unicast] Group setting SRM for dest 192.168.3.3/32
05:28:11.478682: (default) BRIB: [IPv4 Unicast] Group setting SRM for dest 192.168.2.2/32
05:28:11.478678: (default) BRIB: [IPv4 Unicast] Group setting SRM for dest 192.168.1.1/32
05:28:11.478666: (default) EVT: [IPv4 Unicast] 1 peer(s) being soft refreshed out
05:28:11.478661: (default) EVT: [IPv4 Unicast] 10.1.23.2 [peer index 2]
05:28:11.478638: (default) EVT: [IPv4 Unicast] Doing soft out BGP table walk for peers
05:28:10.478332: (default) EVT: [IPv4 Unicast] Scheduling peer 10.1.23.2 for soft refresh out
05:28:10.478321: (default) EVT: Received ROUTEREFRESH message from 10.1.23.2
```

Troubleshooting with NX-OS

Conditional Debugging and URIB

- Conditional Debugging

```
Debug logfile bgp
debug bgp events updates rib brib import
debug logfile bgp
debug-filter bgp vrf vpn1
debug-filter bgp address-family ipv4 unicast
debug-filter bgp neighbor 10.1.202.2
debug-filter bgp prefix 192.168.2.2/32
```

- Troubleshooting URIB

```
Show routing internal event-history ufdm
Show routing internal event-history ufdm-summary
Show routing internal event-history recursive
```

Troubleshooting with NX-OS

Route Policy Manager

- Route-map functionality is provided by a new process in DC-OS called Route Policy Manager (RPM)
- RPM handles route-maps, AS path access lists, community lists and prefix lists
- The route-maps are configured the same way as they are configured in Cisco IOS, but are managed by RPM
  - If there are any issues seen with route-maps not functioning

Troubleshooting with NX-OS

Route Policy Manager

```
NX-1# show system internal sysmgr service name rpm
Service "rpm" ("rpm", 203):
        UUID = 0x131, PID = 5265, SAP = 348
        State: SRV_STATE_HANDSHAKED (entered at time Mon Jan 30 03:07:59
2017).
        Restart count: 1
        Time of last restart: Mon Aug 22 03:07:57 2016.
        The service never crashed since the last reboot.
        Tag = N/A
        Plugin ID: 1
```

Troubleshooting with NX-OS

Route Policy Manager

```
template peer-policy PP-Test1
   send-community
   route-map RM-Test1 out
!
neighbor 192.168.2.2 remote-as 65000
     inherit peer-session ps-ebgp-peer-to-mpls-core
       address-family ipv4 unicast
       inherit peer-policy PP-Test1 5
       send-community
       prefix-list pl-nab-core-devl-routes in
       no prefix-list pl-cloud-routes out
       route-map RM-Test2 out
       soft-reconfiguration inbound
. . . .
```

```
NX-1#  sh route-map RM-Test1
route-map RM-Test1, permit, sequence 10
  Match clauses:
    ip address prefix-lists: sy3-routes
  Continue: sequence 20
  Set clauses:
    community 65135:999
route-map RM-Test1, permit, sequence 999
  Match clauses:
  Set clauses:
!
NX-1# sh route-map RM-Test2
route-map RM-Test1, permit, sequence 10
  Match clauses:
    ip address prefix-lists: pl-cloud-routes
  Set clauses:
route-map RM-Test1, permit, sequence 20
  Match clauses:
    as-path (as-path filter): as-me1-o365-ext-routes
  Set clauses:
```

Troubleshooting with NX-OS

```
NX-2# show system internal rpm route-map
Policy name: RM-Test1              Type: route-map
Version: 6                         State: Ready
Ref. count: 1                      PBR refcount: 0
Stmt count: 5                      Last stmt seq: 999
Set nhop cmd count: 0              Set vrf cmd count: 0
Set intf cmd count: 0              Flags: 0x00000003
PPF nodeid: 0x00000000             Config refcount: 0
PBR Stats: No
Clients:
    bgp-65136 (Route filtering/redistribution)    ACN version: 0
```

Troubleshooting with NX-OS

 # show system internal rpm event-history rsw

Routing software interaction logs of RPM
1) Event:E_DEBUG, length:88, at 96760 usecs after Sun Apr 23 22:19:12 2017
[120] [3959]: **Bind ack sent - client bgp-65136 uuid 0x0000011b for policy RM-Test2 <<<<< Outbound route-map bound to BGP client**
2) Event:E_DEBUG, length:83, at 96717 usecs after Sun Apr 23 22:19:12 2017
[120] [3959]: Bind request - client bgp-65136 uuid 0x0000011b policy RM-Test2
3) Event:E_DEBUG, length:88, at 782159 usecs after Sun Apr 23 21:51:06 2017
[120] [3959]: Bind ack sent - client bgp-65136 uuid 0x0000011b for policy RM-Test2
<snip>
[120] [3959]: **UnBind request succesfull - client bgp-65136 policy RM-Test1 <<<<<Unbind for route-map referenced in peer-policy**
6) Event:E_DEBUG, length:99, at 781950 usecs after Sun Apr 23 21:51:06 2017
[120] [3959]: **UnBind request - client bgp-65136 uuid 0x0000011b policy RM-Test1**
7) Event:E_DEBUG, length:102, at 344591 usecs after Sun Apr 23 21:47:39 2017
[120] [3959]: **Bind ack sent - client bgp-65136 uuid 0x0000011b for policy RM-Test1 <<<<< Route-map referenced in peer-policy**
8) Event:E_DEBUG, length:97, at 344557 usecs after Sun Apr 23 21:47:39 2017
[120] [3959]: Bind request - client bgp-65136 uuid 0x0000011b policy RM-Test1

Troubleshooting with NX-OS

Route Policy Manager

- Use RPM Event-history when troubleshooting any misbehavior of route policy / redistribution / missing routes / routes not learnt
- In case of issues, collect "**`show tech rpm`**"
- Use the below commands to troubleshoot RPM issues
  - `Show system internal rpm event-history events (For RPM Events)`
  - `Show system internal rpm event-history errors (For errors with RPM)`
  - `Show system internal rpm event-history rsw (RPM Interaction with RPM software)`
  - `Show system internal rpm event-history msgs (RPM Message logs)`
  - `Show system internal rpm event-history trace (RPM Traces)`

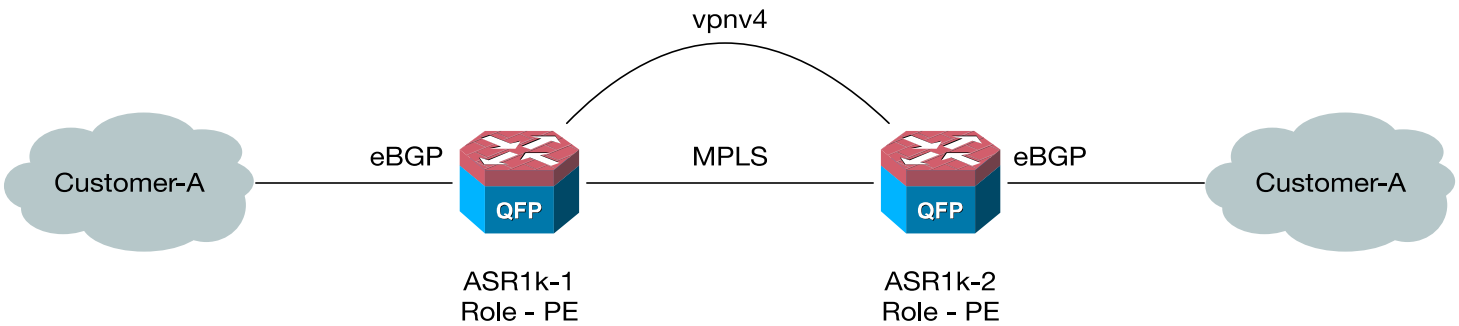
BGP and Automation

- Automation using EEM – Case Study
- ExaBGP

Troubleshooting BGP with Automation

Case Study – Description

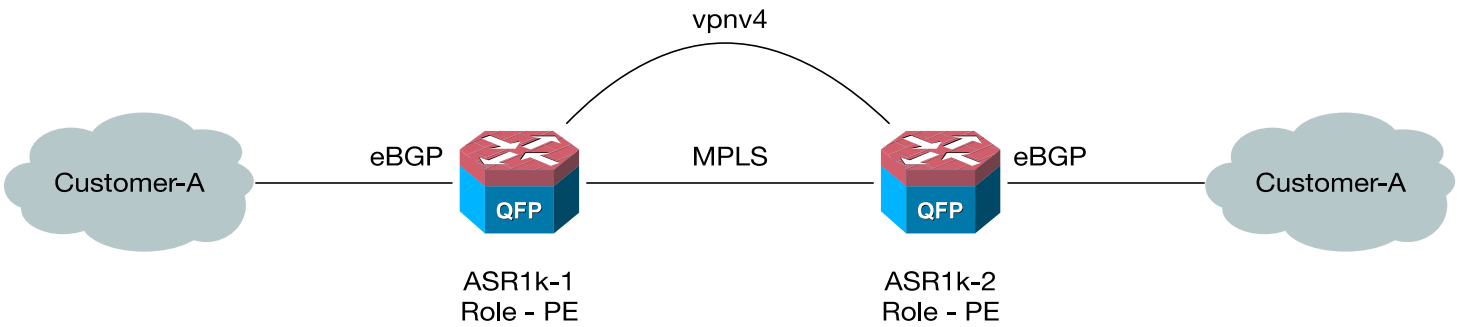
- Customer-A reported their eBGP peering to the MPLS ISP was not coming up
- MPLS ISP troubleshoot the issue and couldn't bring up the BGP for 2 hrs. Caused an major financial loss to Customer-A
- Switchover of the RP card on PE router restored the services



Troubleshooting BGP with Automation

Case Study - Symptoms

- No IP reachability between PE and CE
- Packets wedged in the interface input-queue and the Interface
- The issue was caused by a DoS attack due to NTP



Troubleshooting BGP with Automation

```
event manager applet Temp-Workaround auth bypass
event timer watchdog time 600 maxrun 600
action 023 cli command "en”
action 024 info type interface-names
action 025 foreach _iface "$_info_interface_names”
action 026   set result1 "none”
action 027   set result2 "none”
action 028   set result3 "none”
action 031   cli command "show int $_iface | in Input queue”
action 033   regexp "Input queue: ([A-Za-z0-9]+)/([A-Za-z0-9]+)" $_cli_result result1
result2 result3
action 035   multiply $result2 100
action 040   divide $_result $result3
action 042   if $_result gt 80
action 043     syslog msg "$_iface input queue above 80%. Increasing Queue size" pri 1
action 044     cli command "conf t”
action 045     cli command "interface $_iface”
action 046     cli command "hold-queue 2000 in”
action 050   end
action 055 end
```

Troubleshooting BGP with Automation

ExaBGP

- Python implementation of BGP – The BGP swiss army knife of networking
  - **`https://github.com/Exa-Networks/exabgp/`**
- Installable on your laptop / pc
- Allows users to connect to a real or virtual router and advertise routes, simulate routes flapping
- Have support for multiple AFI/SAFI including ASN4, IPv6, MPLS, VPLS, Flow, Graceful Restart, Enhanced Route Refresh, AIGP, etc
- Can serve handy for Internal testing, learning and pre-deployment simulations

Troubleshooting BGP with Automation

ExaBGP

```
test:~ test$ pip3 install exabgp
Collecting exabgp
 Downloading exabgp-4.0.5-py3-none-any.whl (551kB)
   100% |████████████████████████████████| 552kB 239kB/s
Installing collected packages: exabgp
Successfully installed exabgp-4.0.5
```

```
test:~ test$ cat conf.ini
neighbor 172.16.2.1 {
     router-id 172.16.2.1;
    local-address 172.16.2.2;          # Our local update-source
    local-as 65000;                    # Our local AS
    peer-as 65000;                     # Peer's AS}
}
```

Troubleshooting BGP with Automation

ExaBGP

```
$ exabgp ./conf.ini
! Output omitted for brevity
04:31:19 | 27403  | welcome       | Thank you for using ExaBGP
04:31:19 | 27403  | version       | 4.0.5
04:31:19 | 27403  | configuration | performing reload of exabgp 4.0.2-1c737d99
04:31:19 | 27403  | reactor       | loaded new configuration successfully
04:31:19 | 27403  | reactor       | connected to peer-1 with outgoing-1 172.16.2.1-
172.16.2.2
```

```
R1#show bgp ipv4 unicast summary | i Neighbor|172.16.2.1

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
172.16.2.1      4        65000       6       8       23    0    0 00:02:48        0
```

Troubleshooting BGP with Automation

ExaBGP

```
#!/usr/bin/env python3

import sys
import time

messages = [
'announce route 10.1.0.0/24 next-hop 10.1.101.1',
'announce route 10.2.0.0/22 next-hop 10.1.101.1',
'withdraw route 10.3.0.0/24 next-hop 10.1.101.1',
]

time.sleep(2)

while messages:
          message = messages.pop(0)
          sys.stdout.write( message + '\n')
          sys.stdout.flush()
          time.sleep(1)

while True:
          time.sleep(1)
```

Troubleshooting BGP with Automation

ExaBGP

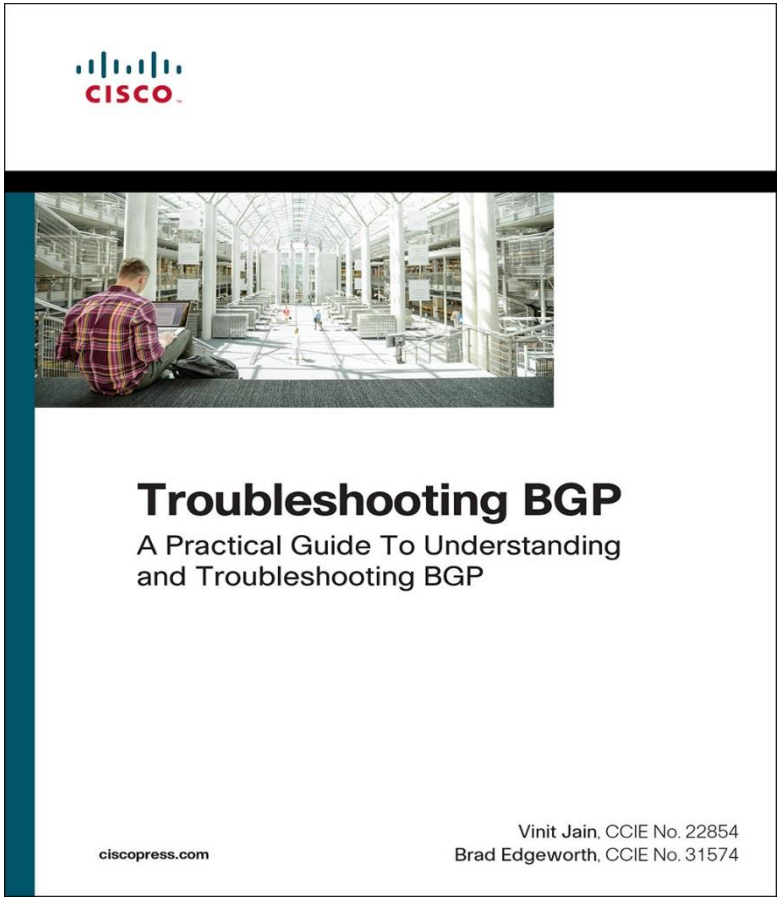
```
test:~ test$ cat conf.ini
process announce-routes {
    run /path/to/python3 /path/to/announce_pfx.py;
    encoder json;
}

neighbor 172.16.2.1 {
     router-id 172.16.2.1;
    local-address 172.16.2.2;          # Our local update-source
    local-as 65000;                    # Our local AS
    peer-as 65000;                     # Peer's AS}

  api {
        processes [announce-routes];
    }
}
```

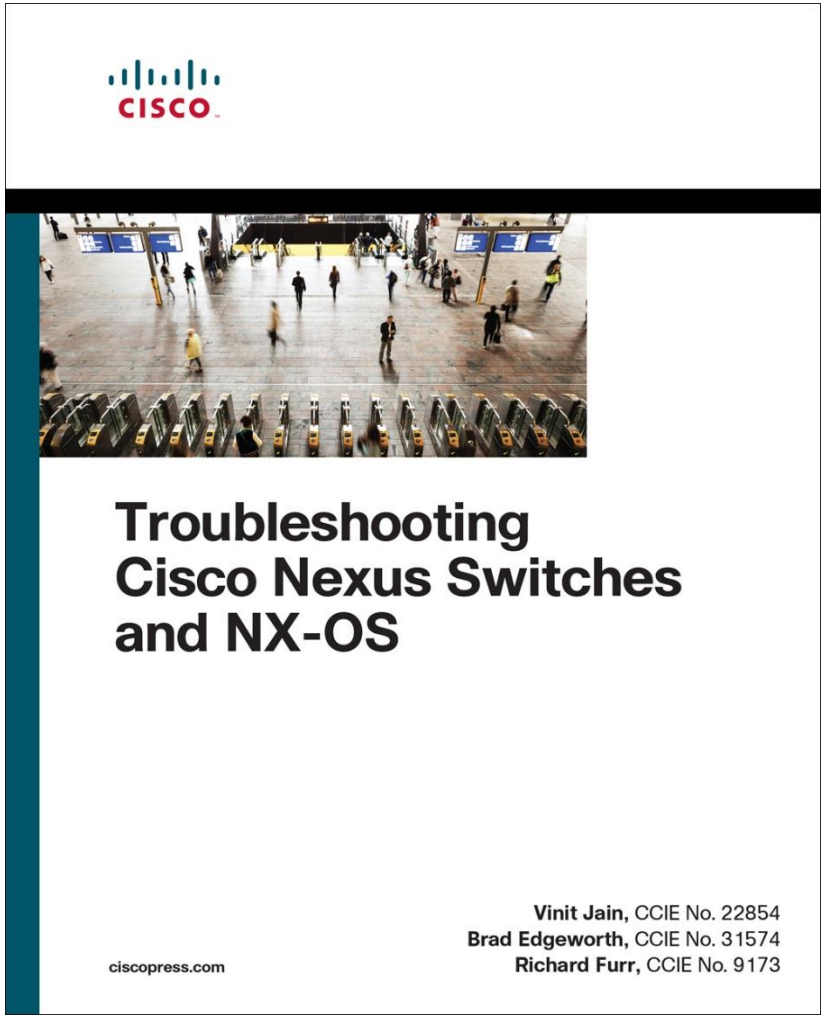
Troubleshooting BGP with Automation

ExaBGP

```
$ exabgp ./conf.ini
! Output omitted for brevity
04:45:57 | 27403  | reactor   | loaded new configuration successfully
04:45:57 | 27403  | reactor   | connected to peer-1 with outgoing-1 172.16.2.1-172.16.2.2
04:45:57 | 27396  | api       | route added to neighbor 172.16.2.2 local-
ip 172.16.2.1 local-as 65000 peer-as 65000 router-id 172.16.2.1 family-allowed in-
open : 10.1.0.0/24 next-hop 10.1.101.1
04:45:58 | 27396  | api       | route added to neighbor 172.16.2.2 local-
ip 172.16.2.1 local-as 65000 peer-as 65000 router-id 172.16.2.1 family-allowed in-
open : 10.2.0.0/24 next-hop 10.1.101.1
. . .
```

```
R1#sh bgp ipv4 unicast | b Network
     Network          Next Hop            Metric LocPrf Weight Path
*>i 10.1.0.0/24     10.1.101.1               0          32768    i
*>i 10.2.0.0/24     10.1.101.1                    100        0    i
*>i 10.3.0.0/24     10.1.101.1                    100        0    i
```





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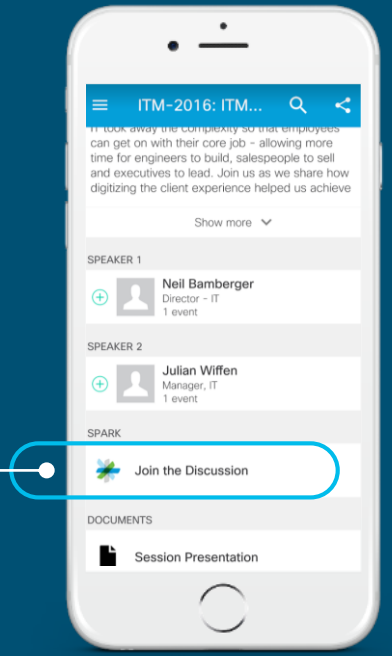

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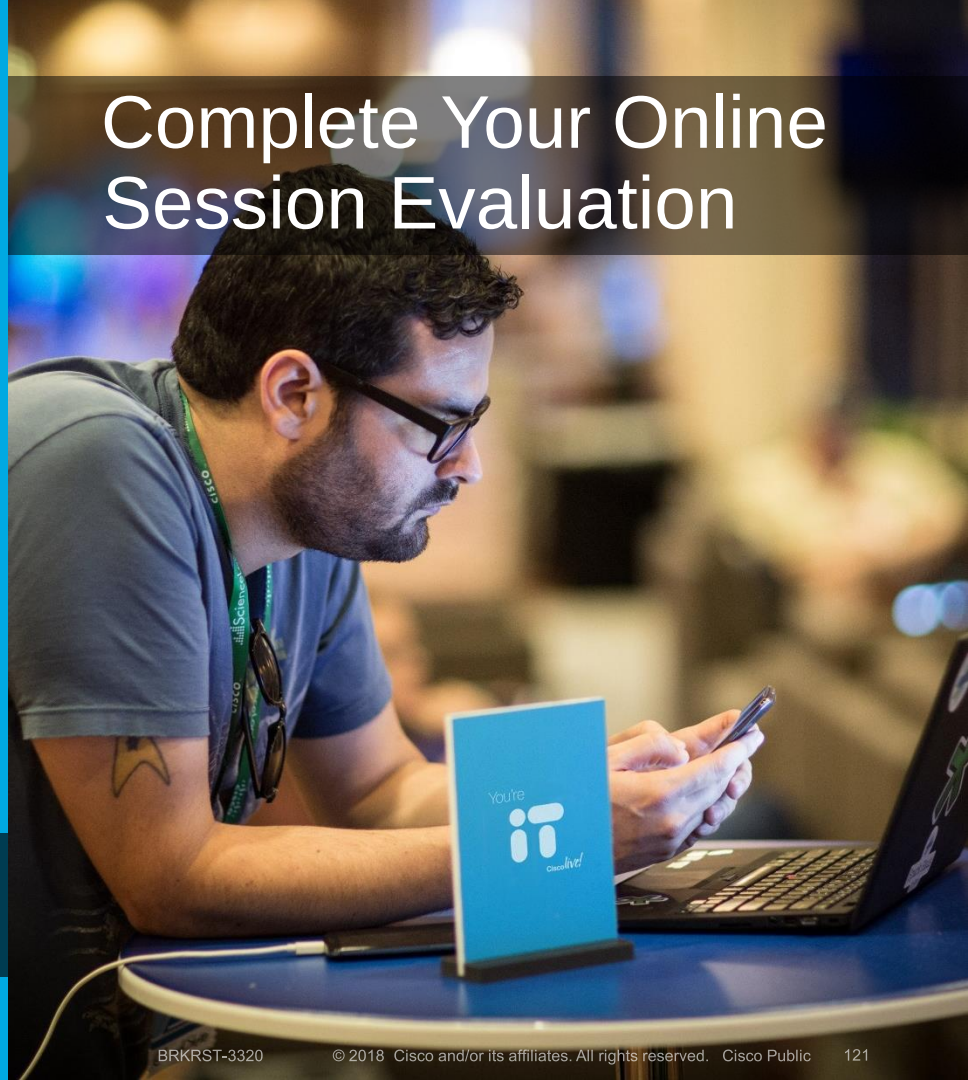

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