

HY-335b

Project - Phase B

Configuring a “mini” world wide network.

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Question 2.1

Update-source is used to ensure that each router is using its own lo interface address as source address. Using the loopback interface instead of any other physical interface prevents the BGP session to go down in case a physical interface becomes unavailable, ensuring that the neighbour's IP address remains active for TCP connection. In order to use loopback addresses for a BGP session, the “*update-source lo*” command has to be properly configured when the internal BGP sessions are being established.

After configuring iBGP neighbors only in ATLA.

```
ATLA_router# show ip bgp summary

IPv4 Unicast Summary:
BGP router identifier 84.157.0.1, local AS number 84 vrf-id 0
BGP table version 0
RIB entries 0, using 0 bytes of memory
Peers 7, using 143 KiB of memory

Neighbor      V      AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down State/PfxRcd
84.151.0.1    4      84      0      0      0      0      0      never   Active
84.152.0.1    4      84      0      0      0      0      0      never   Active
84.153.0.1    4      84      0      0      0      0      0      never   Active
84.154.0.1    4      84      0      0      0      0      0      never   Active
84.155.0.1    4      84      0      0      0      0      0      never   Active
84.156.0.1    4      84      0      0      0      0      0      never   Active
84.158.0.1    4      84      0      0      0      0      0      never   Active

Total number of neighbors 7
```

After configuring iBGP neighbors in every router.

```
ATLA_router# show ip bgp summary

IPv4 Unicast Summary:
BGP router identifier 84.157.0.1, local AS number 84 vrf-id 0
BGP table version 0
RIB entries 0, using 0 bytes of memory
Peers 7, using 143 KiB of memory

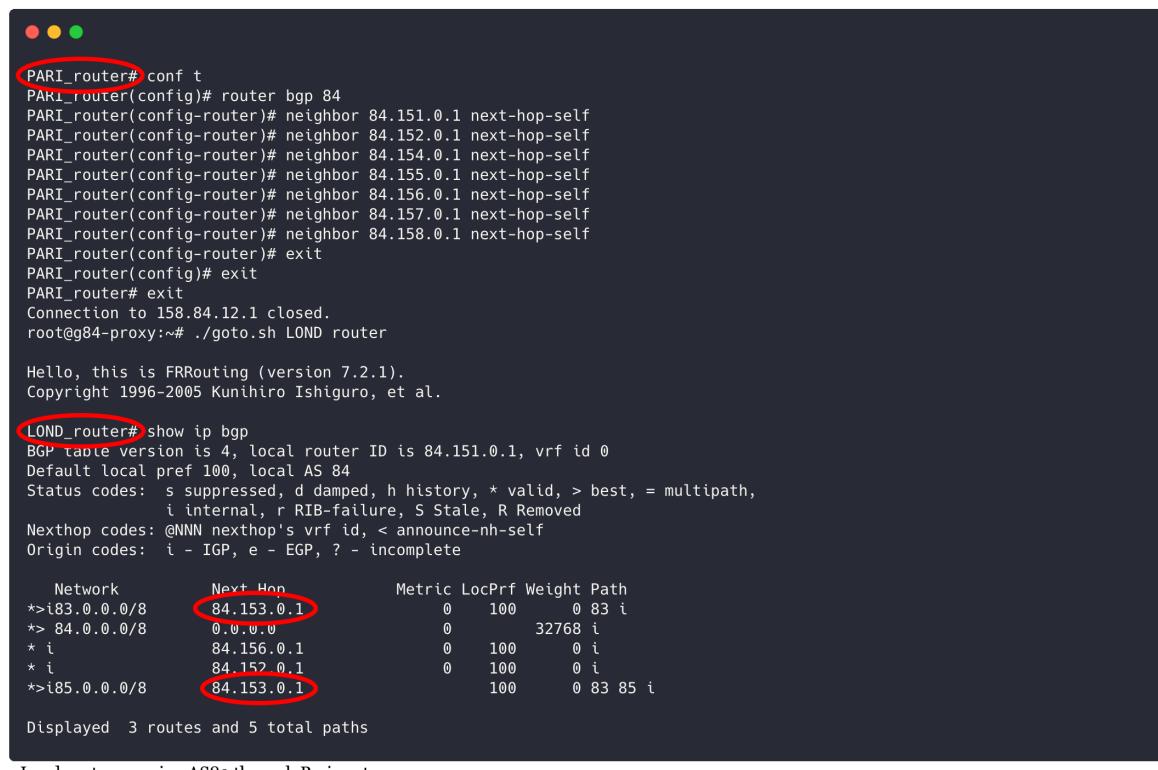
Neighbor      V      AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down State/PfxRcd
84.151.0.1    4      84     13     17      0      0      0      00:07:13   0
84.152.0.1    4      84     10     11      0      0      0      00:07:09   0
84.153.0.1    4      84     13     16      0      0      0      00:07:04   0
84.154.0.1    4      84     12     15      0      0      0      00:06:59   0
84.155.0.1    4      84     12     15      0      0      0      00:06:53   0
84.156.0.1    4      84      9     10      0      0      0      00:06:46   0
84.158.0.1    4      84      5      6      0      0      0      00:02:38   0

Total number of neighbors 7
```

Question 2.2

When setting up an eBGP connection, the router's interface address that is connected to the eBGP is initially distributed to the AS. Next-hop-self advertises the prefix of an external BGP connection of a router, to every other in its AS. When other routers need to send packets of the given prefix towards the eBGP, they send it to the initial router instead, without having to know the interface the packet will end up using. The router advertises itself as a path to the eBGP connection.

For example, PARI router needs to connect with AS83. By using next-hop-self, we let the iBGP know that PARI router is the one that handles this eBGP connection. In the example we can see that after setting this up, LOND router knows that 83.0.0.0/8 packets go through PARI. Once the packet arrives, PARI router uses its interface with AS83 to send it.



The screenshot shows a terminal window with two sessions: PARI_router and LOND_router.

PARI_router# conf t

```
PARI_router(config)# router bgp 84
PARI_router(config-router)# neighbor 84.151.0.1 next-hop-self
PARI_router(config-router)# neighbor 84.152.0.1 next-hop-self
PARI_router(config-router)# neighbor 84.154.0.1 next-hop-self
PARI_router(config-router)# neighbor 84.155.0.1 next-hop-self
PARI_router(config-router)# neighbor 84.156.0.1 next-hop-self
PARI_router(config-router)# neighbor 84.157.0.1 next-hop-self
PARI_router(config-router)# neighbor 84.158.0.1 next-hop-self
PARI_router(config-router)# exit
PARI_router(config)# exit
Connection to 158.84.12.1 closed.
root@g84-proxy:~# ./goto.sh LOND router
```

Hello, this is FRRouting (version 7.2.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

LOND_router# show ip bgp

```
BGP table version is 4, local router ID is 84.151.0.1, vrf id 0
Default local pref 100, local AS 84
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
              i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes: i - IGP, e - EGP, ? - incomplete

Network          Next Hop           Metric LocPrf Weight Path
*>i83.0.0.0/8    84.153.0.1        0      100      0 83 i
*> 84.0.0.0/8    0.0.0.0          0      32768    i
* i              84.156.0.1        0      100      0 i
* i              84.152.0.1        0      100      0 i
*>i85.0.0.0/8    84.153.0.1        100     0 83 85 i

Displayed 3 routes and 5 total paths
```

Lond router can ping AS83 through Pari router.

We can conclude that next-hop-self is required for every AS that uses an iBGP and needs to send information to one or more eBGP connections through a router, in order to advertise the prefix to the internal network.

The following screenshot displays the “show ip bgp” command when every router has gone through the process above, advertising itself for specific prefixes within the iBGP.



```
PARI_router# show ip bgp
BGP table version is 47, local router ID is 84.153.0.1, vrf id 0
Default local pref 100, local AS 84
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNNN nexthop's vrf id, < announce-nh-self
Origin codes: i - IGP, e - EGP, ? - incomplete

      Network          Next Hop            Metric LocPrf Weight Path
* 3.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 4 5 3 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 3 i
* 4.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 4 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 i
* 5.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 8 i
* >i              84.157.0.1          100      0 85 87 89 108 109 8 i
* 6.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 6 i
* >i              84.157.0.1          100      0 85 87 89 108 109 6 i
* 7.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 6 7 i
* >i              84.157.0.1          100      0 85 87 89 108 109 6 7 i
* 8.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 4 5 8 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 8 i
* 9.0.0.0/8        179.1.85.1          0       83 85 87 89 108 109 4 5 9 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 9 i
* 10.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 8 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 8 i
* 11.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 9 11 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 9 11 i
* 12.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 12 i
* >i              84.157.0.1          100      0 85 87 89 108 109 12 i
* 13.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 9 11 13 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 9 11 13 i
* 14.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 14 i
* >i              84.157.0.1          100      0 85 87 89 108 109 14 i
* 22.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 22 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 22 i
* 23.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 22 23 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 22 23 i
* 24.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 24 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 24 i
* 25.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 24 25 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 24 25 i
* 26.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 26 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 26 i
* 27.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 26 27 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 26 27 i
* 28.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 28 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 28 i
* 29.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 28 29 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 28 29 i
* 30.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 30 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 30 i
* 31.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 30 31 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 30 31 i
* 32.0.0.0/8       179.1.85.1          0       83 85 87 89 108 109 4 5 32 i
* >i              84.157.0.1          100      0 85 87 89 108 109 4 5 32 i
*>i61.0.0.0/8     84.155.0.1          0       61 i
*>i63.0.0.0/8     84.155.0.1          0       63 i
*>i64.0.0.0/8     84.155.0.1          100      61 64 i
*>i66.0.0.0/8     84.155.0.1          100      63 66 i
*>i67.0.0.0/8     84.155.0.1          0       67 i
*>i69.0.0.0/8     84.155.0.1          100      67 69 i
*>i72.0.0.0/8     84.155.0.1          100      67 70 72 i
*> 83.0.0.0/8      179.1.85.1          0       83 i
* i84.0.0.0/8      84.155.0.1          0       0 i
* i                84.158.0.1          0       0 i
* i                84.154.0.1          0       0 i
* i                84.157.0.1          0       0 i
*> 0.0.0.0          0                   32768 i
* i                84.151.0.1          0       0 i
* i                84.156.0.1          0       0 i
* i                84.152.0.1          0       0 i
*>i85.0.0.0/8     84.157.0.1          0       85 i
* 179.1.85.1       0                   0 83 85 i
* 89.0.0.0/8       179.1.85.1          0       83 85 87 89 i
*>i              84.157.0.1          100      85 87 89 i
* 90.0.0.0/8       179.1.85.1          0       83 85 87 89 90 i
*>i              84.155.0.1          0       90 i
* 91.0.0.0/8       179.1.85.1          0       83 85 87 89 91 i
*>i              84.155.0.1          100      90 91 i
* 92.0.0.0/8       179.1.85.1          0       83 85 87 89 92 i
*>i              84.155.0.1          100      90 92 i
* 103.0.0.0/8      179.1.85.1          0       83 85 87 89 108 109 4 5 8 103 i
*>i              84.157.0.1          100      85 87 89 108 109 4 5 8 103 i
* 108.0.0.0/8      179.1.85.1          0       83 85 87 89 108 i
*>i              84.157.0.1          100      85 87 89 108 109 i
* 109.0.0.0/8      179.1.85.1          0       83 85 87 89 108 109 i
*>i              84.157.0.1          100      85 87 89 108 109 i
* 110.0.0.0/8      179.1.85.1          0       83 85 87 89 108 110 i
*>i              84.157.0.1          100      85 87 89 108 110 i
```

Displayed 41 routes and 80 total paths

The screenshot below was taken with looking glass from 85-ZURI. As we can see, AS84 is being advertised.

```
python database-query.py 85-ZURI
Database query script, trigger timestamp --> ****2021-05-31 23:08:31****
85-ZURI
BGP table version is 2431, local router ID is 85.152.0.1, vrf id 0
Default local pref 100, local AS 85
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes: i - IGP, e - EGP, ? - incomplete

      Network          Next Hop            Metric LocPrf Weight Path
*>i1.0.0.0/8        85.155.0.1          50      0 108 109 4 5 22 23 26 1 i
*>i3.0.0.0/8        85.155.0.1          50      0 108 109 4 5 3 i
*>i4.0.0.0/8        85.155.0.1          50      0 108 109 4 i
*>i5.0.0.0/8        85.155.0.1          50      0 108 109 8 i
*>i6.0.0.0/8        85.155.0.1          50      0 108 109 6 i
*>i7.0.0.0/8        85.155.0.1          50      0 108 109 6 7 i
*>i8.0.0.0/8        85.155.0.1          50      0 108 109 4 5 8 i
*>i9.0.0.0/8        85.155.0.1          50      0 108 109 4 5 9 i
*>i10.0.0.0/8       85.155.0.1          50      0 108 109 4 5 8 i
*>i11.0.0.0/8       85.155.0.1          50      0 108 109 4 5 9 11 i
*>i12.0.0.0/8       85.155.0.1          50      0 108 109 12 i
*>i13.0.0.0/8       85.155.0.1          50      0 108 109 4 5 9 11 13 i
*>i14.0.0.0/8       85.155.0.1          50      0 108 109 14 i
*>i22.0.0.0/8       85.155.0.1          50      0 108 109 4 5 22 i
*>i23.0.0.0/8       85.155.0.1          50      0 108 109 4 5 22 23 i
*>i24.0.0.0/8       85.155.0.1          50      0 108 109 4 5 24 i
*>i25.0.0.0/8       85.155.0.1          50      0 108 109 4 5 24 25 i
*>i26.0.0.0/8       85.155.0.1          50      0 108 109 4 5 26 i
*>i27.0.0.0/8       85.155.0.1          50      0 108 109 4 5 24 25 27 i
*>i28.0.0.0/8       85.155.0.1          50      0 108 109 4 5 28 i
*>i29.0.0.0/8       85.155.0.1          50      0 108 109 4 5 28 29 i
*>i30.0.0.0/8       85.155.0.1          50      0 108 109 4 5 30 i
*>i31.0.0.0/8       85.155.0.1          50      0 108 109 4 5 30 31 i
*>i32.0.0.0/8       85.155.0.1          50      0 108 109 4 5 32 i
*  83.0.0.0/8        179.1.88.1         20      0 84 83 i
*>i                          85.155.0.1          50      0 83 i
*> 84.0.0.0/8        179.1.88.1         0      20      0 84 i
*  85.0.0.0/8        85.157.0.1          0      100     0 i
*  i                          85.155.0.1          0      100     0 i
*  i                          85.151.0.1          0      100     0 i
*  i                          85.154.0.1          0      100     0 i
*  i                          85.153.0.1          0      100     0 i
*  i                          85.158.0.1          0      100     0 i
*  i                          85.156.0.1          0      100     0 i
*> 0.0.0.0             0                  32768 i
*>i89.0.0.0/8        85.155.0.1          0      50      0 89 i
*>i103.0.0.0/8       85.155.0.1          50      0 108 109 4 5 8 103 i
*>i108.0.0.0/8       85.155.0.1          0      50      0 108 i
*>i109.0.0.0/8       85.155.0.1          50      0 108 109 i
*>i110.0.0.0/8       85.155.0.1          50      0 108 110 i

Displayed 32 routes and 40 total paths
```

The screenshot below is a traceroute from PARI router to PARI of AS83.

```
PARI_router# traceroute 83.153.0.1
traceroute to 83.153.0.1 (83.153.0.1), 64 hops max
 1  83.153.0.1  2.519ms  2.179ms  2.061ms
```

Question 2.3



```
NEWY_router# conf t
NEWY_router(config)# ip prefix-list OWN_PREFIX seq 5 permit 84.0.0.0/8      Create a prefix-list named OWN_PREFIX that stores our subnet.
NEWY_router(config)# route-map IXP_OUT permit 10                            Create a route-map named IXP_OUT used for filtering.
NEWY_router(config-route-map)# match ip address prefix-list OWN_PREFIX        If the ip address matches the prefix-list OWN_PREFIX.
NEWY_router(config-route-map)# set community 124:82 124:86 124:88 124:90 124:92 124:61 124:63 124:65 124:67 124:69          Establish connection with this community.
124:71
NEWY_router(config-route-map)# exit
NEWY_router(config)# router bgp 84
NEWY_router(config-router)# neighbor 180.124.0.124 route-map IXP_OUT out      Apply the route-map filter to the outbound traffic from the EXP.
NEWY_router(config-router)# exit
NEWY_router(config)# exit
```

Looking glass from AS61-ZURI has AS84 advertised to it.



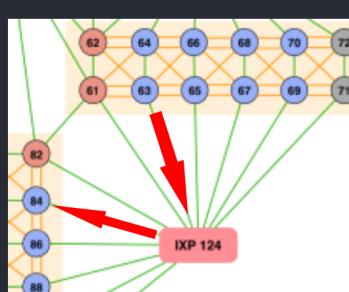
```
> python database-query.py 61-ZURI
Database query script, trigger timestamp --> ****2021-06-01 19:53:06****
61-ZURI
BGP table version is 3054, local router ID is 61.152.0.1, vrf id 0
Default local pref 100, local AS 61
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes: i - IGP, e - EGP, ? - incomplete

Network          Next Hop            Metric LocPrf Weight Path
*>i1.0.0.0/8     61.151.0.1        0      50    0 1 i
*>i2.0.0.0/8     61.151.0.1        0      50    0 2 i
*>i3.0.0.0/8     61.151.0.1        50    0 1 3 i
*  4.0.0.0/8      180.124.0.84      50    0 84 85 87 89 108 109 4 i
• • •
*> 67.0.0.0/8     179.0.27.2        100   0 63 66 67 i
*  180.124.0.67    0      50    0 67 i
*  69.0.0.0/8      180.124.0.69      0      50    0 69 i
*> 179.0.27.2        100   0 63 66 67 69 i
*  72.0.0.0/8      180.124.0.67      50    0 67 70 72 i
*> 179.0.27.2        100   0 63 66 67 69 72 i
*>i81.0.0.0/8     61.151.0.1        0      50    0 81 i
*  83.0.0.0/8      180.124.0.84      50    0 84 85 87 89 83 i
*> 179.0.27.2        100   0 63 66 67 69 84 85 87 89 83 i
*  84.0.0.0/8      180.124.0.84      0      50    0 84 i
*> 179.0.27.2        100   0 63 66 67 69 84 i
*  85.0.0.0/8      180.124.0.84      50    0 84 85 i
*> 179.0.27.2        100   0 63 66 67 69 84 85 i
*  87.0.0.0/8      180.124.0.84      50    0 84 85 87 i
*> 179.0.27.2        100   0 63 66 67 69 84 85 87 i
*  89.0.0.0/8      180.124.0.84      50    0 84 85 87 89 i
*> 179.0.27.2        100   0 63 66 67 69 84 85 87 89 i
• • •
*  110.0.0.0/8     180.124.0.84      50    0 84 85 87 89 110 i
*> 179.0.27.2        100   0 63 66 67 69 84 85 87 89 110 i

Displayed 61 routes and 91 total paths
```

Traceroute from AS63 towards AS84 the path goes through IXP124.

```
root@ba8e646f2945:~# ./launch_traceroute.sh 63 84.101.0.1
Hop 1: 63.0.199.1 TTL=0 during transit
Hop 2: 63.0.4.2 TTL=0 during transit
Hop 3: 63.0.7.2 TTL=0 during transit
Hop 4: 63.0.10.1 TTL=0 during transit
Hop 5: 180.124.0.84 TTL=0 during transit
Hop 6: 84.0.10.2 TTL=0 during transit
Hop 7: 84.0.7.1 TTL=0 during transit
Hop 8: 84.101.0.1 Echo reply (type=0/code=0)
Hop 9: 84.101.0.1 Echo reply (type=0/code=0)
Hop 10: 84.101.0.1 Echo reply (type=0/code=0)
```



Question 2.4

The community tags we've been instructed to use (that follow Gao_Rexford guidelines) are 84:20 for peers, 84:10 for customers and 84:30 for providers.

The screenshot below displays a peer-to-peer connection, specifically the NEWY with IXP124 link.

```
NEWY_router# conf t
NEWY_router(config)# route-map IXP_IN permit 10
NEWY_router(config-route-map)# set community 84:20
NEWY_router(config-route-map)# set local-preference 50
NEWY_router(config-route-map)# exit
NEWY_router(config)# ip prefix-list OWN_PREFIX seq 5 permit 84.0.0.0/8
NEWY_router(config)# bgp community-list 1 permit 84:10
NEWY_router(config)# route-map IXP_OUT permit 10
NEWY_router(config-route-map)# match ip address prefix-list OWN_PREFIX
NEWY_router(config-route-map)# set community 124:82 124:86 124:88 124:90 124:92 124:61 124:63 124:65 124:67 124:69
124:71
NEWY_router(config-route-map)# exit
NEWY_router(config)# route-map IXP_OUT permit 20
NEWY_router(config-route-map)# match community 1
NEWY_router(config-route-map)# set community 124:82 124:86 124:88 124:90 124:92 124:61 124:63 124:65 124:67 124:69
124:71
NEWY_router(config-route-map)# exit
NEWY_router(config)# router bgp 84
NEWY_router(config-router)# neighbor 180.124.0.124 route-map IXP_IN in
NEWY_router(config-router)# neighbor 180.124.0.124 route-map IXP_OUT out
NEWY_router(config-router)# exit
NEWY_router(config)# exit
NEWY_router#
```

Create a route-map named IXP_IN
Set that incoming traffic is tagged as Peer.
Set the priority of the incoming traffic.

Create a prefix-list named OWN_PREFIX of our subnet.
Create a community-list that matches outbound traffic with tag 10.

Create a route-map named IXP_OUT.
If ip address is in our prefix.
Announce prefix to the entire community connected through the IXP.

If ip is in the community 1 that has ip's with tag 10 (Customer).

Apply the route-map IXP_IN as filter for inbound traffic.
Apply the route-map IXP_OUT as filter for outbound traffic.

Examples of a customer and a provider connection are displayed in the screenshots below.

```
ZURI_router# conf t
ZURI_router(config)# route-map CUSTOMER_IN permit 10
ZURI_router(config-route-map)# set community 84:30
ZURI_router(config-route-map)# set local-preference 20
ZURI_router(config-route-map)# exit
ZURI_router(config)# ip prefix-list OWN_PREFIX seq 5 permit 84.0.0.0/8
ZURI_router(config)# bgp community-list 1 permit 84:10
ZURI_router(config)# route-map CUSTOMER_OUT permit 5
ZURI_router(config-route-map)# match ip address prefix-list OWN_PREFIX
ZURI_router(config-route-map)# exit
ZURI_router(config)# route-map CUSTOMER_OUT permit 10
ZURI_router(config-route-map)# match community 1
ZURI_router(config-route-map)# exit
ZURI_router(config)# router bgp 84
ZURI_router(config-router)# neighbor 179.0.37.1 route-map CUSTOMER_IN in
ZURI_router(config-router)# neighbor 179.0.37.1 route-map CUSTOMER_OUT out
ZURI_router(config-router)# exit
ZURI_router(config)# exit
ZURI_router#
```

```
GENE_router# conf t
GENE_router(config)# route-map PROVIDER_IN permit 10
GENE_router(config-route-map)# set community 84:10
GENE_router(config-route-map)# set local-preference 100
GENE_router(config-route-map)# exit
GENE_router(config)# router bgp 84
GENE_router(config-router)# neighbor 179.1.87.2 route-map PROVIDER_IN in
GENE_router(config-router)# exit
GENE_router(config)# exit
```

For AS84, AS81 and AS82 are providers. This means that their prefixes should NOT be advertised from AS84 to peers/providers. However, AS85 and AS86 are customers, which means that they SHOULD be advertised through AS84 to everyone. As indicated with green colour in the screenshot below, AS81 is being advertised by AS61 and AS81, even though it is also directly connected to AS84. On the other hand, indicated with red colour, AS85 which is a customer is advertised through AS84.

(AS82 and AS86 should also be in the screenshot but they are inactive.)

```

• • •

> python database-query.py 63-ZURI
Database query script, trigger timestamp --> ****2021-06-01 21:10:31****
63-ZURI
BGP table version is 2356, local router ID is 63.152.0.1, vrf id 0
Default local pref 100, local AS 63
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
              i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes: i - IGP, e - EGP, ? - incomplete

      Network          Next Hop          Metric LocPrf Weight Path
* i1.0.0.0/8        63.156.0.1        20      0 61 1 i
*>i                 63.151.0.1        20      0 61 1 i
* i2.0.0.0/8        63.156.0.1        20      0 61 2 i
*>i                 63.151.0.1        20      0 61 2 i
* i3.0.0.0/8        63.156.0.1        20      0 61 1 3 i
*>i                 63.151.0.1        20      0 61 1 3 i
*>i4.0.0.0/8        63.155.0.1        50      0 84 85 87 89 108 109 4 i
*>i5.0.0.0/8        63.155.0.1        50      0 84 85 87 89 108 109 8 i
• • •

* >i66.0.0.0/8      63.157.0.1        0      100    0 66 i
* >i67.0.0.0/8      63.157.0.1        100    0 66 67 i
* >i69.0.0.0/8      63.157.0.1        100    0 66 67 69 i
* >i72.0.0.0/8      63.157.0.1        100    0 66 67 69 72 i
* >i81.0.0.0/8    63.156.0.1        20      0 61 81 i   81 is our provider so we must not advertise he's
*>i                  63.151.0.1        20      0 61 81 i   prefixes to our peer (61) only to our providers.
* >i83.0.0.0/8      63.155.0.1        50      0 84 85 87 89 83 i
*>i84.0.0.0/8      63.155.0.1        0      50      0 84 i
*>i85.0.0.0/8    63.155.0.1        50      0 84 85 i   85 is our customer so we must advertise him to our
*>i87.0.0.0/8      63.155.0.1        50      0 84 85 87 i   peers (61 is our peer).
*>i89.0.0.0/8      63.155.0.1        50      0 84 85 87 89 i
*>i90.0.0.0/8      63.155.0.1        0      50      0 90 i
*>i91.0.0.0/8      63.155.0.1        50      0 90 91 i
*>i92.0.0.0/8      63.155.0.1        0      50      0 92 i
* i101.0.0.0/8      63.156.0.1        20      0 61 101 i
*>i                  63.151.0.1        20      0 61 101 i
*>i103.0.0.0/8      63.155.0.1        50      0 84 85 87 89 108 109 4 5 8 103 i
*>i105.0.0.0/8      63.155.0.1        50      0 84 85 87 89 108 109 105 i
*>i106.0.0.0/8      63.155.0.1        50      0 84 85 87 89 106 i
*>i108.0.0.0/8      63.155.0.1        50      0 84 85 87 89 108 i
*>i109.0.0.0/8      63.155.0.1        50      0 84 85 87 89 108 109 i
*>i110.0.0.0/8      63.155.0.1        50      0 84 85 87 89 110 i

Displayed 61 routes and 99 total paths

```

Finally, we launched a traceroute from one of our customers (AS85) to AS63, who is a peer via IXP124. As expected, the traceroute went from the IXP and not towards our provider, AS82.

```
root@ba8e646f2945:~# ./launch_traceroute.sh 85 63.101.0.1
Hop 1: 85.0.199.1 TTL=0 during transit
Hop 2: 179.1.88.1 TTL=0 during transit
Hop 3: 84.0.11.1 TTL=0 during transit
Hop 4: 180.124.0.63 TTL=0 during transit
Hop 5: 63.0.10.2 TTL=0 during transit
Hop 6: 63.0.7.1 TTL=0 during transit
Hop 7: 63.101.0.1 Echo reply (type=0/code=0)
Hop 8: 63.101.0.1 Echo reply (type=0/code=0)
Hop 9: 63.101.0.1 Echo reply (type=0/code=0)
Hop 10: 63.101.0.1 Echo reply (type=0/code=0)
Hop 11: 63.101.0.1 Echo reply (type=0/code=0)
Hop 12: 63.101.0.1 Echo reply (type=0/code=0)
```

The network diagram illustrates a traceroute path. On the left, nodes 81, 82, 83, 84, 85, and 86 are shown in blue circles. On the right, nodes 61, 63, 65, and 67 are shown in red circles. A pink rounded rectangle labeled "IXP 124" is positioned at the bottom right. Green lines represent connections between nodes, while orange lines represent connections between the blue and red groups. Red arrows point from node 85 to node 84, and from node 84 to node 63. A large red 'X' is placed over the connection between nodes 82 and 84. A red arrow also points from node 63 towards the IXP 124 area.

Question 2.5

After developing the .py files, running the client.py from student_1 while running server.py from LOND_host, PARI_host, BOST_host, NEWY_host, stud3, MIAM_host, ATLA_host and executing the command indicated in the screenshot, the desired result is produced with a simple traceroute format.

```

root@student_1:~/python# python3 client.py [LOND_host,PARI_host,BOST_host,NEWY_host,stud3,MIAM_host,ATLA_host]
LOND_host --> PARI_host
    Latency: 0.772 ms, Hops: 4.
LOND_host --> BOST_host
    Latency: 23.0 ms, Hops: 4.
LOND_host --> NEWY_host
    Latency: 22.2 ms, Hops: 5.
LOND_host --> stud3
    Latency: 13.9 ms, Hops: 4.
LOND_host --> MIAM_host
    Latency: 2.47 ms, Hops: 5.
LOND_host --> ATLA_host
    Latency: 22.3 ms, Hops: 7.

PARI_host --> LOND_host
    Latency: 0.307 ms, Hops: 4.
PARI_host --> BOST_host
    Latency: 20.5 ms, Hops: 5.
PARI_host --> NEWY_host
    Latency: 25.0 ms, Hops: 6.
PARI_host --> stud3
    Latency: 6.34 ms, Hops: 4.
PARI_host --> MIAM_host
    Latency: 1.10 ms, Hops: 4.
PARI_host --> ATLA_host
    Latency: 3.81 ms, Hops: 6.

BOST_host --> LOND_host
    Latency: 22.2 ms, Hops: 4.
BOST_host --> PARI_host
    Latency: 23.1 ms, Hops: 5.
BOST_host --> NEWY_host
    Latency: 1.25 ms, Hops: 4.
BOST_host --> stud3
    Latency: 40.1 ms, Hops: 5.
BOST_host --> MIAM_host
    Latency: 2.22 ms, Hops: 5.
BOST_host --> ATLA_host
    Latency: 4.58 ms, Hops: 6.

NEWY_host --> LOND_host
    Latency: 22.4 ms, Hops: 5.
NEWY_host --> PARI_host
    Latency: 22.5 ms, Hops: 6.
NEWY_host --> BOST_host
    Latency: 0.969 ms, Hops: 4.
NEWY_host --> stud3
    Latency: 40.3 ms, Hops: 6.
NEWY_host --> MIAM_host
    Latency: 1.37 ms, Hops: 4.
NEWY_host --> ATLA_host
    Latency: 6.91 ms, Hops: 5.

stud3 --> LOND_host
    Latency: 16.9 ms, Hops: 5.
stud3 --> PARI_host
    Latency: 13.3 ms, Hops: 4.
stud3 --> BOST_host
    Latency: 28.7 ms, Hops: 6.
stud3 --> NEWY_host
    Latency: 32.5 ms, Hops: 7.
stud3 --> MIAM_host
    Latency: 8.49 ms, Hops: 5.
stud3 --> ATLA_host
    Latency: 8.86 ms, Hops: 6.

MIAM_host --> LOND_host
    Latency: 1.65 ms, Hops: 5.
MIAM_host --> PARI_host
    Latency: 3.76 ms, Hops: 4.
MIAM_host --> BOST_host
    Latency: 3.99 ms, Hops: 6.
MIAM_host --> NEWY_host
    Latency: 1.38 ms, Hops: 4.
MIAM_host --> stud3
    Latency: 5.79 ms, Hops: 5.
MIAM_host --> ATLA_host
    Latency: 4.70 ms, Hops: 4.

ATLA_host --> LOND_host
    Latency: 24.4 ms, Hops: 6.
ATLA_host --> PARI_host
    Latency: 4.38 ms, Hops: 5.
ATLA_host --> BOST_host
    Latency: 6.22 ms, Hops: 5.
ATLA_host --> NEWY_host
    Latency: 4.52 ms, Hops: 5.
ATLA_host --> stud3
    Latency: 24.9 ms, Hops: 7.
ATLA_host --> MIAM_host
    Latency: 2.39 ms, Hops: 4.

root@LOND_host:~/python# python3 server.py 84.101.0.1
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.103.0.1', '84.106.0.1', '84.105.0.1', '84.200.0.3', '84.108.0.1', '84.107.0.1']
Tool finished
root@LOND_host:~/python#
```



```

root@PARI_host:~/python# python3 server.py 84.103.0.1
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.101.0.1', '84.106.0.1', '84.105.0.1', '84.200.0.3', '84.108.0.1', '84.107.0.1']
Tool finished
root@PARI_host:~/python#
```



```

root@BOST_host:~/python# python3 server.py 84.106.0.1
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.101.0.1', '84.103.0.1', '84.105.0.1', '84.200.0.3', '84.108.0.1', '84.107.0.1']
Tool finished
root@BOST_host:~/python#
```



```

root@NEWY_host:~/python# python3 server.py 84.105.0.1
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.101.0.1', '84.103.0.1', '84.106.0.1', '84.200.0.3', '84.108.0.1', '84.107.0.1']
Tool finished
root@NEWY_host:~/python#
```



```

root@student_3:~/python# python3 server.py 84.200.0.3
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.101.0.1', '84.103.0.1', '84.106.0.1', '84.105.0.1', '84.108.0.1', '84.107.0.1']
Tool finished
root@student_3:~/python#
```



```

root@MIAM_host:~/python# python3 server.py 84.108.0.1
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.101.0.1', '84.103.0.1', '84.106.0.1', '84.105.0.1', '84.200.0.3', '84.107.0.1']
Tool finished
root@MIAM_host:~/python#
```



```

root@ATLA_host:~/python# python3 server.py 84.107.0.1
['LOND_host', 'PARI_host', 'BOST_host', 'NEWY_host', 'stud3', 'MIAM_host', 'ATLA_host']
['84.101.0.1', '84.103.0.1', '84.106.0.1', '84.105.0.1', '84.200.0.3', '84.108.0.1']
Tool finished
root@ATLA_host:~/python#
```