Routerlab

Summer semester 2018

Worksheet 9
Group 08

Valentin Franck, 364066
Nikhil Singh, 387694

Pages: 30

Submission Date: July 5, 2018

Question 1

1a

There are the following four categories of path attributes:

- Well-known mandatory - needs to be included in every UPDATE message and understood by all BGP implementations
- Well-known discretionary - must be understood by all implementations, but are not necessarily included in every UPDATE message.
- Optional transitive - are not necessarily understood by all implementations and are never required to be included in a message. If such a Path is accepted, the (unrecognized) optional attribute must also be passed to other peers. In case such an attribute is not recognized the Patial Bit is set when passing the message.
- Optional non-transitive - are not necessarily understood by all implementations and are never required to be included in a message. If such an attribute is not recognized, then it must be excluded when passing the message to peers.

1b

The mandatory attributes, which are required in both eBGP and iBGP are: Origin, AS_Path and NEXT_HOP.

1c

BGP is a distance-vector protocol, because it works such that nodes tell each other their known "best" routes including a distance metric. This holds both for internal and external BGP. However, BGP UPDATE messages also include AS_PATH information, which goes beyond what distance vector protocols usually do, because it represents some limited knowledge of the used topology. Also BGP is heavily influenced by policy decision, which means that only a certain subset of possible routes will ever be advertised to peers.

1d

The default value for LOCAL_PREF is 100.

1e

BGP peers can aggregate several routes, when announcing them to a particular peer. In such case if the sender excludes some ASes which form part of the PATH, because it drops the AS_SET, it should include the ATOMIC_AGGREGATE attribute

1f

The first route is selected with the next hop 10.13.4.2.

1g

The route is chosen, because it was learned from a router with lower address and all other selection criteria are the same between both routes. So rule g) makes the tie break (according to the information we get from the given output).

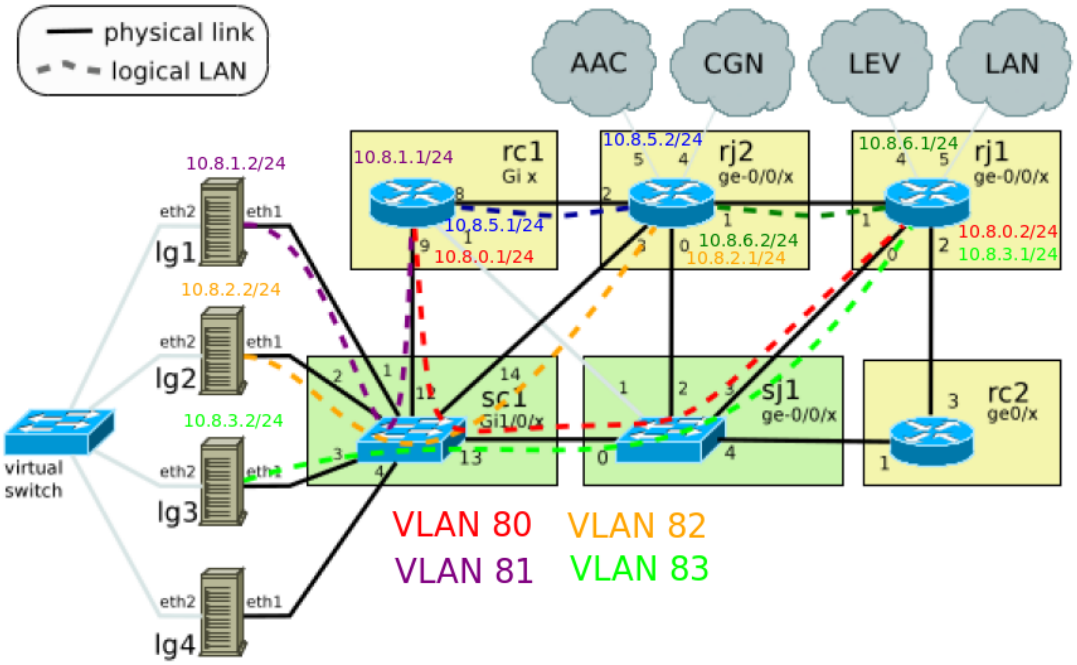

Figure 1: The topology we use for Question 2.

1h

Route reflectors are used to avoid the necessity of constructing a full mesh of all internal BGP routers, i.e. they are essential to make iBGP scale. Route reflectors act as servers and the routers connect as clients only to the route reflectors instead of every other router.

There may be several route reflectors inside one AS, which are also connected to each other and there respective peers (also called clusters). So when learning routes from clients and non-clients the route reflectors know where to propagate this route (e.g. routes learned from another route reflector are not announced to other route reflectors but only to clients and via eBGP).

1i

Looking Glass servers are connected to selected routers inside one AS and collect the routing information of these routers (read-only). They serve as a frontend for administrators that can easily access the information from remote routers via the looking glass for trouble shooting or just to check their routes. Looking glasses also provide some more statistical information regarding the BGP protocol, which can be useful to administrators when checking that everything works as intended.

Question 2

2a

We are using the topology as shown in Figure 1. On sc1 interface Gi1/0/1 VLAN81 is used in access mode. On interface Gi1/0/2 VLAN82 is used in access mode. On interface Gi1/0/3 VLAN83 is used in access mode. On interface Gi1/0/12 VLAN80 and VLAN 81 are used in trunk mode. On interface Gi1/0/13 VLAN 83 and VLAN 80 are used in trunk mode. On interface Gi1/0/14 VLAN 82 is used in access mode. On router rc1 interface Gi9 uses VLAN 80 and VLAN 81 in trunk mode. On switch sj1 interface ge-0/0/0 and ge-0/0/3, VLAN 80 and VLAN 83 are configured in trunk mode. On router rj2 interface ge-0/0/3, VLAN 82 is configured in access mode. On router rj1 interface ge-0/0/0, VLAN 80 and VLAN 83 are configured in trunk mode.

2b

We provide only the successful traceroutes (see Table):

```
root@group08-lg1:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.1.2 (10.8.1.2)  0.048 ms  0.016 ms  0.013 ms
root@group08-lg1:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.202 ms * *
root@group08-lg1:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.098 ms * *
root@group08-lg1:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.203 ms * *

root@group08-lg2:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.2.2 (10.8.2.2)  0.051 ms  0.016 ms  0.013 ms
root@group08-lg2:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  2.601 ms  2.553 ms  2.498 ms
root@group08-lg2:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.6.2 (10.8.6.2)  2.304 ms  2.199 ms  2.209 ms
root@group08-lg2:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.5.2 (10.8.5.2)  2.528 ms  2.496 ms  2.458 ms

root@group08-lg3:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.3.2 (10.8.3.2)  0.046 ms  0.014 ms  0.014 ms
root@group08-lg3:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  3.222 ms  3.172 ms  3.141 ms
root@group08-lg3:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.6.1 (10.8.6.1)  2.706 ms  2.663 ms  2.622 ms
root@group08-lg3:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.0.2 (10.8.0.2)  2.461 ms  2.383 ms  2.362 ms
```

Note that we configured default routes on the loadgens, because otherwise the rest of this assignment does not make much sense.

For our connectivity matrix see Table 1. We did not make it a square matrix including all configured interfaces, but only focused on the loadgens vs. all interfaces, so it is rectangular.

2c

From lg1 we can reach all the interfaces of rc1, because lg1 and rc1 form part of the same Vlan. Since we have not configured routing on the routers no other interfaces are reachable. Although we have a default route configured to rc1 (on lg1), the devices do not exchange routing information so that either rc1 is not able to forward our packet sent from lg1 (depending on the destination address) or at the latest at the destination device the route back to lg1 is unknown, so that it is impossible to receive a reply packet.

We hope this is the expected behavior. If we had turned routing off completely, it would have been to obvious we could only reach one interface of rc1 (in the same subnet as lg1).

Interface	LG1 10.8.1.2	LG2 10.8.2.2	LG3 10.8.3.2
10.8.0.1	✓	X	X
10.8.0.2	X	X	✓
10.8.1.1	✓	X	X
10.8.1.2	✓	X	X
10.8.2.1	X	✓	X
10.8.2.2	X	✓	X
10.8.3.1	X	X	✓
10.8.3.2	X	X	✓
10.8.5.1	✓	X	X
10.8.5.2	X	✓	X
10.8.6.1	X	X	✓
10.8.6.2	X	✓	X

Table 1: The initial connectivity matrix

2d

We configured the routers like this:

```
root@lev-rj1# set protocols bgp group external-peers type external
root@lev-rj1# set protocols bgp group external-peers neighbor 10.8.0.1
    peer-as 65001
root@lev-rj1# set protocols bgp group external-peers neighbor 10.8.6.2
    peer-as 65002
root@lev-rj1# set routing-options autonomous-system 65003
root@lev-rj1# set policy-options policy-statement send-direct term 1
    from protocol direct
root@lev-rj1# set policy-options policy-statement send-direct term 1
    then accept
root@lev-rj1# set protocols bgp group external-peers export send-direct

root@lev-rj2# set protocols bgp group external-peers type external
root@lev-rj2# set routing-options autonomous-system 65002
root@lev-rj2# set protocols bgp group external-peers neighbor 10.8.5.1
    peer-as 65001
root@lev-rj2# set protocols bgp group external-peers neighbor 10.8.6.1
    peer-as 65003
root@lev-rj1# set policy-options policy-statement send-direct term 1
    from protocol direct
root@lev-rj1# set policy-options policy-statement send-direct term 1
    then accept
root@lev-rj1# set protocols bgp group external-peers export send-direct

lev-rc1(config)#router bgp 65001
lev-rc1(config-router)#neighbor 10.8.5.2 remote-as 65002
lev-rc1(config)#router bgp 65001
lev-rc1(config-router)#neighbor 10.8.0.2 remote-as 65003
lev-rc1(config-router)#address-family ipv4
lev-rc1(config-router-af)#network 10.8.1.0 mask 255.255.255.0
lev-rc1(config-router-af)#network 10.8.0.0 mask 255.255.255.0
lev-rc1(config-router-af)#network 10.8.5.0 mask 255.255.255.0
```

2e

From lg1 -

```
root@group08-lg1:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.140 ms * *
root@group08-lg1:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.224 ms * *
root@group08-lg1:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.075 ms * *
root@group08-lg1:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.845 ms  0.794 ms  0.767 ms
 2  10.8.5.2 (10.8.5.2)  2.966 ms  2.905 ms  2.882 ms
root@group08-lg1:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.844 ms  0.800 ms  0.782 ms
 2  10.8.2.1 (10.8.2.1)  2.987 ms  2.947 ms  2.912 ms
root@group08-lg1:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.838 ms  0.797 ms  0.780 ms
 2  10.8.6.2 (10.8.6.2)  3.356 ms  3.323 ms  3.279 ms
root@group08-lg1:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.854 ms  0.807 ms  0.822 ms
 2  10.8.5.2 (10.8.5.2)  1.162 ms  1.129 ms  1.049 ms
 3  10.8.6.1 (10.8.6.1)  3.168 ms  3.128 ms  3.366 ms
root@group08-lg1:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.858 ms  0.817 ms  0.788 ms
 2  10.8.0.2 (10.8.0.2)  2.998 ms  2.960 ms  2.917 ms
root@group08-lg1:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.827 ms  0.790 ms  0.775 ms
 2  10.8.3.1 (10.8.3.1)  3.167 ms  3.123 ms  3.102 ms
root@group08-lg1:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.797 ms  0.743 ms  0.706 ms
 2  10.8.5.2 (10.8.5.2)  1.010 ms  0.959 ms  0.925 ms
 3  10.8.2.2 (10.8.2.2)  1.490 ms  1.458 ms  1.420 ms
root@group08-lg1:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.879 ms  0.825 ms  0.785 ms
 2  10.8.0.2 (10.8.0.2)  1.158 ms  1.133 ms  1.085 ms
 3  10.8.3.2 (10.8.3.2)  1.644 ms  1.614 ms  1.578 ms
```

From lg2 -

```
root@group08-lg2:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.616 ms  0.505 ms  0.541 ms
 2  10.8.5.1 (10.8.5.1)  1.162 ms  1.137 ms  1.097 ms
 3  10.8.1.2 (10.8.1.2)  1.449 ms  1.424 ms  1.378 ms
root@group08-lg2:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
```

```
 1  10.8.2.1 (10.8.2.1)  0.557 ms  0.514 ms  0.497 ms
 2  10.8.5.1 (10.8.5.1)  1.320 ms * *
root@group08-lg2:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.535 ms  0.474 ms  0.520 ms
 2  10.8.5.1 (10.8.5.1)  1.080 ms * *
root@group08-lg2:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.536 ms  0.486 ms  0.498 ms
 2  10.8.6.1 (10.8.6.1)  1.157 ms  1.117 ms  1.077 ms
 3  10.8.0.1 (10.8.0.1)  1.677 ms * *
root@group08-lg2:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.5.2 (10.8.5.2)  2.616 ms  2.525 ms  2.503 ms
root@group08-lg2:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  2.999 ms  2.858 ms  2.834 ms
root@group08-lg2:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.6.2 (10.8.6.2)  2.317 ms  2.209 ms  2.199 ms
root@group08-lg2:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.567 ms  0.516 ms  0.496 ms
 2  10.8.6.1 (10.8.6.1)  2.992 ms  2.954 ms  2.912 ms
root@group08-lg2:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.582 ms  0.488 ms  0.519 ms
 2  10.8.0.2 (10.8.0.2)  2.640 ms  2.601 ms  2.559 ms
root@group08-lg2:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.599 ms  0.501 ms  0.479 ms
 2  10.8.3.1 (10.8.3.1)  2.644 ms  2.583 ms  2.561 ms
root@group08-lg2:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.525 ms  0.471 ms  0.463 ms
 2  10.8.6.1 (10.8.6.1)  1.093 ms  1.045 ms  1.013 ms
 3  10.8.3.2 (10.8.3.2)  1.354 ms  1.324 ms  1.285 ms
```

From lg3 -

```
root@group08-lg3:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.547 ms  0.468 ms  0.520 ms
 2  10.8.0.1 (10.8.0.1)  1.104 ms  1.188 ms  1.156 ms
 3  10.8.1.2 (10.8.1.2)  1.306 ms  1.273 ms  1.241 ms
root@group08-lg3:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.573 ms  0.517 ms  0.473 ms
 2  10.8.6.2 (10.8.6.2)  1.121 ms  1.081 ms  1.039 ms
 3  10.8.2.2 (10.8.2.2)  1.294 ms  1.261 ms  1.220 ms
root@group08-lg3:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.584 ms  0.541 ms  0.545 ms
 2  10.8.0.1 (10.8.0.1)  1.145 ms * *
root@group08-lg3:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.634 ms  0.592 ms  0.562 ms
```

Interface	LG1 10.8.1.2	LG2 10.8.2.2	LG3 10.8.3.2
10.8.0.1	✓	✓	✓
10.8.0.2	✓	✓	✓
10.8.1.1	✓	✓	✓
10.8.1.2	✓	✓	✓
10.8.2.1	✓	✓	✓
10.8.2.2	✓	✓	✓
10.8.3.1	✓	✓	✓
10.8.3.2	✓	✓	✓
10.8.5.1	✓	✓	✓
10.8.5.2	✓	✓	✓
10.8.6.1	✓	✓	✓
10.8.6.2	✓	✓	✓

Table 2: The connectivity matrix after BGP is set up

```
 2  10.8.0.1 (10.8.0.1)  1.446 ms * *
root@group08-lg3:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.542 ms  0.464 ms  0.513 ms
 2  10.8.6.2 (10.8.6.2)  1.193 ms  1.156 ms  1.118 ms
 3  10.8.5.1 (10.8.5.1)  1.580 ms * *
root@group08-lg3:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.621 ms  0.542 ms  0.520 ms
 2  10.8.5.2 (10.8.5.2)  2.980 ms  2.949 ms  2.916 ms
root@group08-lg3:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.533 ms  0.446 ms  0.425 ms
 2  10.8.6.2 (10.8.6.2)  2.790 ms  2.734 ms  2.736 ms
root@group08-lg3:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.543 ms  0.457 ms  0.463 ms
 2  10.8.2.1 (10.8.2.1)  2.501 ms  2.406 ms  2.457 ms
root@group08-lg3:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.6.1 (10.8.6.1)  1.939 ms  1.850 ms  4.155 ms
root@group08-lg3:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.0.2 (10.8.0.2)  2.724 ms  2.624 ms  2.613 ms
root@group08-lg3:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  2.702 ms  2.606 ms  2.622 ms
```

For our connectivity matrix see Table 2. Again we did not make it a square matrix including all configured interfaces, but only focused on the loadgens vs. all interfaces, so it is rectangular.

2f

```
lev-rc1#show ip bgp
BGP table version is 11, local router ID is 10.8.5.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
    internal,
```

```
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-
                  Filter,
               x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.8.0.0/24      0.0.0.0                  0         32768 i
 *                    10.8.0.2                               0 65003 i
 *                    10.8.5.2                               0 65002
    65003 i
 *>  10.8.1.0/24      0.0.0.0                  0         32768 i
 *   10.8.2.0/24      10.8.0.2                               0 65003
    65002 i
 *>                   10.8.5.2                               0 65002 i
 *>  10.8.3.0/24      10.8.0.2                               0 65003 i
 *                    10.8.5.2                               0 65002
    65003 i
 *>  10.8.5.0/24      0.0.0.0                  0         32768 i
 *                    10.8.0.2                               0 65003
    65002 i
 *                    10.8.5.2                               0 65002 i
 *   10.8.6.0/24      10.8.0.2                               0 65003 i
 *>                   10.8.5.2                               0 65002 i
```

As per the dump of BGP routing table on rc1. Two routes are available on loadgen 2 and loadgen 3 each and one route is available on loadgen 1, which is parts of the same AS and therefore the other extern BGP speakers do not announce it back to rc1 (otherwise there would be a loop in the AS path).

2g

The best route is mentioned by *> in the dump. In this case the best path is chosen on the basis of the minimum number of AS path. For lg1 it is -

```
     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.8.0.0/24      0.0.0.0                  0         32768 i
```

For lg2 it is -

```
     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.8.2.0/24      10.8.5.2                               0 65002 i
```

For lg3 it is -

```
     Network          Next Hop            Metric LocPrf Weight Path
 *>  10.8.3.0/24      10.8.0.2                               0 65003 i
```

2h

RIB-failure means that a route is rejected when trying to select the best path. A RIB-failure means that the (valid and best) route is advertised in BGP, but it is not part of the IP routing table. (It is still advertised to peers in BGP.) This may happen for different reasons. Especially the first one should be considered:

- a better route is already available in IGP, e.g. configured by static routing
- a failure when performing the computations (such as memory failure)
- the number of routes is exceeded in VPN routing

2i

We can get a RIB-failure by manipulating the administrative distance. A RIB-failure will occur if the BGP route is valid and the best route, but there is another route with lower administrative distance. So we can set up static routing for a route and apply a lower administrative distance than for BGP. In such case we will see a RIB-failure.

For example we can set administrative distance to lg2 via rj2 to a low administrative distance and set the administrative distance of the externally learned BGP routes to lg2 to a higher value. Then rc1 will use the statically configured route and BGP will show a RIB-failure.

Here is how we achieved it from the previous setup including a verification of the resulting RIB-failure (metric for static route is 1, while the BGP routes have a metric of 20):

```
lev-rc1(config)#ip route 10.8.2.0 255.255.255.0 10.8.0.2 1

lev-rc1#show ip route
Codes: L - local, 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, H - NHRP, l -
           LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks
C        10.8.0.0/24 is directly connected, GigabitEthernet9.80
L        10.8.0.1/32 is directly connected, GigabitEthernet9.80
C        10.8.1.0/24 is directly connected, GigabitEthernet9.81
L        10.8.1.1/32 is directly connected, GigabitEthernet9.81
S        10.8.2.0/24 [1/0] via 10.8.0.2
B        10.8.3.0/24 [20/0] via 10.8.0.2, 00:11:53
C        10.8.5.0/24 is directly connected, GigabitEthernet8
L        10.8.5.1/32 is directly connected, GigabitEthernet8
B        10.8.6.0/24 [20/0] via 10.8.0.2, 00:11:10

lev-rc1# show ip bgp
BGP table version is 10, local router ID is 10.8.5.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
    internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
                  Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *   10.8.0.0/24      10.8.0.2                               0 65003 i
 *>                   0.0.0.0                  0         32768 i
 *>  10.8.1.0/24      0.0.0.0                  0         32768 i
 r   10.8.2.0/24      10.8.0.2                               0 65003
    65002 i
```

```
r>                    10.8.5.2                               0 65002 i
*    10.8.3.0/24      10.8.5.2                               0 65002
    65003 i
*>                    10.8.0.2                               0 65003 i
*    10.8.5.0/24      10.8.0.2                               0 65003
    65002 i
*                     10.8.5.2                               0 65002 i
*>                    0.0.0.0                  0         32768 i
*    10.8.6.0/24      10.8.5.2                               0 65002 i
*>                    10.8.0.2                               0 65003 i
```

Question 3

3a

We use route-map to set the maximum local-preference to any route announced by AS65002:

```
lev-rc1(config)#router bgp 65001
lev-rc1(config-router)#neighbor 10.8.5.2 route-map mymap in
lev-rc1(config-router)#exit
lev-rc1(config)#route-map mymap permit 10
lev-rc1(config)#match ip address 1
lev-rc1(config)#set community 10:1
lev-rc1(config)#continue
lev-rc1(config)#set local-preference 4294967295
lev-rc1(config)#end
lev-rc1#show route-map
route-map mymap, permit, sequence 10
  Match clauses:
    ip address (access-lists): 1
  Continue: to next entry is undefined
  Set clauses:
    local-preference 4294967295
    community 655361
  Policy routing matches: 0 packets, 0 bytes
```

And we see that all bgp routes go through AS65002 (on rc1). However the routes remain the same on rj1 and rj2:

```
lev-rc1#show ip bgp
BGP table version is 14, local router ID is 10.8.5.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
    internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
                  Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
*    10.8.0.0/24      10.8.0.2                               0 65003 i
*>                    0.0.0.0                  0         32768 i
*>   10.8.1.0/24      0.0.0.0                  0         32768 i
*    10.8.2.0/24      10.8.0.2                               0 65003
    65002 i
*>                    10.8.5.2                       4294967295      0
    65002 i
```

```
 *>  10.8.3.0/24       10.8.5.2                 4294967295        0
    65002 65003 i
 *                     10.8.0.2                               0 65003 i
 *   10.8.5.0/24       10.8.0.2                               0 65003
    65002 i
 *                     10.8.5.2                 4294967295        0
    65002 i
 *>                    0.0.0.0                  0         32768 i
 *>  10.8.6.0/24       10.8.5.2                 4294967295        0
    65002 i
 *                     10.8.0.2                               0 65003 i

lev-rc1# show ip route
Codes: L - local, 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, H - NHRP, l -
           LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks
C        10.8.0.0/24 is directly connected, GigabitEthernet9.80
L        10.8.0.1/32 is directly connected, GigabitEthernet9.80
C        10.8.1.0/24 is directly connected, GigabitEthernet9.81
L        10.8.1.1/32 is directly connected, GigabitEthernet9.81
B        10.8.2.0/24 [20/0] via 10.8.5.2, 00:09:31
B        10.8.3.0/24 [20/0] via 10.8.5.2, 00:09:31
C        10.8.5.0/24 is directly connected, GigabitEthernet8
L        10.8.5.1/32 is directly connected, GigabitEthernet8
B        10.8.6.0/24 [20/0] via 10.8.5.2, 00:09:31

root@lev-rj1# run show route
inet.0: 10 destinations, 17 routes (10 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
10.8.0.0/24             *[Direct/0] 00:37:31
                         > via ge-0/0/0.80
                         [BGP/170] 00:37:27, MED 0, localpref 100
                           AS path: 65001 I
                         > to 10.8.0.1 via ge-0/0/0.80
                         [BGP/170] 00:36:40, localpref 100
                           AS path: 65002 65001 I
                         > to 10.8.6.2 via ge-0/0/1.0
10.8.0.2/32             *[Local/0] 00:37:37
                           Local via ge-0/0/0.80
10.8.1.0/24             *[BGP/170] 00:37:27, MED 0, localpref 100
                           AS path: 65001 I
                         > to 10.8.0.1 via ge-0/0/0.80
                         [BGP/170] 00:36:40, localpref 100
```

```
                    AS path: 65002 65001 I
                  > to 10.8.6.2 via ge-0/0/1.0
10.8.2.0/24       *[BGP/170] 00:36:40, localpref 100
                    AS path: 65002 I
                  > to 10.8.6.2 via ge-0/0/1.0
                   [BGP/170] 00:36:26, localpref 100
                    AS path: 65001 65002 I
                  > to 10.8.0.1 via ge-0/0/0.80
10.8.3.0/24       *[Direct/0] 00:37:31
                  > via ge-0/0/0.83
10.8.3.1/32       *[Local/0] 00:37:37
                    Local via ge-0/0/0.83
10.8.5.0/24       *[BGP/170] 00:36:40, localpref 100
                    AS path: 65002 I
                  > to 10.8.6.2 via ge-0/0/1.0
                   [BGP/170] 00:36:26, MED 0, localpref 100
                    AS path: 65001 I
                  > to 10.8.0.1 via ge-0/0/0.80
10.8.6.0/24       *[Direct/0] 00:36:44
                  > via ge-0/0/1.0
                   [BGP/170] 00:36:40, localpref 100
                    AS path: 65002 I
                  > to 10.8.6.2 via ge-0/0/1.0
                   [BGP/170] 00:03:10, localpref 100
                    AS path: 65001 65002 I
                  > to 10.8.0.1 via ge-0/0/0.80
10.8.6.1/32       *[Local/0] 00:37:37
                    Local via ge-0/0/1.0
224.0.0.5/32      *[OSPF/10] 00:37:40, metric 1
                    MultiRecv

root@lev-rj2# run show route
inet.0: 9 destinations, 13 routes (9 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
10.8.0.0/24       *[BGP/170] 00:36:51, MED 0, localpref 100
                    AS path: 65001 I
                  > to 10.8.5.1 via ge-0/0/2.0
                   [BGP/170] 00:36:50, localpref 100
                    AS path: 65003 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.1.0/24       *[BGP/170] 00:36:51, MED 0, localpref 100
                    AS path: 65001 I
                  > to 10.8.5.1 via ge-0/0/2.0
                   [BGP/170] 00:36:50, localpref 100
                    AS path: 65003 65001 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.2.0/24       *[Direct/0] 00:36:55
                  > via ge-0/0/3.0
10.8.2.1/32       *[Local/0] 00:36:59
                    Local via ge-0/0/3.0
10.8.3.0/24       *[BGP/170] 00:36:50, localpref 100
                    AS path: 65003 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.5.0/24       *[Direct/0] 00:36:55
                  > via ge-0/0/2.0
                   [BGP/170] 00:36:37, MED 0, localpref 100
```

```
                    AS path: 65001 I
                  > to 10.8.5.1 via ge-0/0/2.0
10.8.5.2/32       *[Local/0] 00:36:59
                    Local via ge-0/0/2.0
10.8.6.0/24       *[Direct/0] 00:36:55
                  > via ge-0/0/1.0
                   [BGP/170] 00:36:50, localpref 100
                    AS path: 65003 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.6.2/32       *[Local/0] 00:36:59
                    Local via ge-0/0/1.0
```

3b

We can see that we still have the same reachability. However, there are additional hops introduced, when tracerouting from lg1 to lg3, because our traffic passes rj2, instead of rc1 directly forwarding it to rj1 (as it did before):

```
root@group08-lg1:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.843 ms  0.792 ms  0.804 ms
 2  10.8.0.2 (10.8.0.2)  3.256 ms  3.201 ms  3.174 ms
root@group08-lg1:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.119 ms * *
root@group08-lg1:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.157 ms * *
root@group08-lg1:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.1.2 (10.8.1.2)  0.067 ms  0.016 ms  0.014 ms
root@group08-lg1:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.809 ms  0.759 ms  0.719 ms
 2  10.8.5.2 (10.8.5.2)  1.040 ms  1.007 ms  0.969 ms
 3  10.8.2.2 (10.8.2.2)  1.489 ms  1.456 ms  1.416 ms
root@group08-lg1:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.897 ms  0.865 ms  0.833 ms
 2  10.8.2.1 (10.8.2.1)  3.113 ms  3.083 ms  3.044 ms
root@group08-lg1:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.839 ms  0.800 ms  0.785 ms
 2  10.8.5.2 (10.8.5.2)  1.100 ms  1.044 ms  1.020 ms
 3  10.8.3.1 (10.8.3.1)  3.003 ms  2.980 ms  2.943 ms
root@group08-lg1:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.767 ms  0.734 ms  0.743 ms
 2  10.8.5.2 (10.8.5.2)  1.042 ms  0.989 ms  0.957 ms
 3  10.8.6.1 (10.8.6.1)  1.446 ms  1.413 ms  1.373 ms
 4  10.8.3.2 (10.8.3.2)  1.689 ms  1.654 ms  1.614 ms
root@group08-lg1:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.123 ms * *
root@group08-lg1:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
```

```
 1  10.8.1.1 (10.8.1.1)  0.839 ms  0.789 ms  0.757 ms
 2  10.8.5.2 (10.8.5.2)  3.182 ms  3.126 ms  3.093 ms
root@group08-lg1:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.855 ms  0.823 ms  0.788 ms
 2  10.8.6.2 (10.8.6.2)  2.389 ms  2.337 ms  2.316 ms
root@group08-lg1:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.852 ms  0.747 ms  0.702 ms
 2  10.8.5.2 (10.8.5.2)  1.038 ms  0.987 ms  0.955 ms
 3  10.8.6.1 (10.8.6.1)  3.456 ms  3.407 ms  3.376 ms
```

In lg2 we see unchanged behaviour as before:

```
root@group08-lg2:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  1.984 ms  1.852 ms  1.854 ms
 2  10.8.5.1 (10.8.5.1)  1.850 ms * *
root@group08-lg2:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.544 ms  0.445 ms  0.440 ms
 2  10.8.5.1 (10.8.5.1)  1.040 ms  1.006 ms  1.021 ms
 3  10.8.0.2 (10.8.0.2)  3.196 ms  3.166 ms  3.308 ms
root@group08-lg2:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.599 ms  0.535 ms  0.501 ms
 2  10.8.5.1 (10.8.5.1)  1.204 ms * *
root@group08-lg2:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.631 ms  0.531 ms  0.520 ms
 2  10.8.5.1 (10.8.5.1)  1.093 ms  1.058 ms  1.075 ms
 3  10.8.1.2 (10.8.1.2)  1.350 ms  1.319 ms  1.277 ms
root@group08-lg2:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.2.2 (10.8.2.2)  0.061 ms  0.015 ms  0.013 ms
root@group08-lg2:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  1.947 ms  1.849 ms  1.853 ms
root@group08-lg2:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.603 ms  0.521 ms  0.525 ms
 2  10.8.3.1 (10.8.3.1)  3.129 ms  3.072 ms  3.079 ms
root@group08-lg2:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.569 ms  0.487 ms  0.489 ms
 2  10.8.6.1 (10.8.6.1)  1.124 ms  1.068 ms  1.016 ms
 3  10.8.3.2 (10.8.3.2)  1.401 ms  1.366 ms  1.325 ms
root@group08-lg2:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.5.2 (10.8.5.2)  2.408 ms  2.314 ms  2.309 ms
root@group08-lg2:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.603 ms  0.506 ms  0.488 ms
 2  10.8.5.1 (10.8.5.1)  1.188 ms * *
root@group08-lg2:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.605 ms  0.524 ms  0.528 ms
```

```
 2  10.8.6.1 (10.8.6.1)  3.167 ms  3.134 ms  3.158 ms
root@group08-lg2:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.6.2 (10.8.6.2)  2.638 ms  2.578 ms  2.558 ms
```

In lg3 we can see that everything works as expected except for the network 10.8.1.0/24 (and interface 10.8.0.1 of rc1) in which lg1 is located. While it is possible to ping the devices in this network it is not possible to traceroute them. This is because rc1 receives the traceroute packet forwarded by rj1, but it does not send the icmp reply back over the same link, but via rj2. This is why it does not work. (It works for the rest of interfaces, because in these cases rc1 is accessed via rj2, so the reply takes the same path)

```
root@group08-lg3:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.578 ms  0.522 ms  0.529 ms
 2  10.8.2.1 (10.8.2.1)  2.990 ms  2.936 ms  2.912 ms
root@group08-lg3:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.586 ms  0.509 ms  0.494 ms
 2  10.8.6.2 (10.8.6.2)  1.192 ms  1.135 ms  1.100 ms
 3  10.8.2.2 (10.8.2.2)  1.368 ms  1.345 ms  1.303 ms
root@group08-lg3:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.3.2 (10.8.3.2)  0.060 ms  0.016 ms  0.012 ms
root@group08-lg3:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  2.598 ms  2.498 ms  2.508 ms
root@group08-lg3:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.576 ms  0.491 ms  0.521 ms
 2  10.8.6.2 (10.8.6.2)  1.235 ms  1.203 ms  1.171 ms
 3  10.8.5.1 (10.8.5.1)  1.730 ms * *
root@group08-lg3:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.533 ms  0.481 ms  0.473 ms
 2  10.8.5.2 (10.8.5.2)  3.445 ms  3.392 ms  3.597 ms
root@group08-lg3:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.581 ms  0.535 ms  0.530 ms
 2  10.8.6.2 (10.8.6.2)  2.977 ms  2.937 ms  2.967 ms
root@group08-lg3:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.6.1 (10.8.6.1)  2.591 ms  2.495 ms  2.514 ms
root@group08-lg3:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.640 ms  0.558 ms  0.570 ms
 2  * * *
...
30  * * *
root@group08-lg3:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.590 ms  0.524 ms  0.486 ms
 2  * * *
...
30  * * *
root@group08-lg3:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
```

```
 1  10.8.3.1 (10.8.3.1)  0.564 ms  0.474 ms  0.511 ms
 2  * * *
...
30  * * *
root@group08-lg3:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.0.2 (10.8.0.2)  2.237 ms  2.189 ms  2.186 ms
```

3c

Setting the local preference for AS65002 in rj1:

```
[edit]
root@lev-rj1# set policy-options policy-statement local-pref-high term
    1 from protocol bgp
root@lev-rj1# set policy-options policy-statement local-pref-high term
    1 then local-preference 10000
[edit protocols bgp group external-peers neighbor 10.8.6.2]
root@lev-rj1# set import local-pref-high
```

We can now see that rj1 also routes all traffic via rj2 (except for the traffic towards lg3, which is directly connected only to rj1):

```
root@lev-rj1# run show route
inet.0: 10 destinations, 17 routes (10 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
10.8.0.0/24             *[Direct/0] 01:45:12
                         > via ge-0/0/0.80
                         [BGP/170] 00:31:19, localpref 10000
                           AS path: 65002 65001 I
                         > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 01:45:08, MED 0, localpref 100
                           AS path: 65001 I
                         > to 10.8.0.1 via ge-0/0/0.80
10.8.0.2/32             *[Local/0] 01:45:18
                           Local via ge-0/0/0.80
10.8.1.0/24             *[BGP/170] 00:31:19, localpref 10000
                           AS path: 65002 65001 I
                         > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 01:45:08, MED 0, localpref 100
                           AS path: 65001 I
                         > to 10.8.0.1 via ge-0/0/0.80
10.8.2.0/24             *[BGP/170] 00:31:19, localpref 10000
                           AS path: 65002 I
                         > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 01:44:07, localpref 100
                           AS path: 65001 65002 I
                         > to 10.8.0.1 via ge-0/0/0.80
10.8.3.0/24             *[Direct/0] 01:45:12
                         > via ge-0/0/0.83
10.8.3.1/32             *[Local/0] 01:45:18
                           Local via ge-0/0/0.83
10.8.5.0/24             *[BGP/170] 00:31:19, localpref 10000
                           AS path: 65002 I
                         > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 01:44:07, MED 0, localpref 100
                           AS path: 65001 I
```

```
                    > to 10.8.0.1 via ge-0/0/0.80
10.8.6.0/24         *[Direct/0] 01:44:25
                    > via ge-0/0/1.0
                     [BGP/170] 00:31:19, localpref 10000
                       AS path: 65002 I
                     > to 10.8.6.2 via ge-0/0/1.0
                     [BGP/170] 01:10:51, localpref 100
                       AS path: 65001 65002 I
                     > to 10.8.0.1 via ge-0/0/0.80
10.8.6.1/32         *[Local/0] 01:45:18
                       Local via ge-0/0/1.0
224.0.0.5/32        *[OSPF/10] 01:45:21, metric 1
                       MultiRecv
```

The routes learned from rc1 are not used any more:

```
root@lev-rj1# run show route receive-protocol bgp 10.8.6.2
inet.0: 10 destinations, 17 routes (10 active, 0 holddown, 0 hidden)
  Prefix                  Nexthop              MED     Lclpref    AS
     path
  10.8.0.0/24             10.8.6.2                                65002
     65001 I
* 10.8.1.0/24             10.8.6.2                                65002
    65001 I
* 10.8.2.0/24             10.8.6.2                                65002
    I
* 10.8.5.0/24             10.8.6.2                                65002
    I
  10.8.6.0/24             10.8.6.2                                65002
     I

root@lev-rj1# run show route receive-protocol bgp 10.8.0.1
inet.0: 10 destinations, 17 routes (10 active, 0 holddown, 0 hidden)
  Prefix                  Nexthop              MED     Lclpref    AS
     path
  10.8.0.0/24             10.8.0.1             0                  65001
     I
  10.8.1.0/24             10.8.0.1             0                  65001
     I
  10.8.2.0/24             10.8.0.1                                65001
     65002 I
  10.8.5.0/24             10.8.0.1             0                  65001
     I
  10.8.6.0/24             10.8.0.1                                65001
     65002 I
```

No changes at rj2:

```
root@lev-rj2# run show route
inet.0: 9 destinations, 12 routes (9 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both
10.8.0.0/24         *[BGP/170] 01:48:27, MED 0, localpref 100
                       AS path: 65001 I
                     > to 10.8.5.1 via ge-0/0/2.0
                     [BGP/170] 00:35:25, localpref 100
                       AS path: 65003 I
                     > to 10.8.6.1 via ge-0/0/1.0
10.8.1.0/24         *[BGP/170] 01:48:27, MED 0, localpref 100
```

```
                      AS path: 65001 I
                    > to 10.8.5.1 via ge-0/0/2.0
10.8.2.0/24         *[Direct/0] 01:48:31
                    > via ge-0/0/3.0
10.8.2.1/32         *[Local/0] 01:48:35
                      Local via ge-0/0/3.0
10.8.3.0/24         *[BGP/170] 00:35:25, localpref 100
                      AS path: 65003 I
                    > to 10.8.6.1 via ge-0/0/1.0
10.8.5.0/24         *[Direct/0] 01:48:31
                    > via ge-0/0/2.0
                     [BGP/170] 01:48:13, MED 0, localpref 100
                      AS path: 65001 I
                    > to 10.8.5.1 via ge-0/0/2.0
10.8.5.2/32         *[Local/0] 01:48:35
                      Local via ge-0/0/2.0
10.8.6.0/24         *[Direct/0] 01:48:31
                    > via ge-0/0/1.0
                     [BGP/170] 00:35:25, localpref 100
                      AS path: 65003 I
                    > to 10.8.6.1 via ge-0/0/1.0
10.8.6.2/32         *[Local/0] 01:48:35
                      Local via ge-0/0/1.0
```

Nothing changes for rc1:

```
lev-rc1#show ip route
Codes: L - local, 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, H - NHRP, l -
           LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks
C        10.8.0.0/24 is directly connected, GigabitEthernet9.80
L        10.8.0.1/32 is directly connected, GigabitEthernet9.80
C        10.8.1.0/24 is directly connected, GigabitEthernet9.81
L        10.8.1.1/32 is directly connected, GigabitEthernet9.81
B        10.8.2.0/24 [20/0] via 10.8.5.2, 01:16:15
B        10.8.3.0/24 [20/0] via 10.8.5.2, 00:36:44
C        10.8.5.0/24 is directly connected, GigabitEthernet8
L        10.8.5.1/32 is directly connected, GigabitEthernet8
B        10.8.6.0/24 [20/0] via 10.8.5.2, 01:16:15
```

3d

```
root@group08-lg1:~# traceroute 10.8.1.1
```

```
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.035 ms * *
root@group08-lg1:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.1.2 (10.8.1.2)  0.060 ms  0.017 ms  0.013 ms
root@group08-lg1:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.766 ms  0.756 ms  0.736 ms
 2  10.8.5.2 (10.8.5.2)  1.071 ms  1.047 ms  1.018 ms
 3  10.8.2.2 (10.8.2.2)  1.541 ms  1.519 ms  1.475 ms
root@group08-lg1:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.779 ms  0.746 ms  0.764 ms
 2  10.8.2.1 (10.8.2.1)  3.031 ms  2.979 ms  2.948 ms
root@group08-lg1:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.824 ms  0.752 ms  0.774 ms
 2  10.8.5.2 (10.8.5.2)  1.038 ms  0.986 ms  0.957 ms
 3  10.8.3.1 (10.8.3.1)  3.139 ms  3.113 ms  3.075 ms
root@group08-lg1:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.822 ms  0.777 ms  0.744 ms
 2  10.8.5.2 (10.8.5.2)  1.029 ms  0.979 ms  0.950 ms
 3  10.8.6.1 (10.8.6.1)  1.530 ms  1.498 ms  1.458 ms
 4  10.8.3.2 (10.8.3.2)  1.702 ms  1.673 ms  1.634 ms
root@group08-lg1:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.821 ms  0.770 ms  0.753 ms
 2  10.8.5.2 (10.8.5.2)  3.114 ms  3.063 ms  3.037 ms
root@group08-lg1:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.813 ms * *
root@group08-lg1:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.842 ms  0.811 ms  0.765 ms
 2  10.8.5.2 (10.8.5.2)  1.085 ms  1.045 ms  1.007 ms
 3  10.8.6.1 (10.8.6.1)  3.597 ms  3.568 ms  3.531 ms
root@group08-lg1:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.785 ms  0.738 ms  0.730 ms
 2  10.8.6.2 (10.8.6.2)  3.252 ms  3.200 ms  3.174 ms
 root@group08-lg1:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.879 ms  0.836 ms  0.800 ms
 2  * * *
...
30  * * *
root@group08-lg1:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.151 ms * *

root@group08-lg2:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.598 ms  0.525 ms  0.491 ms
 2  10.8.5.1 (10.8.5.1)  1.127 ms * *
root@group08-lg2:~# traceroute 10.8.1.2
```

```
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.532 ms  0.479 ms  0.493 ms
 2  10.8.5.1 (10.8.5.1)  1.009 ms  1.058 ms  1.020 ms
 3  10.8.1.2 (10.8.1.2)  1.374 ms  1.340 ms  1.299 ms
root@group08-lg2:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.2.2 (10.8.2.2)  0.047 ms  0.016 ms  0.013 ms
root@group08-lg2:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  2.345 ms  2.284 ms  2.263 ms
root@group08-lg2:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.539 ms  0.476 ms  0.474 ms
 2  10.8.3.1 (10.8.3.1)  2.698 ms  2.639 ms  2.667 ms
root@group08-lg2:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.609 ms  0.526 ms  0.498 ms
 2  10.8.6.1 (10.8.6.1)  1.224 ms  1.168 ms  1.139 ms
 3  10.8.3.2 (10.8.3.2)  1.345 ms  1.312 ms  1.272 ms
root@group08-lg2:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.5.2 (10.8.5.2)  3.074 ms  3.032 ms  2.996 ms
root@group08-lg2:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.610 ms  0.485 ms  0.472 ms
 2  10.8.5.1 (10.8.5.1)  1.141 ms * *
root@group08-lg2:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.561 ms  0.506 ms  0.489 ms
 2  10.8.6.1 (10.8.6.1)  2.945 ms  2.922 ms  2.884 ms
root@group08-lg2:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.6.2 (10.8.6.2)  2.524 ms  2.468 ms  2.430 ms
root@group08-lg2:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.667 ms  0.608 ms  0.559 ms
 2  10.8.5.1 (10.8.5.1)  1.060 ms  1.021 ms  1.030 ms
 3  10.8.0.2 (10.8.0.2)  3.215 ms  3.167 ms  3.144 ms
root@group08-lg2:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.659 ms  0.576 ms  0.558 ms
 2  10.8.5.1 (10.8.5.1)  1.281 ms * *

root@group08-lg3:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.590 ms  0.498 ms  0.460 ms
 2  10.8.6.2 (10.8.6.2)  1.065 ms  1.034 ms  0.998 ms
 3  10.8.5.1 (10.8.5.1)  1.576 ms * *
root@group08-lg3:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.613 ms  0.511 ms  0.509 ms
 2  10.8.6.2 (10.8.6.2)  1.181 ms  1.117 ms  1.089 ms
 3  10.8.5.1 (10.8.5.1)  1.532 ms  1.507 ms  1.612 ms
 4  10.8.1.2 (10.8.1.2)  1.848 ms  1.812 ms  1.771 ms
root@group08-lg3:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
```

```
 1  10.8.3.1 (10.8.3.1)  0.523 ms  0.472 ms  0.441 ms
 2  10.8.6.2 (10.8.6.2)  1.156 ms  1.108 ms  1.078 ms
 3  10.8.2.2 (10.8.2.2)  1.404 ms  1.373 ms  1.335 ms
root@group08-lg3:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.570 ms  0.519 ms  0.474 ms
 2  10.8.2.1 (10.8.2.1)  73.440 ms  73.340 ms  73.354 ms
root@group08-lg3:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  2.858 ms  2.771 ms  2.747 ms
root@group08-lg3:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.3.2 (10.8.3.2)  0.048 ms  0.027 ms  0.013 ms
root@group08-lg3:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.649 ms  0.612 ms  0.582 ms
 2  10.8.5.2 (10.8.5.2)  2.852 ms  2.794 ms  2.729 ms
root@group08-lg3:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.603 ms  0.562 ms  0.526 ms
 2  10.8.6.2 (10.8.6.2)  1.134 ms  1.083 ms  1.059 ms
 3  10.8.5.1 (10.8.5.1)  1.668 ms * *
root@group08-lg3:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.6.1 (10.8.6.1)  7.719 ms  7.678 ms  7.649 ms
root@group08-lg3:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.617 ms  0.574 ms  0.541 ms
 2  10.8.6.2 (10.8.6.2)  2.946 ms  2.898 ms  3.241 ms
root@group08-lg3:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.0.2 (10.8.0.2)  3.109 ms  3.071 ms  3.013 ms
root@group08-lg3:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.580 ms  0.533 ms  0.495 ms
 2  * * *
...
30  * * *
```

For our connectivity matrix see Table 3. Again we did not make it a square matrix including all configured interfaces, but only focused on the loadgens vs. all interfaces, so it is rectangular.

We can now see that the only problems occur with the 10.8.0.0/24 network, which is because it is advertised by both rc1 and rj1 to rj2 who advertises both routes back. So rc1 and rj1 route their traffic through rj2 although they have a direct interface. This creates incorrect return paths, which traceroute cannot handle.

3e

Here is how we configured rj2:

```
[edit]
root@lev-rj2# show policy-options
policy-statement no-bgp-advert {
    term 1 {
        from protocol bgp;
        then reject;
    }
    term 2 {
```

Interface	LG1 10.8.1.2	LG2 10.8.2.2	LG3 10.8.3.2
10.8.0.1	✓	✓	X
10.8.0.2	X	✓	✓
10.8.1.1	✓	✓	✓
10.8.1.2	✓	✓	✓
10.8.2.1	✓	✓	✓
10.8.2.2	✓	✓	✓
10.8.3.1	✓	✓	✓
10.8.3.2	✓	✓	✓
10.8.5.1	✓	✓	✓
10.8.5.2	✓	✓	✓
10.8.6.1	✓	✓	✓
10.8.6.2	✓	✓	✓

Table 3: The connectivity matrix for question 3d)

```
        from protocol direct;
        then accept;
    }
}
policy-statement send-direct {
    term 1 {
        from protocol direct;
        then accept;
    }
}

[edit protocols bgp group external-peers]
root@lev-rj2# set export no-bgp-advert
```

Now we can see, that rj2 does no longer advertise the routes it learns via BGP, but only the networks it has direct interfaces to. Therefore we can now see that traffic is not always routed through rj2, but more like it was before changing local-preferences:

```
lev-rc1# show ip route
Codes: L - local, 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, H - NHRP, l -
           LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks
C        10.8.0.0/24 is directly connected, GigabitEthernet9.80
L        10.8.0.1/32 is directly connected, GigabitEthernet9.80
C        10.8.1.0/24 is directly connected, GigabitEthernet9.81
L        10.8.1.1/32 is directly connected, GigabitEthernet9.81
```

```
B        10.8.2.0/24 [20/0] via 10.8.5.2, 01:44:37
B        10.8.3.0/24 [20/0] via 10.8.0.2, 00:05:20
C        10.8.5.0/24 is directly connected, GigabitEthernet8
L        10.8.5.1/32 is directly connected, GigabitEthernet8
B        10.8.6.0/24 [20/0] via 10.8.5.2, 01:44:37

root@lev-rj1# run show route

inet.0: 10 destinations, 15 routes (10 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.8.0.0/24         *[Direct/0] 02:22:14
                     > via ge-0/0/0.80
                     [BGP/170] 02:22:10, MED 0, localpref 100
                       AS path: 65001 I
                     > to 10.8.0.1 via ge-0/0/0.80
10.8.0.2/32         *[Local/0] 02:22:20
                       Local via ge-0/0/0.80
10.8.1.0/24         *[BGP/170] 02:22:10, MED 0, localpref 100
                       AS path: 65001 I
                     > to 10.8.0.1 via ge-0/0/0.80
10.8.2.0/24         *[BGP/170] 01:08:21, localpref 10000
                       AS path: 65002 I
                     > to 10.8.6.2 via ge-0/0/1.0
                     [BGP/170] 02:21:09, localpref 100
                       AS path: 65001 65002 I
                     > to 10.8.0.1 via ge-0/0/0.80
10.8.3.0/24         *[Direct/0] 02:22:14
                     > via ge-0/0/0.83
10.8.3.1/32         *[Local/0] 02:22:20
                       Local via ge-0/0/0.83
10.8.5.0/24         *[BGP/170] 01:08:21, localpref 10000
                       AS path: 65002 I
                     > to 10.8.6.2 via ge-0/0/1.0
                     [BGP/170] 02:21:09, MED 0, localpref 100
                       AS path: 65001 I
                     > to 10.8.0.1 via ge-0/0/0.80
10.8.6.0/24         *[Direct/0] 02:21:27
                     > via ge-0/0/1.0
                     [BGP/170] 01:08:21, localpref 10000
                       AS path: 65002 I
                     > to 10.8.6.2 via ge-0/0/1.0
                     [BGP/170] 01:47:53, localpref 100
                       AS path: 65001 65002 I
                     > to 10.8.0.1 via ge-0/0/0.80
10.8.6.1/32         *[Local/0] 02:22:20
                       Local via ge-0/0/1.0
224.0.0.5/32        *[OSPF/10] 02:22:23, metric 1
                       MultiRecv

root@lev-rj2# run show route

inet.0: 9 destinations, 14 routes (9 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.8.0.0/24         *[BGP/170] 02:21:49, MED 0, localpref 100
```

```
                    AS path: 65001 I
                  > to 10.8.5.1 via ge-0/0/2.0
                  [BGP/170] 01:08:47, localpref 100
                    AS path: 65003 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.1.0/24       *[BGP/170] 02:21:49, MED 0, localpref 100
                    AS path: 65001 I
                  > to 10.8.5.1 via ge-0/0/2.0
                  [BGP/170] 00:09:01, localpref 100
                    AS path: 65003 65001 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.2.0/24       *[Direct/0] 02:21:53
                  > via ge-0/0/3.0
10.8.2.1/32       *[Local/0] 02:21:57
                    Local via ge-0/0/3.0
10.8.3.0/24       *[BGP/170] 01:08:47, localpref 100
                    AS path: 65003 I
                  > to 10.8.6.1 via ge-0/0/1.0
                  [BGP/170] 00:09:01, localpref 100
                    AS path: 65001 65003 I
                  > to 10.8.5.1 via ge-0/0/2.0
10.8.5.0/24       *[Direct/0] 02:21:53
                  > via ge-0/0/2.0
                  [BGP/170] 02:21:35, MED 0, localpref 100
                    AS path: 65001 I
                  > to 10.8.5.1 via ge-0/0/2.0
10.8.5.2/32       *[Local/0] 02:21:57
                    Local via ge-0/0/2.0
10.8.6.0/24       *[Direct/0] 02:21:53
                  > via ge-0/0/1.0
                  [BGP/170] 01:08:47, localpref 100
                    AS path: 65003 I
                  > to 10.8.6.1 via ge-0/0/1.0
10.8.6.2/32       *[Local/0] 02:21:57
                    Local via ge-0/0/1.0
```

3f

We can now see that all traffic directed at networks rj2 has a direct link to is routed via AS65002 (rj2), but all other traffic has to go to the respective other remote AS. So again we are using the shortest AS-Path in these cases (although it is just because these are the only routes available!):

```
lev-rc1# show ip route bgp
Codes: L - local, 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, H - NHRP, l -
           LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 9 subnets, 2 masks
B        10.8.2.0/24 [20/0] via 10.8.5.2, 01:49:23
B        10.8.3.0/24 [20/0] via 10.8.0.2, 00:10:06
B        10.8.6.0/24 [20/0] via 10.8.5.2, 01:49:23

root@lev-rj1# run show route protocol bgp

inet.0: 10 destinations, 15 routes (10 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.8.0.0/24             [BGP/170] 02:28:02, MED 0, localpref 100
                          AS path: 65001 I
                        > to 10.8.0.1 via ge-0/0/0.80
10.8.1.0/24             *[BGP/170] 02:28:02, MED 0, localpref 100
                          AS path: 65001 I
                        > to 10.8.0.1 via ge-0/0/0.80
10.8.2.0/24             *[BGP/170] 01:14:13, localpref 10000
                          AS path: 65002 I
                        > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 02:27:01, localpref 100
                          AS path: 65001 65002 I
                        > to 10.8.0.1 via ge-0/0/0.80
10.8.5.0/24             *[BGP/170] 01:14:13, localpref 10000
                          AS path: 65002 I
                        > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 02:27:01, MED 0, localpref 100
                          AS path: 65001 I
                        > to 10.8.0.1 via ge-0/0/0.80
10.8.6.0/24              [BGP/170] 01:14:13, localpref 10000
                          AS path: 65002 I
                        > to 10.8.6.2 via ge-0/0/1.0
                         [BGP/170] 01:53:45, localpref 100
                          AS path: 65001 65002 I
                        > to 10.8.0.1 via ge-0/0/0.80

root@lev-rj2# run show route protocol bgp

inet.0: 9 destinations, 14 routes (9 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.8.0.0/24             *[BGP/170] 02:27:57, MED 0, localpref 100
                          AS path: 65001 I
                        > to 10.8.5.1 via ge-0/0/2.0
                         [BGP/170] 01:14:55, localpref 100
                          AS path: 65003 I
                        > to 10.8.6.1 via ge-0/0/1.0
10.8.1.0/24             *[BGP/170] 02:27:57, MED 0, localpref 100
                          AS path: 65001 I
                        > to 10.8.5.1 via ge-0/0/2.0
                         [BGP/170] 00:15:09, localpref 100
                          AS path: 65003 65001 I
                        > to 10.8.6.1 via ge-0/0/1.0
10.8.3.0/24             *[BGP/170] 01:14:55, localpref 100
                          AS path: 65003 I
```

```
                    > to 10.8.6.1 via ge-0/0/1.0
                    [BGP/170] 00:15:09, localpref 100
                      AS path: 65001 65003 I
                    > to 10.8.5.1 via ge-0/0/2.0
10.8.5.0/24         [BGP/170] 02:27:43, MED 0, localpref 100
                      AS path: 65001 I
                    > to 10.8.5.1 via ge-0/0/2.0
10.8.6.0/24         [BGP/170] 01:14:55, localpref 100
                      AS path: 65003 I
                    > to 10.8.6.1 via ge-0/0/1.0
```

3g

Again we have full connectivity when checking with traceroute:

```
root@group08-lg1:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.087 ms * *
root@group08-lg1:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.789 ms  0.732 ms  0.725 ms
 2  10.8.0.2 (10.8.0.2)  3.547 ms  3.486 ms  3.470 ms
root@group08-lg1:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.1.2 (10.8.1.2)  0.048 ms  0.015 ms  0.014 ms
root@group08-lg1:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.094 ms * *
root@group08-lg1:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.785 ms  0.756 ms  0.731 ms
 2  10.8.2.1 (10.8.2.1)  2.715 ms  2.666 ms  2.633 ms
root@group08-lg1:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.820 ms  0.782 ms  0.744 ms
 2  10.8.5.2 (10.8.5.2)  1.164 ms  1.109 ms  1.086 ms
 3  10.8.2.2 (10.8.2.2)  1.568 ms  1.546 ms  1.506 ms
root@group08-lg1:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.809 ms  0.776 ms  0.740 ms
 2  10.8.0.2 (10.8.0.2)  1.167 ms  1.112 ms  1.082 ms
 3  10.8.3.2 (10.8.3.2)  1.657 ms  1.622 ms  1.583 ms
root@group08-lg1:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.825 ms  0.786 ms  0.771 ms
 2  10.8.3.1 (10.8.3.1)  3.201 ms  3.145 ms  3.118 ms
root@group08-lg1:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  1.138 ms * *
root@group08-lg1:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.823 ms  0.762 ms  0.729 ms
 2  10.8.5.2 (10.8.5.2)  3.130 ms  3.098 ms  3.066 ms
root@group08-lg1:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.906 ms  0.867 ms  0.832 ms
```

```
 2  10.8.6.2 (10.8.6.2)  2.895 ms  2.871 ms  2.818 ms
root@group08-lg1:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.1.1 (10.8.1.1)  0.881 ms  0.844 ms  0.803 ms
 2  10.8.5.2 (10.8.5.2)  1.129 ms  1.102 ms  1.066 ms
 3  10.8.6.1 (10.8.6.1)  3.832 ms  3.780 ms  3.755 ms

root@group08-lg2:~# traceroute 10.8.0.1
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.595 ms  0.528 ms  0.524 ms
 2  10.8.5.1 (10.8.5.1)  1.230 ms * *
root@group08-lg2:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.529 ms  0.431 ms  0.446 ms
 2  10.8.5.1 (10.8.5.1)  1.073 ms  1.039 ms  0.959 ms
 3  10.8.0.2 (10.8.0.2)  3.266 ms  3.237 ms  3.199 ms
root@group08-lg2:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.598 ms  0.499 ms  0.473 ms
 2  10.8.5.1 (10.8.5.1)  1.023 ms  0.991 ms  0.989 ms
 3  10.8.1.2 (10.8.1.2)  1.390 ms  1.358 ms  1.319 ms
root@group08-lg2:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.579 ms  0.512 ms  0.470 ms
 2  10.8.5.1 (10.8.5.1)  1.153 ms * *
root@group08-lg2:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  2.657 ms  2.602 ms  2.569 ms
root@group08-lg2:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.2.2 (10.8.2.2)  0.049 ms  0.018 ms  0.014 ms
root@group08-lg2:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.584 ms  0.533 ms  0.517 ms
 2  10.8.6.1 (10.8.6.1)  1.135 ms  1.079 ms  1.049 ms
 3  10.8.3.2 (10.8.3.2)  1.395 ms  1.356 ms  1.318 ms
root@group08-lg2:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.526 ms  0.475 ms  0.461 ms
 2  10.8.3.1 (10.8.3.1)  2.723 ms  2.696 ms  2.712 ms
root@group08-lg2:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.569 ms  0.511 ms  0.477 ms
 2  10.8.5.1 (10.8.5.1)  1.196 ms * *
root@group08-lg2:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.5.2 (10.8.5.2)  2.286 ms  2.231 ms  2.198 ms
root@group08-lg2:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.6.2 (10.8.6.2)  2.620 ms  2.563 ms  2.509 ms
root@group08-lg2:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.2.1 (10.8.2.1)  0.513 ms  0.454 ms  0.434 ms
 2  10.8.6.1 (10.8.6.1)  2.773 ms  2.742 ms  2.703 ms

root@group08-lg3:~# traceroute 10.8.0.1
```

```
traceroute to 10.8.0.1 (10.8.0.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.594 ms  0.543 ms  0.496 ms
 2  10.8.0.1 (10.8.0.1)  1.400 ms * *
root@group08-lg3:~# traceroute 10.8.0.2
traceroute to 10.8.0.2 (10.8.0.2), 30 hops max, 60 byte packets
 1  10.8.0.2 (10.8.0.2)  2.635 ms  2.552 ms  2.567 ms
root@group08-lg3:~# traceroute 10.8.1.2
traceroute to 10.8.1.2 (10.8.1.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.632 ms  0.587 ms  0.557 ms
 2  10.8.0.1 (10.8.0.1)  1.221 ms  1.172 ms  1.270 ms
 3  10.8.1.2 (10.8.1.2)  1.392 ms  1.358 ms  1.318 ms
root@group08-lg3:~# traceroute 10.8.1.1
traceroute to 10.8.1.1 (10.8.1.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.595 ms  0.543 ms  0.590 ms
 2  10.8.0.1 (10.8.0.1)  1.310 ms * *
root@group08-lg3:~# traceroute 10.8.2.1
traceroute to 10.8.2.1 (10.8.2.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.626 ms  0.552 ms  0.545 ms
 2  10.8.2.1 (10.8.2.1)  3.150 ms  3.047 ms  3.057 ms
root@group08-lg3:~# traceroute 10.8.2.2
traceroute to 10.8.2.2 (10.8.2.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.547 ms  0.485 ms  0.454 ms
 2  10.8.6.2 (10.8.6.2)  1.100 ms  1.050 ms  1.021 ms
 3  10.8.2.2 (10.8.2.2)  1.391 ms  1.360 ms  1.321 ms
root@group08-lg3:~# traceroute 10.8.3.2
traceroute to 10.8.3.2 (10.8.3.2), 30 hops max, 60 byte packets
 1  10.8.3.2 (10.8.3.2)  0.078 ms  0.017 ms  0.013 ms
root@group08-lg3:~# traceroute 10.8.3.1
traceroute to 10.8.3.1 (10.8.3.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  2.892 ms  2.813 ms  2.810 ms
root@group08-lg3:~# traceroute 10.8.5.1
traceroute to 10.8.5.1 (10.8.5.1), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.656 ms  0.582 ms  0.558 ms
 2  10.8.6.2 (10.8.6.2)  1.150 ms  1.114 ms  1.083 ms
 3  10.8.5.1 (10.8.5.1)  1.580 ms * *
root@group08-lg3:~# traceroute 10.8.5.2
traceroute to 10.8.5.2 (10.8.5.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.559 ms  0.470 ms  0.468 ms
 2  10.8.5.2 (10.8.5.2)  2.934 ms  2.905 ms  2.866 ms
root@group08-lg3:~# traceroute 10.8.6.2
traceroute to 10.8.6.2 (10.8.6.2), 30 hops max, 60 byte packets
 1  10.8.3.1 (10.8.3.1)  0.582 ms  0.526 ms  0.526 ms
 2  10.8.6.2 (10.8.6.2)  3.424 ms  3.400 ms  3.516 ms
root@group08-lg3:~# traceroute 10.8.6.1
traceroute to 10.8.6.1 (10.8.6.1), 30 hops max, 60 byte packets
 1  10.8.6.1 (10.8.6.1)  2.242 ms  2.183 ms  2.158 ms
```

For our connectivity matrix see Table 4. Again we did not make it a square matrix including all configured interfaces, but only focused on the loadgens vs. all interfaces, so it is rectangular.

Included Files

q02-config-rc1.txt, q02-config-rj1.txt, q02-config-rj2.txt, q02-config-sc1.txt, q02-config-sj1.txt, q03-config-rc1.txt, q03-config-rj1.txt, q03-config-rj2.txt, q2-workingconfig-rc1.txt, q2-workingconfig-rj1.txt, q2-workingconfig-rj2.txt

Interface	LG1 10.8.1.2	LG2 10.8.2.2	LG3 10.8.3.2
10.8.0.1	✓	✓	✓
10.8.0.2	✓	✓	✓
10.8.1.1	✓	✓	✓
10.8.1.2	✓	✓	✓
10.8.2.1	✓	✓	✓
10.8.2.2	✓	✓	✓
10.8.3.1	✓	✓	✓
10.8.3.2	✓	✓	✓
10.8.5.1	✓	✓	✓
10.8.5.2	✓	✓	✓
10.8.6.1	✓	✓	✓
10.8.6.2	✓	✓	✓

Table 4: The connectivity matrix for question 3g)