# DATA TRANSMISSION

## LAB5 – REPORT

Configuring BGP Routing Protocol

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## 1. Introduction

In this lab, the aim is to become familiarize with BGP. At first, the IP addresses for interfaces of the routers were chosen and during the lab session the devices were configured according to those IP addresses. Figure 1 shows the IP addresses for each interface.

| Router | Interface | IP Address | AS |
|---|---|---|---|
| R1 | e0/0 | 10.0.12.1/30 | 100 |
| | L0 | 1.1.1.1/32 | |
| | L1 | 192.168.11.1/24 | |
| R2 | e0/0 | 10.0.12.2/30 | 230 |
| | e0/1 | 10.0.24.1/30 | |
| | e0/2 | 10.0.23.1/30 | |
| | L0 | 2.2.2.2/32 | |
| | L1 | 192.168.21.1/24 | |
| R3 | e0/0 | 10.0.35.1/30 | 230 |
| | e0/2 | 10.0.23.2/30 | |
| | e0/3 | 10.0.34.1/30 | |
| | L0 | 3.3.3.3/32 | |
| | L1 | 92.168.31.1/24 | |
| R4 | e0/1 | 10.0.24.2/30 | 400 |
| | e0/2 | 10.0.45.1/30 | |
| | e0/3 | 10.0.34.2/30 | |
| | L0 | 4.4.4.4/32 | |
| | L1 | 192.168.41.1/24 | |
| | L2 | 192.168.42.1/24 | |
| | L3 | 192.168.43.1/24 | |
| R5 | e0/0 | 10.0.35.2/30 | 500 |
| | e0/2 | 10.0.45.2/30 | |
| | L0 | 5.5.5.5/32 | |
| | L1 | 192.168.51.1/24 | |
| | L2 | 192.168.52.1/24 | |

*Figure 1: IP addresses assigned to each interface*

In the figure the interfaces on the routers that forms a network highlighted with the same color so that reader can see the matching interfaces.

According to this lab the neighborhoods can be shown like below:

- R1 - R2
- R2 - R1, R3, R4
- R3 - R2, R4, R5
- R4 - R2, R3, R5
- R5 - R3, R4

In addition to these, I have been requested from the professor that I should inform the reader that I do not have a lab partner, thus, I did all the lab on my own.

## 2. Task 3A – IP Address Assignment

In this task the address assignment for the interfaces was excepted according to the topology given in the lab document.

After the configuration of the interfaces of routers (including loopback interfaces as well) with the designated IP addresses the commands **show cdp neighbor** and **show ip route** were typed. These are for verifying the addressing (neighbors of each router). The results of commands on each router are given below.

```
R1(config-if)#do 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
C    192.168.11.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.12.0 is directly connected, Ethernet0/0
R1(config-if)#do show cdp neighbor
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Eth 0/0            165        R S I      3640      Eth 0/0
R1(config-if)#
```

```
R2(config-if)#do 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

     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
C    192.168.21.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.12.0 is directly connected, Ethernet0/0
C       10.0.24.0 is directly connected, Ethernet0/1
C       10.0.23.0 is directly connected, Ethernet0/2
R2(config-if)#do show cdp neighbor
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R3               Eth 0/2            172        R S I      3640      Eth 0/2
R1               Eth 0/0            151        R S I      3640      Eth 0/0
R4               Eth 0/1            169        R S I      3640      Eth 0/1
R2(config-if)#
```

```
R3(config-if)#do 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

C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.23.0 is directly connected, Ethernet0/2
C       10.0.34.0 is directly connected, Ethernet0/3
C       10.0.35.0 is directly connected, Ethernet0/0
R3(config-if)#do show cdp neighbor
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Eth 0/2           171         R S I      3640      Eth 0/2
R4               Eth 0/3           137         R S I      3640      Eth 0/3
R5               Eth 0/0           157         R S I      3640      Eth 0/0
R3(config-if)#
```

```
R4(config-if)#do 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

C    192.168.42.0/24 is directly connected, Loopback2
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
C    192.168.43.0/24 is directly connected, Loopback3
C    192.168.41.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.24.0 is directly connected, Ethernet0/1
C       10.0.45.0 is directly connected, Ethernet0/2
C       10.0.34.0 is directly connected, Ethernet0/3
R4(config-if)#do show cdp neighbor
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Eth 0/1           158         R S I      3640      Eth 0/1
R3               Eth 0/3           129         R S I      3640      Eth 0/3
R5               Eth 0/2           127         R S I      3640      Eth 0/2
R4(config-if)#
```

```
R5(config-if)#do 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

     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 2 subnets
C       10.0.45.0 is directly connected, Ethernet0/2
C       10.0.35.0 is directly connected, Ethernet0/0
C    192.168.52.0/24 is directly connected, Loopback2
C    192.168.51.0/24 is directly connected, Loopback1
R5(config-if)#do show cdp neighbor
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R3               Eth 0/0            160        R S I      3640      Eth 0/0
R4               Eth 0/2            148        R S I      3640      Eth 0/2
R5(config-if)#
```

For all the routers, the entry for **show cdp neighbor** command shows that the router that this command is typed for is now neighbors of others just like specified in the lab document. In addition to this, the result of **show ip route** command shows us that all of the interfaces were configured as specified in Figure 1.

## 3. Task 3B – OSPF Configuration in AS 230

In this task it is requested to define IGP protocol, which is OSPF protocol in our case, between R2 and R3 so that they can communicate. This step is needed to configure BGP later.

After configuring OSPF, to ensure OSPF works properly **ping** command is used to see each router can ping one to another. The results can be seen below:

```
R2#ping 3.3.3.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/20/24 ms
R2#
```

```
R3#ping 2.2.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/24/36 ms
R3#
```

## 4. Task 3C – Basic BGP Configuration

In this part, it is expected to configure BGP protocol for all networks. At first, by typing the command **router bgp <AS number>** the routing process was started for the given autonomous system and with the help of **neighbor <ip address> remote-as <AS number>** command the neighbors were configured manually since there is no automatic discovery of the neighbor routers in BGP. This command allows us to define iBGP session between routers using the loopback 0 addresses. Then typing **neighbor <ip address> update-source <interface>** command allows us to define the source IP addresses for the BGP session between routers.

### I. Task C1

At first iBGP session is established with the second command written above between R2 and R3 and to see the state of the session **show ip bgp neighbors** command was run.

```
R2(config-router)#do show ip bgp neighbors
BGP neighbor is 3.3.3.3,  remote AS 230, internal link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active
  Last read 00:00:51, last write 00:00:51, hold time is 180, keepalive interval is 60 seconds
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  0          0
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             0          0
    Route Refresh:          0          0
    Total:                  0          0
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 0/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                              Sent       Rcvd
  Prefix activity:            ----       ----
    Prefixes Current:            0          0
    Prefixes Total:              0          0
    Implicit Withdraw:           0          0
    Explicit Withdraw:           0          0
    Used as bestpath:          n/a          0
    Used as multipath:         n/a          0

                                 Outbound    Inbound
  Local Policy Denied Prefixes:  --------    -------
    Total:                                0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 0; dropped 0
  Last reset never
  No active TCP connection
```

It can be seen from the above figure that the Loopback 0 address of R3 is now known as a BGP neighbor of R2, in AS 230 as internal link. The same is valid for Loopback 0 of R2 as well, it is now a neighbor of R3, and this can be seen below:

```
R3(config-router)#do show ip bgp neighbors
BGP neighbor is 2.2.2.2,  remote AS 230, internal link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active
  Last read 00:01:10, last write 00:01:10, hold time is 180, keepalive interval is 60 seconds
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  0          0
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             0          0
    Route Refresh:          0          0
    Total:                  0          0
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 0/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                              Sent       Rcvd
  Prefix activity:            ----       ----
    Prefixes Current:            0          0
    Prefixes Total:              0          0
    Implicit Withdraw:           0          0
    Explicit Withdraw:           0          0
    Used as bestpath:          n/a          0
    Used as multipath:         n/a          0

                                  Outbound    Inbound
  Local Policy Denied Prefixes:   --------    -------
    Total:                                0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 0; dropped 0
  Last reset never
  No active TCP connection
```

After this, the third command typed to specify the source IP addresses for BGP session between R2 and R3 and loopback 0 addresses used as source. Then **show ip bgp neighbors** command was run again and below the result can be seen that the session is established successfully, and loopback 0 addresses are set as remote router ID:

```
R2(config-router)#do show ip bgp neighbor
BGP neighbor is 3.3.3.3,  remote AS 230, internal link
  BGP version 4, remote router ID 192.168.31.1
  BGP state = Established, up for 00:00:38
  Last read 00:00:08, last write 00:00:08, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             2          2
    Route Refresh:          0          0
    Total:                  3          3
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:             0          0
    Prefixes Total:               0          0
    Implicit Withdraw:            0          0
    Explicit Withdraw:            0          0
    Used as bestpath:           n/a          0
    Used as multipath:          n/a          0

                                 Outbound    Inbound
  Local Policy Denied Prefixes:  --------    -------
    Total:                              0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 2.2.2.2, Local port: 60852
Foreign host: 3.3.3.3, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x1D3BDC):
Timer          Starts    Wakeups            Next
Retrans             4          0             0x0
TimeWait            0          0             0x0
AckHold             2          0             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 4123949915  snduna: 4123949999  sndnxt: 4123949999     sndwnd:  16301
irs: 3820351657  rcvnxt: 3820351741  rcvwnd:      16301  delrcvwnd:     83

SRTT: 184 ms, RTTO: 1852 ms, RTV: 1668 ms, KRTT: 0 ms
minRTT: 76 ms, maxRTT: 676 ms, ACK hold: 200 ms
Flags: active open, nagle
IP Precedence value : 6

Datagrams (max data segment is 536 bytes):
Rcvd: 5 (out of order: 0), with data: 2, total data bytes: 83
Sent: 5 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 3, total data bytes: 83
R2(config-router)#
```

```
R3(config-router)#do show ip bgp neighbors
BGP neighbor is 2.2.2.2,  remote AS 230, internal link
  BGP version 4, remote router ID 192.168.21.1
  BGP state = Established, up for 00:02:17
  Last read 00:00:17, last write 00:00:17, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             4          4
    Route Refresh:          0          0
    Total:                  5          5
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:             0          0
    Prefixes Total:               0          0
    Implicit Withdraw:            0          0
    Explicit Withdraw:            0          0
    Used as bestpath:           n/a          0
    Used as multipath:          n/a          0

                                 Outbound    Inbound
  Local Policy Denied Prefixes:  --------    -------
    Total:                              0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 3.3.3.3, Local port: 179
Foreign host: 2.2.2.2, Foreign port: 60852

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x1EAD80):
Timer          Starts    Wakeups            Next
Retrans             5          0             0x0
TimeWait            0          0             0x0
AckHold             5          4             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 3820351657  snduna: 3820351779  sndnxt: 3820351779     sndwnd:  16263
irs: 4123949915  rcvnxt: 4123950037  rcvwnd:      16263  delrcvwnd:    121

SRTT: 146 ms, RTTO: 1283 ms, RTV: 1137 ms, KRTT: 0 ms
minRTT: 76 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs
IP Precedence value : 6

Datagrams (max data segment is 536 bytes):
Rcvd: 9 (out of order: 0), with data: 5, total data bytes: 121
Sent: 9 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 4, total data bytes: 121
R3(config-router)#
```

## II. Task C2

In this step eBGP session is established between R1 and R2 by using the IP addresses of direct link in between, not loopback addresses. Since these routers are in different AS, to generate neighbors by using the default IP addresses of Ethernet0/0 interfaces, the below commands are typed:

For R1:

- router bgp 100
- neighbor 10.0.12.2 remote-as 230 (since R2 is in AS 230 its AS number is used)

For R2:

- router bgp 230
- neighbor 10.0.12.1 remote-as 100 (since R1 is in AS 100 its AS number is used)

To check the status of BGP adjacency on both routers the commands **show ip bgp summary** and **show ip bgp neighbors** typed and results can be seen below:

```
R1(config-router)#do show ip bgp summary
BGP router identifier 192.168.11.1, local AS number 100
BGP table version is 1, main routing table version 1

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.12.2       4   230       0       0        0    0    0 never    Active
```

```
R2(config-router)#do show ip bgp summary
BGP router identifier 192.168.21.1, local AS number 230
BGP table version is 1, main routing table version 1

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4   230       8       8        1    0    0 00:05:36        0
10.0.12.1       4   100       0       0        0    0    0 never    Active
R2(config-router)#
```

As it can be seen in the summary for R1, R2 is recognized as neighbor and the same is valid the other way around. Below the detailed information about the BGP neighbors of both routers can be seen and the remote IP addresses are the same values as written above:

```
R1(config-router)#do show ip bgp neighbors
BGP neighbor is 10.0.12.2,  remote AS 230, external link
  BGP version 4, remote router ID 192.168.21.1
  BGP state = OpenConfirm
  Last read 00:00:01, last write 00:00:01, hold time is 180, keepalive interval is 60 seconds
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             1          0
    Route Refresh:          0          0
    Total:                  2          1
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 0/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                                 Sent       Rcvd
 --More--
*Mar  1 00:36:32.503: %BGP-5-ADJCHANGE: neighbor 10.0.12.2 Up
  Prefix activity:               ----       ----
    Prefixes Current:               0          0
    Prefixes Total:                 0          0
    Implicit Withdraw:              0          0
    Explicit Withdraw:              0          0
    Used as bestpath:             n/a          0
    Used as multipath:            n/a          0

                                   Outbound    Inbound
  Local Policy Denied Prefixes:    --------    -------
    Total:                            0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 1
Local host: 10.0.12.1, Local port: 179
Foreign host: 10.0.12.2, Foreign port: 18149

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x21D014):
Timer          Starts    Wakeups            Next
Retrans             3          0             0x0
TimeWait            0          0             0x0
AckHold             2          0             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 2116615038  snduna: 2116615141  sndnxt: 2116615141     sndwnd:  16282
irs: 1895866984  rcvnxt: 1895867087  rcvwnd:      16282  delrcvwnd:    102

SRTT: 304 ms, RTTO: 3090 ms, RTV: 2786 ms, KRTT: 0 ms
minRTT: 432 ms, maxRTT: 1264 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 7 (out of order: 0), with data: 3, total data bytes: 102
Sent: 4 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 2, total data bytes: 102
```

```
R2(config-router)#do show ip bgp neighbors
BGP neighbor is 3.3.3.3,  remote AS 230, internal link
  BGP version 4, remote router ID 192.168.31.1
  BGP state = Established, up for 00:06:08
  Last read 00:00:08, last write 00:00:08, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             8          8
    Route Refresh:          0          0
    Total:                  9          9
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                                 Sent       Rcvd
  Prefix activity:               ----       ----
    Prefixes Current:               0          0
    Prefixes Total:                 0          0
    Implicit Withdraw:              0          0
    Explicit Withdraw:              0          0
    Used as bestpath:             n/a          0
    Used as multipath:            n/a          0

                                   Outbound    Inbound
  Local Policy Denied Prefixes:    --------    -------
    Total:                                0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 2.2.2.2, Local port: 60852
Foreign host: 3.3.3.3, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x242D2C):
Timer          Starts    Wakeups            Next
Retrans            12          0             0x0
TimeWait            0          0             0x0
AckHold            10          8             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 4123949915  snduna: 4123950151  sndnxt: 4123950151     sndwnd:  16149
irs: 3820351657  rcvnxt: 3820351893  rcvwnd:      16149  delrcvwnd:    235

SRTT: 377 ms, RTTO: 1343 ms, RTV: 966 ms, KRTT: 0 ms
minRTT: 76 ms, maxRTT: 676 ms, ACK hold: 200 ms
Flags: active open, nagle
IP Precedence value : 6

Datagrams (max data segment is 536 bytes):
Rcvd: 18 (out of order: 0), with data: 10, total data bytes: 235
Sent: 21 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 11, total data bytes: 235

BGP neighbor is 10.0.12.1,  remote AS 100, external link
  BGP version 4, remote router ID 192.168.11.1
  BGP state = Established, up for 00:02:31
  Last read 00:00:32, last write 00:00:33, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             5          5
    Route Refresh:          0          0
    Total:                  6          6
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1/0
 Output queue size : 0
  Index 2, Offset 0, Mask 0x4
  2 update-group member
                                 Sent       Rcvd
  Prefix activity:               ----       ----
    Prefixes Current:               0          0
    Prefixes Total:                 0          0
    Implicit Withdraw:              0          0
    Explicit Withdraw:              0          0
    Used as bestpath:             n/a          0
    Used as multipath:            n/a          0

                                   Outbound    Inbound
  Local Policy Denied Prefixes:    --------    -------
    Total:                                0          0
  Number of NLRIs in the update sent: max 0, min 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 1
Local host: 10.0.12.2, Local port: 18149
Foreign host: 10.0.12.1, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x2458D4):
Timer          Starts    Wakeups            Next
Retrans             6          1             0x0
TimeWait            0          0             0x0
AckHold             4          3             0x0
SendWnd             0          0             0x0
```

## III. Task C3

In this stage the task is to assign networks to BGP, i.e., to advertise prefixes via BGP, the **network <network prefix> mask <mask>** command is used. After this command is used the subnets added will be propagated by the BGP throughout the network.

At first network of Loopback1 of R1 is added to BGP and the same is done for R3 – network of L1 of R3 is added to BGP-. After this the tables of routers belonging to AS100 and AS230, which are R1, R2 and R3, checked with the following commands and the results for each router can be seen below the commands.

- **show ip route**
- **show ip bgp**

```
R1(config-router)#do 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
B    192.168.31.0/24 [20/0] via 10.0.12.2, 00:00:46
C    192.168.11.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.12.0 is directly connected, Ethernet0/0
R1(config-router)#do show ip bgp
BGP table version is 3, local router ID is 192.168.11.1
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
*> 192.168.11.0     0.0.0.0                  0         32768 i
*> 192.168.31.0     10.0.12.2                              0 230 i
R1(config-router)#
```

In the above picture we can see that the loopback 1 of R3 is shown in the table of R1 as an entry starting with letter B, which stands for BGP. In the BGP table we can see IP addresses the Loopback of R1 and R3 as well.

```
R2(config-router)#do 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

     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
B    192.168.31.0/24 [200/0] via 3.3.3.3, 00:01:26
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 10.0.23.2, 00:18:32, Ethernet0/2
B    192.168.11.0/24 [20/0] via 10.0.12.1, 00:02:07
C    192.168.21.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.12.0 is directly connected, Ethernet0/0
C       10.0.24.0 is directly connected, Ethernet0/1
C       10.0.23.0 is directly connected, Ethernet0/2
R2(config-router)#do show ip bgp
BGP table version is 3, local router ID is 192.168.21.1
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
*> 192.168.11.0     10.0.12.1                0             0 100 i
*>i192.168.31.0     3.3.3.3                  0    100      0 i
R2(config-router)#
```

In the table of R2 it is seen that both L1 of R1 and R3 is shown as BGP entry and in the BGP table we see those IP addresses as well.

```
R3(config-router)#do 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

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 10.0.23.1, 00:19:06, Ethernet0/2
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.23.0 is directly connected, Ethernet0/2
C       10.0.34.0 is directly connected, Ethernet0/3
C       10.0.35.0 is directly connected, Ethernet0/0
R3(config-router)#do show ip bgp
BGP table version is 2, local router ID is 192.168.31.1
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
* i192.168.11.0     10.0.12.1                0    100      0 100 i
*> 192.168.31.0     0.0.0.0                  0         32768 i
R3(config-router)#
```

In the table R3 we cannot see Loopback 1 of R1, but we see that the prefix is advertised in BGP table, however, the IP address of next hop is 10.0.12.1 which is the interface of R1 in the network between R1-R2 and this is unknown for R3. Thus, for R3 this address is inaccessible, and this is the reason we cannot see IP address of L1 of R1 in the routing table. To be able to fix this it is needed to override the next hop address in iBGP session between R2 and R3in the configuration of R2.

As a next step, in R2 with the help of the command **neighbor <ip address> next-hop-self** this issue is fixed. In here the Loopback 0 of R3 needs to be put in the place of <ip address> since the other side of iBGP session with R3 is pointing to this address, hence, the command becomes **neighbor 3.3.3.3 next-hop-self.** This way we make sure that R2 will send the prefix with substituted address during the specific BGP session. After this step, the above table of R3 has changed and the changes can be seen below:

```
R3(config-router)#do 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

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 10.0.23.1, 00:21:05, Ethernet0/2
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
B    192.168.11.0/24 [200/0] via 2.2.2.2, 00:00:11
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.23.0 is directly connected, Ethernet0/2
C       10.0.34.0 is directly connected, Ethernet0/3
C       10.0.35.0 is directly connected, Ethernet0/0
R3(config-router)#do show ip bgp
BGP table version is 3, local router ID is 192.168.31.1
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
*>i192.168.11.0     2.2.2.2                  0    100      0 100 i
*> 192.168.31.0     0.0.0.0                  0         32768 i
```

Now in the table, we can see that the Loopback 1 of R1 is placed as BGP entry, that means it should be accessible form R3. However, when we try to ping the IP address of L1 of R1 we see that the packages cannot be send as it can be seen below:

```
R3#ping 192.168.11.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
R3#
```

As it is seen above the success rate is zero, this is because even though R3 knows the way to R1, R1 does not know the way to R3, and ping commands works in both ways. As a result, packets can be sent to R1 but R3 cannot receive the acknowledgements from R1, and ping fails. The problem can be solved by advertising the R2-R3 interface via BGP session, but this will be done in one of the next tasks since it is not requested in the lab was not done in this phase.

## IV. Task C4

In this step all remaining eBGP sessions between Ass was set using the relevant IP addresses of the interfaces, not the loopback addresses. The summary of all BGP sessions of each routers can be seen below as a proof:

```
R1(config-router)#do show ip bgp summary
BGP router identifier 192.168.11.1, local AS number 100
BGP table version is 3, main routing table version 3
2 network entries using 234 bytes of memory
2 path entries using 104 bytes of memory
3/2 BGP path/bestpath attribute entries using 372 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 734 total bytes of memory
BGP activity 2/0 prefixes, 2/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.12.2       4   230      19      19        3    0    0 00:14:35        1
R1(config-router)#
```

```
R2(config-router)#do show ip bgp summary
BGP router identifier 192.168.21.1, local AS number 230
BGP table version is 3, main routing table version 3
2 network entries using 234 bytes of memory
2 path entries using 104 bytes of memory
3/2 BGP path/bestpath attribute entries using 372 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 734 total bytes of memory
BGP activity 2/0 prefixes, 2/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4   230      29      30        3    0    0 00:25:11        1
10.0.12.1       4   100      24      24        3    0    0 00:19:14        1
10.0.24.2       4   400       6       6        3    0    0 00:00:58        0
```

```
R3(config-router)#do show ip bgp summary
BGP router identifier 192.168.31.1, local AS number 230
BGP table version is 3, main routing table version 3
2 network entries using 234 bytes of memory
2 path entries using 104 bytes of memory
3/2 BGP path/bestpath attribute entries using 372 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 734 total bytes of memory
BGP activity 2/0 prefixes, 2/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
2.2.2.2         4   230      32      31        3    0    0 00:27:10        1
10.0.34.2       4   400       9       9        3    0    0 00:03:04        0
10.0.35.2       4   500       6       8        3    0    0 00:02:19        0
R3(config-router)#
```

```
R4(config-router)#do show ip bgp summary
BGP router identifier 192.168.43.1, local AS number 400
BGP table version is 3, main routing table version 3
2 network entries using 234 bytes of memory
6 path entries using 312 bytes of memory
6/2 BGP path/bestpath attribute entries using 744 bytes of memory
4 BGP AS-PATH entries using 96 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 1386 total bytes of memory
BGP activity 2/0 prefixes, 6/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.24.1       4   230       9       9        3    0    0 00:03:56        2
10.0.34.1       4   230      10      10        3    0    0 00:04:02        2
10.0.45.2       4   500       8       8        3    0    0 00:02:48        2
R4(config-router)#
```

```
R5(config-router)#do show ip bgp summary
BGP router identifier 192.168.52.1, local AS number 500
BGP table version is 3, main routing table version 3
2 network entries using 234 bytes of memory
4 path entries using 208 bytes of memory
5/2 BGP path/bestpath attribute entries using 620 bytes of memory
4 BGP AS-PATH entries using 96 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 1158 total bytes of memory
BGP activity 2/0 prefixes, 4/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.35.1       4   230      10       8        3    0    0 00:04:14        2
10.0.45.1       4   400       9       9        3    0    0 00:03:44        2
R5(config-router)#
```

We can see that all the sessions established by looking each entry of the tables, we can also get the information about AS numbers of the connected neighbors.

## V. Task C5

In this step the task is to advertise all remaining L1, L2 and L3 loopback addresses via BGP where the addresses are applicable. Then with the help of the command **show ip route** we can see those IP addressed were propagated into the routing tables of all routes and the information can be found below:

```
R1(config-router)#do 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
B    192.168.31.0/24 [20/0] via 10.0.12.2, 00:21:43
B    192.168.42.0/24 [20/0] via 10.0.12.2, 00:01:26
B    192.168.43.0/24 [20/0] via 10.0.12.2, 00:01:26
C    192.168.11.0/24 is directly connected, Loopback1
B    192.168.41.0/24 [20/0] via 10.0.12.2, 00:01:56
B    192.168.21.0/24 [20/0] via 10.0.12.2, 00:03:36
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.12.0 is directly connected, Ethernet0/0
B    192.168.52.0/24 [20/0] via 10.0.12.2, 00:00:56
B    192.168.51.0/24 [20/0] via 10.0.12.2, 00:00:56
R1(config-router)#
```

```
R2(config-router)#do 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

     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
B    192.168.31.0/24 [200/0] via 3.3.3.3, 00:21:24
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 10.0.23.2, 00:38:31, Ethernet0/2
B    192.168.42.0/24 [20/0] via 10.0.24.2, 00:01:08
B    192.168.43.0/24 [20/0] via 10.0.24.2, 00:01:08
B    192.168.11.0/24 [20/0] via 10.0.12.1, 00:22:06
B    192.168.41.0/24 [20/0] via 10.0.24.2, 00:01:38
C    192.168.21.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.12.0 is directly connected, Ethernet0/0
C       10.0.24.0 is directly connected, Ethernet0/1
C       10.0.23.0 is directly connected, Ethernet0/2
B    192.168.52.0/24 [20/0] via 10.0.24.2, 00:00:45
B    192.168.51.0/24 [20/0] via 10.0.24.2, 00:00:46
R2(config-router)#
```

```
R3(config-router)#do 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

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 10.0.23.1, 00:39:30, Ethernet0/2
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
B    192.168.42.0/24 [20/0] via 10.0.34.2, 00:02:07
B    192.168.43.0/24 [20/0] via 10.0.34.2, 00:02:07
B    192.168.11.0/24 [200/0] via 2.2.2.2, 00:18:37
B    192.168.41.0/24 [20/0] via 10.0.34.2, 00:02:38
B    192.168.21.0/24 [200/0] via 2.2.2.2, 00:04:17
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.23.0 is directly connected, Ethernet0/2
C       10.0.34.0 is directly connected, Ethernet0/3
C       10.0.35.0 is directly connected, Ethernet0/0
B    192.168.52.0/24 [20/0] via 10.0.35.2, 00:01:48
B    192.168.51.0/24 [20/0] via 10.0.35.2, 00:01:48
R3(config-router)#
```

```
R4(config-router)#do 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

B    192.168.31.0/24 [20/0] via 10.0.24.1, 00:10:38
C    192.168.42.0/24 is directly connected, Loopback2
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
C    192.168.43.0/24 is directly connected, Loopback3
B    192.168.11.0/24 [20/0] via 10.0.24.1, 00:10:39
C    192.168.41.0/24 is directly connected, Loopback1
B    192.168.21.0/24 [20/0] via 10.0.24.1, 00:04:26
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.24.0 is directly connected, Ethernet0/1
C       10.0.45.0 is directly connected, Ethernet0/2
C       10.0.34.0 is directly connected, Ethernet0/3
B    192.168.52.0/24 [20/0] via 10.0.45.2, 00:01:47
B    192.168.51.0/24 [20/0] via 10.0.45.2, 00:02:01
R4(config-router)#
```

```
R5(config-router)#do 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

B    192.168.31.0/24 [20/0] via 10.0.35.1, 00:10:34
B    192.168.42.0/24 [20/0] via 10.0.45.1, 00:02:49
B    192.168.43.0/24 [20/0] via 10.0.45.1, 00:02:49
     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
B    192.168.11.0/24 [20/0] via 10.0.35.1, 00:10:34
B    192.168.41.0/24 [20/0] via 10.0.45.1, 00:03:20
B    192.168.21.0/24 [20/0] via 10.0.35.1, 00:04:59
     10.0.0.0/30 is subnetted, 2 subnets
C       10.0.45.0 is directly connected, Ethernet0/2
C       10.0.35.0 is directly connected, Ethernet0/0
C    192.168.52.0/24 is directly connected, Loopback2
C    192.168.51.0/24 is directly connected, Loopback1
R5(config-router)#
```

In the entries starting with B, we can see all of the Loopbacks having BGP connection, hence, this proves that the addresses are advertised.

## VI. Task C6

In this task, the connection between advertised R5 Loopback 1 interface and R1 is checked on R1 at first by pinging the L1 of R5 from R1 and using L1 of R1 as source and we can see in the below picture the packets are sent successfully and when the traceroute is checked with the same addresses the route is set as R1-R2-R4-R5.

```
R1#ping 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.51.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.11.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 92/610/1456 ms
R1#traceroute 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 120 msec 20 msec 24 msec
  2 10.0.24.2 64 msec 40 msec 16 msec
  3 10.0.45.2 136 msec 124 msec 68 msec
R1#
```

By looking at the BGP table of each router we can see the path is like this. In the table of R1 we see for 192.168.51.0 the next hop is 10.12.2(R2) as it is in the first entry of the result of traceroute command.

```
R1#show ip bgp
BGP table version is 9, local router ID is 192.168.11.1
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
*> 192.168.11.0     0.0.0.0                  0         32768 i
*> 192.168.21.0     10.0.12.2                0             0 230 i
*> 192.168.31.0     10.0.12.2                              0 230 i
*> 192.168.41.0     10.0.12.2                              0 230 400 i
*> 192.168.42.0     10.0.12.2                              0 230 400 i
*> 192.168.43.0     10.0.12.2                              0 230 400 i
*> 192.168.51.0     10.0.12.2                              0 230 400 500 i
*> 192.168.52.0     10.0.12.2                              0 230 400 500 i
R1#
```

If we check the table of R2, we see that the next hop for 192.168.51.0 is 10.0.24.2(R4) as it is in the second entry of traceroute.

```
R2(config-router)#do show ip bgp
BGP table version is 9, local router ID is 192.168.21.1
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
*> 192.168.11.0     10.0.12.1                0             0 100 i
*> 192.168.21.0     0.0.0.0                  0         32768 i
*>i192.168.31.0     3.3.3.3                  0    100      0 i
*> 192.168.41.0     10.0.24.2                0             0 400 i
* i                  10.0.34.2                0    100      0 400 i
* i192.168.42.0     10.0.34.2                0    100      0 400 i
*>                  10.0.24.2                0             0 400 i
* i192.168.43.0     10.0.34.2                0    100      0 400 i
*>                  10.0.24.2                0             0 400 i
*> 192.168.51.0     10.0.24.2                              0 400 500 i
* i                  10.0.35.2                0    100      0 500 i
*> 192.168.52.0     10.0.24.2                              0 400 500 i
* i                  10.0.35.2                0    100      0 500 i
R2(config-router)#
```

When we look at the table of R4, there are 2 next hops for 192.168.51.0 which are 10.0.34.1 and 10.0.45.2. Route chooses 10.0.45.2. Then we reach the destination.

```
R4(config-router)#do show ip bgp
BGP table version is 9, local router ID is 192.168.43.1
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
*  192.168.11.0     10.0.45.2                              0 500 230 100 i
*>                  10.0.24.1                              0 230 100 i
*                   10.0.34.1                              0 230 100 i
*  192.168.21.0     10.0.45.2                              0 500 230 i
*                   10.0.34.1                              0 230 i
*>                  10.0.24.1                0             0 230 i
*  192.168.31.0     10.0.45.2                              0 500 230 i
*>                  10.0.24.1                              0 230 i
*                   10.0.34.1                0             0 230 i
*> 192.168.41.0     0.0.0.0                  0         32768 i
*> 192.168.42.0     0.0.0.0                  0         32768 i
*> 192.168.43.0     0.0.0.0                  0         32768 i
*  192.168.51.0     10.0.34.1                              0 230 500 i
*>                  10.0.45.2                0             0 500 i
*  192.168.52.0     10.0.34.1                              0 230 500 i
*>                  10.0.45.2                0             0 500 i
R4(config-router)#
```

The reason for this path is the same reason what we had in task C3. R5 announces the prefix, then R3 sends this information to R2 but it does not change the next hop value. Hence, R2 does not know how to get to this specified address, but, because of R4 being in a different AS, the value of next hop is modified as default and R2 know it can send packets R5 through R4.

The step we skipped in the task C3 which is configuring R3 to override the next hop in BGP advertisements with its own address is done by using the command **neighbor 2.2.2.2 next-hop-self.** Then the traceroute command is typed again:

```
R1#traceroute 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 20 msec 12 msec 20 msec
  2 10.0.23.2 40 msec 40 msec 40 msec
  3 10.0.35.2 84 msec 48 msec 76 msec
R1#
```

Now it can be seen that the packets go through R2-R3 which belongs to the same AS then arrives R5. The difference can be seen from tracing the tables of each router and in R2 now packets go to the interface of R3 since it has a better path and then from R3 it goes to R5.

```
R2(config-router)#do show ip bgp
BGP table version is 11, local router ID is 192.168.21.1
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
*> 192.168.11.0     10.0.12.1                0             0 100 i
*> 192.168.21.0     0.0.0.0                  0         32768 i
*>i192.168.31.0     3.3.3.3                  0    100      0 i
*> 192.168.41.0     10.0.24.2                0             0 400 i
* i                  3.3.3.3                  0    100      0 400 i
* i192.168.42.0     3.3.3.3                  0    100      0 400 i
*>                  10.0.24.2                0             0 400 i
* i192.168.43.0     3.3.3.3                  0    100      0 400 i
*>                  10.0.24.2                0             0 400 i
*  192.168.51.0     10.0.24.2                              0 400 500 i
*>i                 3.3.3.3                  0    100      0 500 i
*  192.168.52.0     10.0.24.2                              0 400 500 i
*>i                 3.3.3.3                  0    100      0 500 i
R2(config-router)#
```

```
R3(config-router)#neighbor 2.2.2.2 next-hop-self
R3(config-router)#do show ip bgp
BGP table version is 9, local router ID is 192.168.31.1
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
*>i192.168.11.0     2.2.2.2                  0    100      0 100 i
*>i192.168.21.0     2.2.2.2                  0    100      0 i
*> 192.168.31.0     0.0.0.0                  0         32768 i
*  192.168.41.0     10.0.35.2                              0 500 400 i
* i                  2.2.2.2                  0    100      0 400 i
*>                  10.0.34.2                0             0 400 i
* i192.168.42.0     2.2.2.2                  0    100      0 400 i
*                   10.0.35.2                              0 500 400 i
*>                  10.0.34.2                0             0 400 i
* i192.168.43.0     2.2.2.2                  0    100      0 400 i
*                   10.0.35.2                              0 500 400 i
*>                  10.0.34.2                0             0 400 i
*  192.168.51.0     10.0.34.2                              0 400 500 i
*>                  10.0.35.2                0             0 500 i
*  192.168.52.0     10.0.34.2                              0 400 500 i
*>                  10.0.35.2                0             0 500 i
R3(config-router)#
```

## 5. Task 3D – Advanced BGP Configuration

In this task, the goal is to become familiar to the Advance BGP configuration.

### I. Task D1 (Local Preference)

Local preference attribute is used to control how the traffic leaves a given AS system. It has no effect on the inbound traffic, it only allows network administrator to control the outbound traffic flow. It is only sent to all internal BGP routers in an autonomous system but not to the external peers.

In this task the goal is to configure AS230 in a way that all traffic from R1 to R4 will leave AS230 via the interface Ethernet 0/3 of R3.

```
R1#traceroute 192.168.41.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.41.1

  1 10.0.12.2 16 msec 12 msec 28 msec
  2 10.0.24.2 68 msec 32 msec 24 msec
R1#
```

Before the configuration was done the traceroute command was run on R1 to R4 by setting the source IP as L1 of R1. In the result we see that it goes R2 and then R4, but we want it to be from R2 to R3 and then to R4.

Hence, it is needed to set the value of local preference to a higher one than 100 since this is the default. By setting it to 200, we will be sure that the path we desired will be chosen since higher capacity links to a route will be preferred out of an AS.

The below commands were typed on R2 to manage the configuration mentioned above.

- **route-map local_preference permit 10**
- **set local-preference 200**
- **neighbor 3.3.3.3 route-map local_preference in**

To see the result, the clear option given in the lab document is used by typing **clear ip bgp 3.3.3.3 soft.** The result of **show ip bgp** will show us the result of these commands and as it can be seen below the local preferences changed.

```
R2#clear ip bgp 3.3.3.3 soft
R2#show ip bgp
BGP table version is 17, local router ID is 192.168.21.1
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
*> 192.168.11.0     10.0.12.1                0             0 100 i
*> 192.168.21.0     0.0.0.0                  0         32768 i
*>i192.168.31.0     3.3.3.3                  0    200      0 i
*  192.168.41.0     10.0.24.2                0             0 400 i
*>i                 3.3.3.3                  0    200      0 400 i
*>i192.168.42.0     3.3.3.3                  0    200      0 400 i
*                   10.0.24.2                0             0 400 i
*>i192.168.43.0     3.3.3.3                  0    200      0 400 i
*                   10.0.24.2                0             0 400 i
*  192.168.51.0     10.0.24.2                              0 400 500 i
*>i                 3.3.3.3                  0    200      0 500 i
*  192.168.52.0     10.0.24.2                              0 400 500 i
*>i                 3.3.3.3                  0    200      0 500 i
R2#
```

After the configuration, traceroute command was run again and the path is changed and become the one as we wanted it to become.

```
R1#traceroute 192.168.41.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.41.1

  1 10.0.12.2 4 msec 20 msec 20 msec
  2 10.0.23.2 48 msec 36 msec 40 msec
  3 10.0.34.2 56 msec 40 msec 56 msec
R1#
```

## II. Task D2 (Address Aggregation)

Address aggregation allows us to minimize the routing table of the routers by aggregating couple subnets into one network covering them. This way the size of routing tables can be decreased, and this is something chosen to be done because of the massive number of connections we have on Internet and if we want to choose advertising all IP addresses the size of the routing tables might become so large that it will become harder and harder to manage.

Using **aggregate address 192.168.48.0 255.255.248.0 summary-only** command on R5 we will have L1 and L2 subnets aggregated to 192.168.48.0/21 network and by typing summary-only only this network will be advertised and instead of having 2 entries for both L1 and L2 we will have 1 entry for this network. We can check the correction of this in the BGP table of R3 as it is shown below:

```
R3(config-router)#do show ip bgp
BGP table version is 14, local router ID is 192.168.31.1
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
*>i192.168.11.0     2.2.2.2                  0    100      0 100 i
*>i192.168.21.0     2.2.2.2                  0    100      0 i
*> 192.168.31.0     0.0.0.0                  0         32768 i
*  192.168.41.0     10.0.35.2                              0 500 400 i
*>                  10.0.34.2                0             0 400 i
*  192.168.42.0     10.0.35.2                              0 500 400 i
*>                  10.0.34.2                0             0 400 i
*  192.168.43.0     10.0.35.2                              0 500 400 i
*>                  10.0.34.2                0             0 400 i
*  192.168.48.0/21  10.0.34.2                              0 400 500 i
*>                  10.0.35.2                0             0 500 i
R3(config-router)#
```

In the last entry we see that we have the newly aggregated network is here instead of L1 and L2.

After this, traceroute command was run in R1, from R1 to R5 and using L1 of R1 as source, also, BGP table of R1 is shown as well. The result of both commands is:

```
R1#show ip bgp
BGP table version is 16, local router ID is 192.168.11.1
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
*> 192.168.11.0     0.0.0.0                  0         32768 i
*> 192.168.21.0     10.0.12.2                0             0 230 i
*> 192.168.31.0     10.0.12.2                              0 230 i
*> 192.168.41.0     10.0.12.2                              0 230 400 i
*> 192.168.42.0     10.0.12.2                              0 230 400 i
*> 192.168.43.0     10.0.12.2                              0 230 400 i
*> 192.168.48.0/21  10.0.12.2                              0 230 500 i
R1#traceroute 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 20 msec 16 msec 20 msec
  2 10.0.23.2 32 msec 36 msec 44 msec
  3 10.0.35.2 80 msec 40 msec 80 msec
R1#
```

### III. Task D3 (Path Prepending)

In this task the aim is to modify aggregate address advertisement on R5 with the help of path prepending in a way that the packets coming to L1 or L2 of R5 will come from AS400.

To be able to this, from getting help of the CiscoIOS Manual the following commands were typed.

```
R5(config)#access-list 35 permit 192.168.48.0 0.0.7.255
R5(config)#no route-map AS500
R5(config)#do show route-map

R5(config)#route-map inprepend permit 10
R5(config-route-map)#match ip address 35
R5(config-route-map)#set as-path prepend 500 500 500 500 500
R5(config-route-map)#router bgp 500
R5(config-router)#neighbor 10.0.35.1 route-map inprepend out
R5(config-router)#clear ip bgp 10.0.35.1 soft
                  ^
% Invalid input detected at '^' marker.

R5(config-router)#do clear ip bgp 10.0.35.1 soft
R5(config-router)#route-map inprepend permit 10
R5(config-route-map)#match ip address 35
R5(config-route-map)#set as-path prepend 400
R5(config-route-map)#router bgp 500
R5(config-router)#neighbor 10.0.35.1 route-map inprepend out
R5(config-router)#do clear ip bgp 10.0.35.1 soft
R5(config-router)#route-map inprepend permit 10
R5(config-route-map)#match ip address 35
R5(config-route-map)#$ prepend 400 400 400 400 400 400 400 400 400 400
R5(config-route-map)#router bgp 500
R5(config-router)#neighbor 10.0.35.1 route-map inprepend out
R5(config-router)#do clear ip bgp 10.0.35.1 soft
R5(config-router)#
```

Not all the commands on above figure were necessary but this happened because I tried to learn the effects of the commands.

In here the main idea is to set the path of the packets coming to the network 192.168.48.0/21 in a way that the interface of R4 will always be chosen. To do this I created an access list named 35 for this network with yellow shaded command above. Then generated a route-map called inprepend with permit of 10 and match the IP address with access-list 35. After these I set the as-path prepend with the values and assigned this route-map inprepend as out so that it will work the way we want. I changed the values couple times and tried to reach the aim that the path for interface 10.0.35.2 will not be chosen. The assigned path can be seen below:

```
R3(config-router)#do show ip bgp
BGP table version is 19, local router ID is 192.168.31.1
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
*>i192.168.11.0     2.2.2.2                  0    100      0 100 i
*>i192.168.21.0     2.2.2.2                  0    100      0 i
*> 192.168.31.0     0.0.0.0                  0         32768 i
*> 192.168.41.0     10.0.34.2                0             0 400 i
*> 192.168.42.0     10.0.34.2                0             0 400 i
*> 192.168.43.0     10.0.34.2                0             0 400 i
*> 192.168.48.0/21  10.0.34.2                              0 400 500 500 500 500 500 500 i
*                   10.0.35.2                0             0 500 400 400 400 400 400 400 400 400 400 400 i
R3(config-router)#
```

The path for 10.0.35.2 assigned longer so that 10.0.34.2, which is interface of R4, will be chosen always. The result of traceroute command has changed to R2-R3-R4-R5, and this proves that the above conditions are satisfied.

```
R1#traceroute 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 8 msec 20 msec 16 msec
  2 10.0.23.2 28 msec 40 msec 40 msec
  3 10.0.34.2 44 msec 56 msec 44 msec
  4 10.0.45.2 76 msec 68 msec 72 msec
R1#
```