A Morsel of BGP Routing Protocol

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Abstract— Router is an intelligent which is used in abundance in networking. The main purpose of router is to route the packets from source to destination. Router refers its routing table to select the best path to reach its destination. The routing table of router should be populated with routes. Router will discard any packet for which the route to reach the destination will be missing. This paper presents detailed information about BGP (Border Gateway protocol) Protocol by which we often add public route entries in router's routing table. C3725 router has been used for this purpose as it supports both serial and ethernet communication and the topology is implemented in GNS3 software. The topology is implemented on GNS3 and various attributes of BGP such as AS-Path, Local Preference, Multi exit Discriminator etc. are implemented on the same topology and manipulated. Entries of different ways to enter routes, are represented by different symbols on the router's route table.

Key words: C3725, BGP, GNS3, Protocols, Topology, Attributes

I. INTRODUCTION

Router is an intelligent device. Router is an intelligent device. On receiving a packet on its ports, router will check IP address, refer routing table and take forwarding decision. As router refers routing table, reads IP addresses, router is a layer 3 device.

On receiving a packet on one of its ports, router will check layer 3 information (Destination IP address), read destination IP address and forward the packet only if it has a route to reach the destination network or else the packet will be discarded. As router refers routing table, it should be populated with entries. We have three ways to populate routing table with entries:

1) Directly connected routes will automatically reflect in routers routing table.
2) Administrator can make static route entries in routers routing table.
3) With the help of dynamic routing protocol, routers can learn routes dynamically in their routing table.

Fig. 1:

Router consist of two ports:

1) Access port.
2) Communication port.

Router dynamicaly learn routes using various routing protocols such OSPF, IGRP, EIGRP, RIP, ISIS and BGP. Out of all these, BGP is often used to learn public IP address.

IP address is a 32 bit logical address which is given on the interfaces of routers, smart phones/laptops/desktops, switches (for TELNET) etc and used for communication between devices. IP address ranges from 0.0.0.0 to 255.255.255.255. IP range from 10.0.0.0-10.255.255.255,172.16.0.0 172.31.255.255 & 192.168.0.0-192.168.255.255 belongs to Private IP ranges. To communicate on internet we require public ip addresses (for ex: 20.0.0.1).

BGP attributes are called Path attributes. It is a classless routing protocol and a variant of Distance vector Protocol (Path vector protocol).It is used to communicate on internet and between different Autonomous systems. BGP is mainly used for route manipulation and so it works on public IP addresses. It works on various attributes and with the help of it, it does route manipulation. Various attributes of BGP include:

A. As-Path

This attribute tell us the autonomous system, the respective packet has to traverse to reach respective network.

B. Next-Hop

This attribute is used to change the next hop to itself. While announcing a route to a router, router change the next hop value to itself.

C. Local Reference

This is a local value and it's local to an autonomous. It is used to change the decision of router within an AS.

D. Multi-Exit Discrimination (MED)

If a router has two routes to reach a network, the point with least MED value will be selected.

E. Origin

This attributes tells us the origin of the packet.

F. Community

This attribute is used to put a tag on the packet and then manipulation of the packet is done.

BGP routing protocol consist of bgp table which has all the routes to reach all the network. BGP has two variants : 1) EBGP (External BGP) and 2) IBGP (Internal BGP).EBGP should be directly connected neighbours and their AD value is 20 and IBGP neighbours may or may not be connected directly (AD value is 200). AD value of IBGP neighbours is greater than EBGP neighbours since EBGP are directly connected and trustworthy. BGP is used by utmost all the ISP's due to its route manipulation capability.

G. BGP Configuration

1) Fig 1.1 shows the architecture on which BGP is configured.
2) Fig 1.2 shows BGP configuration.
3) Fig 1.3 shows routers route table in which route is learned through BGP routing protocol, indicated with 'B' symbol.

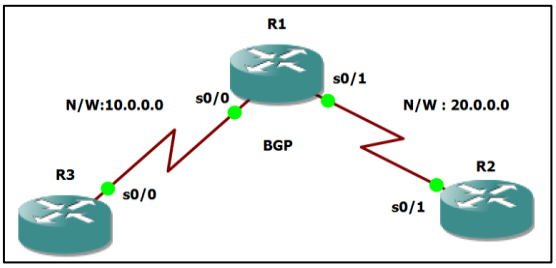

Fig. 1.1: Architecture

```
R2(config)# router bgp 65000
R2(config-router)#netw
R2(config-router)#network 20.0.0.0 mask 255.255.255.252
R2(config-router)#neighbor 20.0.0.1 remot
R2(config-router)#neighbor 20.0.0.1 remote-as 65400
R2(config-router)#exit
R2(config)#do wr
Building configuration...
[OK]
R2(config)#exit
```

Fig. 1.2: BGP Configuration

```
R3#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     20.0.0.0/30 is subnetted, 1 subnets
B       20.0.0.0 [20/0] via 10.0.0.2, 00:01:41
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, Serial0/0
R3#
```

Fig. 1.3: Routing Table

II. CIRCUIT IMPLEMENTATION & TESTING

The entire circuit is implemented in GNS3 and different entries in routers routing table is checked in the same.

1) Network Topology

First move is to create network topology as shown.

- Download router C3725 iso image.
- Open GNS3
- Go to edit, preferences, dynamips, iso image and add router image.
- Create network topology as shown in fig 2
- Select on WIC-2T on C3725 for enabling serial link.
- For Fast Ethernet select NM-1FE-TX in slots.

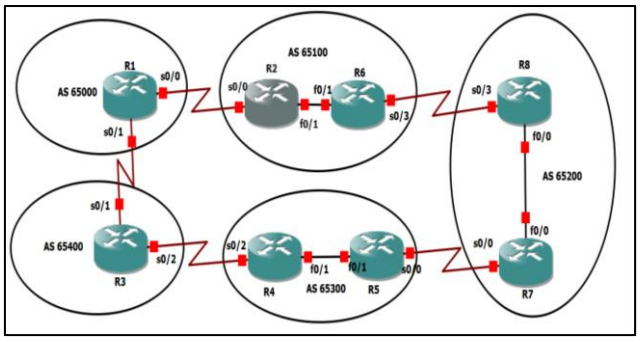

Fig. 2: Network Topology

2) Configuration of Interface

Go to router's R1 console and you will enter into privilege mode.

- All configuration is done in Global configuration mode.
- Press 'Configure terminal' to enter into global config. Mode.
- Select any interface which you have used in your router and provide ip address as shown in fig 3.
- IP can be any ip address of the subnet along with its mask and gateway used.

```
R1#conf
R1#configure t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int
R1(config)#interface fa
R1(config)#interface fastEthernet 0/1
R1(config-if)#ip add
R1(config-if)#ip address 30.0.0.1 255.0.0.0
R1(config-if)#no shut
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#
```

Fig. 3: IP Address Configuration

3) Routing Table of R1

Fig 4 shows the routing table of R1 router which consist of directly connected routes (C) and routes learned from BGP routing protocol (B).

- Fig 5 shows the ping reply of R1 router to Network 80.0.0.0.

```
R1#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     50.0.0.0/24 is subnetted, 1 subnets
B       50.0.0.0 [20/0] via 20.0.0.2, 00:02:59
     70.0.0.0/24 is subnetted, 1 subnets
B       70.0.0.0 [20/0] via 20.0.0.2, 00:02:59
     80.0.0.0/24 is subnetted, 1 subnets
B       80.0.0.0 [20/0] via 20.0.0.2, 00:02:59
     20.0.0.0/24 is subnetted, 1 subnets
C       20.0.0.0 is directly connected, Serial0/0
     40.0.0.0/24 is subnetted, 1 subnets
B       40.0.0.0 [20/0] via 20.0.0.2, 00:02:59
     90.0.0.0/24 is subnetted, 1 subnets
C       90.0.0.0 is directly connected, Serial0/1
     60.0.0.0/24 is subnetted, 1 subnets
B       60.0.0.0 [20/0] via 20.0.0.2, 00:03:03
     30.0.0.0/24 is subnetted, 1 subnets
B       30.0.0.0 [20/0] via 20.0.0.2, 00:17:49
```

Fig. 4: R1 routing table

```
R1#ping 80.0.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 80.0.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 96/109/132 ms
R1#
```

Fig. 5: R1 ping

4) Attributes of BGP

Various attributes of BGP are tested and manipulated, various attributes are mentioned below:

a) AS–Path

AS-path is the Autonomous system, the packet has travelled to reach the specific network.

- AS-path traversed can be seen in the path column of BGP network table as shown in fig 6.
- From router 1, AS-path to reach network 50.0.0.0 is from AS 65100, 65200 and this is the best path to reach the network, the other path is from AS 65400, 65300 and 65200.
- To check this table, use command 'show IP BGP 'in privilege mode.
- The second path is not selected as the best path since the packet has to travel 3 AS's.

```
*Mar  1 00:00:11.047: %LINK-5-CHANGED: Interface FastEthernet1/0, changed state to administratively down
*Mar  1 00:00:11.047: %LINK-5-CHANGED: Interface FastEthernet2/0, changed state to administratively down
*Mar  1 00:00:38.943: %BGP-5-ADJCHANGE: neighbor 20.0.0.2 Up
*Mar  1 00:00:41.143: %BGP-5-ADJCHANGE: neighbor 90.0.0.1 Up
R1#show ip bgp
BGP table version is 13, local router ID is 90.0.0.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 20.0.0.0/24      0.0.0.0                  0         32768 i
*> 30.0.0.0/24      20.0.0.2                 0             0 65100 i
*> 40.0.0.0/24      20.0.0.2                               0 65100 65200 i
*                   90.0.0.1                               0 65400 65300 65200 i
*> 50.0.0.0/24      20.0.0.2                               0 65100 65200 i
*                   90.0.0.1                               0 65400 65300 65200 i
*  60.0.0.0/24      20.0.0.2                               0 65100 65200 i
*>                  90.0.0.1                               0 65400 65300 i
*> 70.0.0.0/24      90.0.0.1                               0 65400 65300 i
*> 80.0.0.0/24      90.0.0.1                 0             0 65400 i
*  90.0.0.0/24      90.0.0.1                 0             0 65400 i
*>                  0.0.0.0                  0         32768 i
R1#
```

Fig 6: R1 BGP network table

b) Manipulation of route

- Manipulation of route is done with commands mentioned in fig 7.
- We have virtually added 2 AS's that is 222 222 in the middle of the AS 65100 and 65200 to reach network 50.0.0.0.
- Thus, the best path will be manipulated to the next path with 3 AS's (65400, 65300 & 65200).

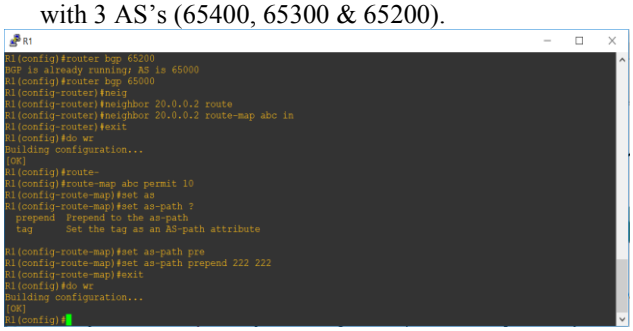

Fig. 7: AS-PATH manipulation

Thus, we can see the result in fig 8, the best path indicated with '>' is changed to the route via 65400, 65300 and 65200.

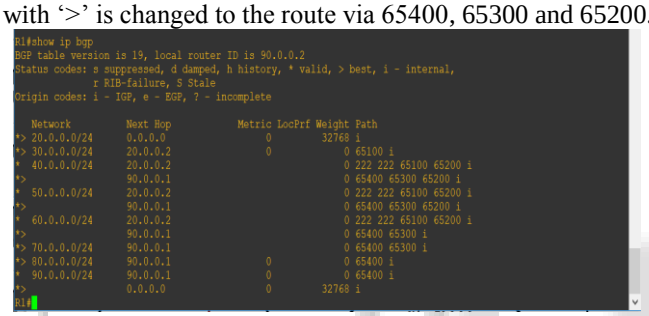

Fig. 8: Manipulated Route

c) MED

MED is local to a router, lower the MED value, and better the path.

- This attribute is used to change router's decision when it has multiple exit to reach a same AS.
- Fig 9 shows the network architecture, Fig 10 shows the steps to manipulate the MED attribute and Fig 11 shows the manipulated route.
- The path to reach network 40.0.0.0 has been manipulated with MED value as shown in fig 11.

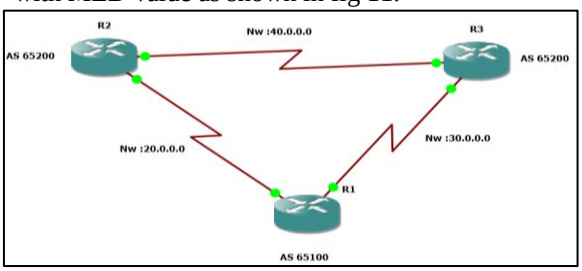

Fig 9: MED network architecture

```
R1(config)#router bgp 65100
R1(config-router)#neighbor 30.0.0.1 route-map xyz in
R1(config-router)#exit
R1(config)#rou
R1(config)#route-
R1(config)#route-map xyz permit 30
R1(config-route-map)#set
R1(config-route-map)#set me
R1(config-route-map)#set metric 150
R1(config-route-map)#exit
```

Fig 10: MED configuration

```
R1#show ip bgp
BGP table version is 5, local router ID is 30.0.0.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 20.0.0.0/24      0.0.0.0                  0         32768 i
*  30.0.0.0/24      30.0.0.1               150             0 65200 i
*>                  0.0.0.0                  0         32768 i
*> 40.0.0.0/24      30.0.0.1               150             0 65200 i
*                   20.0.0.2               500             0 65200 i
R1#
```

Fig. 11: Manipulated route

d) Local Preference and Next Hop Self

Local preference is local value to an AS, higher the value, better the path.

- In BGP, IBGP neighbours don't trust routes by other IBGP neighbour.
- So, the next hop changes to the next EBGP neighbour.
- To make next hop as IBGP, we use the Next hop-self attribute.
- Fig 13 shows the BGP table after running BGP protocol and we are going to manipulate route to reach network 30.0.0.0 from router R3. Next hop from R3 is the external router interface R1.
- Fig 14 shows Next hop configuration.
- Fig 15 shows the BGP table after NEXT hop attribute.
- Fig 16 shows local configuration for manipulating the route to reach 30.0.0.0 NW.
- Fig 17 shows the manipulated route.

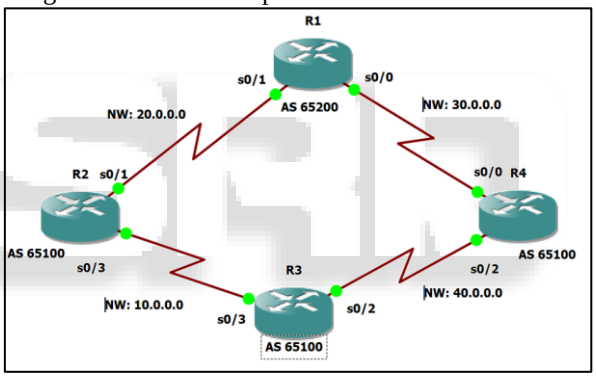

Fig. 12: Network Architecture

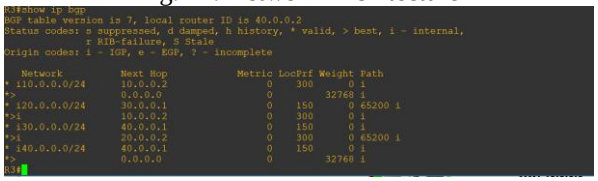

Fig. 13: Initial BGP Configuration

```
R2(config)#router bgp 65100
R2(config-router)#neighbor
R2(config-router)#neighbor 10.0.0.1 next
R2(config-router)#neighbor 10.0.0.1 next-hop-self
R2(config-router)#exit
R2(config)#
```

Fig. 14: Next Hop Configuration

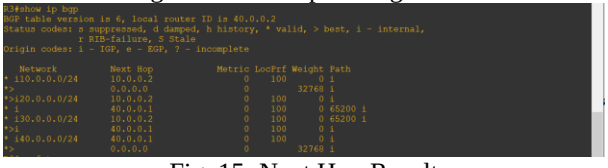

Fig. 15: Next Hop Result

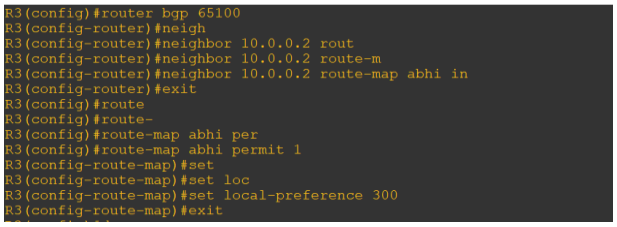

Fig. 16: Local Preference Configuration

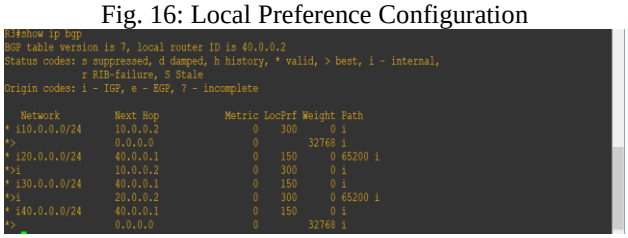

Fig. 17: Manipulated Route

III. Results & Discussion

- We have configured BGP routing protocol in the routers and observed the same.
- Various attributes such as AS-path, MED, Local preference and Next hop self were checked and manipulation performed on the same.
- After manipulation, routes to reach the specific network have been changed.
- Thus we have implemented the ultimate role of BGP , which is route manipulation.

References

[1] Issues and trends in router design S. Keshav R. Sharma skeshav@cs.cornell.edu sharma@cs.cornell.edu.

[2] Traffic Engineering With Traditional IP Routing Protocols Bernard Fortz Jennifer Rexford Mikkel Thorup Institut d'Administration et de Gestion Internet and Networking Systems Universite Catholique de Louvain AT&T Labs – Research Louvain-la-Neuve, Belgium Florham Park, NJ 07932 fortz@poms.ucl.ac.be jrex,mthorup @research.att.co.

[3] Network performance evaluation for RIP, OSPF and EIGRP routing protocols Ioan Fițigău Department of CommunicationGavril Toderean Department of Communication IEEE21OctoberDOI:10.1109/ECAI.2013.6636217.

[4] Andrew S. Tanenbaum, "Computer Networks 4Th Ed.", Prentice Hall, 2003.

[5] Lydia Parziale, David T. Britt, Chuck Davis "TCP/IP Tutorial and Technical Overview", ibm.com/redbooks, December 2006.

[6] B.R Smith , J.J Garcia- luna " Securing the border gateway protocol " DOI: 10.1109/GLOCOM.1996.586129 Proceedings of GLOBECOM'96. 1996 IEEE Global Telecommunications Conference.

