EINTE lab3 - BGP
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A - IP address assignment

First, we will show how the IP addresses are assigned to different interfaces for the routers found in our topology:

- Subnet address for a link between routers Rx and Ry is 10.0.xy.1 for Rx and 10.0.xy.2 for Ry, where x < y. x and y denoting router numbers.
- Loopback interfaces are as follows:

Router	AS	Interface	Address
R1	AS100	L0	1.1.1.1/32
		L1	192.168.11.1/24
R4	AS400	L0	4.4.4.4/32
		L1	192.168.41.1/24
		L2	192.168.42.1/24
		L3	192.168.43.1/24
R5	AS500	L0	5.5.5.5/32
		L1	192.168.51.1/24
R2	AS230	L0	2.2.2.2/32
		L1	192.168.21.1/24
R3	AS230	L0	3.3.3.3/32
		L1	192.168.31.1/24

It should be noted that there exist multiple loopback interfaces for some routers, because they:
" [...] will be used in the exercise to emulate hosts in customer networks attached to the routers, and are all intended to be advertised between all AS using BGP"

All of the above-mentioned information is provided based on the lab exercise .pdf.

Task B - OSPF configuration in AS230

For this task we are going to perform OSPF configuration for the AS230. This AS has two routers, hence this configuration is needed in the first place. The configuration commands that will be used are as in the previous laboratory:

```
config t
router ospf 1
network <IP> 0.0.0.0 area 0
network <IP> 0.0.0.0 area 0
exit
exit
```

Where the <IP> depends on the router that's being configured. e.g. for router 2 the <IP>s will be the loopback 0 IP of R2 and f2/0 interface IP of R2. Same set of commands should be executed on R3 with different IPs, but analogically as in R2.

Determining the correctness of OSPF configuration

The following commands show that the OSPF has been correctly configured for both routers. Notice how R2 sees the L0 interface of R3, and R3 sees L0 of R2:

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/2] via 10.0.23.2, 00:02:39, FastEthernet2/0
C    192.168.21.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.12.0 is directly connected, FastEthernet0/0
C       10.0.24.0 is directly connected, FastEthernet1/0
C       10.0.23.0 is directly connected, FastEthernet2/0
```

And R3 routing table:

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

Gateway of last resort is not set

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 10.0.23.1, 00:02:14, FastEthernet2/0
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.23.0 is directly connected, FastEthernet2/0
C       10.0.34.0 is directly connected, FastEthernet3/0
C       10.0.35.0 is directly connected, FastEthernet0/0
```

In the task it is written to ping L0 of R3 from R2, and vice-versa:

```
R3#ping 2.2.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/16/32 ms
```

```
R2#ping 3.3.3.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/10/12 ms
```

The above-mentioned commands show that OSPF has been configured properly.

Task C1 - iBGP configuration on R2 and R3

For this task, we are going to configure the iBGP session between routers R2 and R3. One remark about the task is that we need to use L0 addresses for defining the BGP neighbors.

BGP configuration commands - appendix from the lab exercise .pdf

The commands given in the C subpoint in the exercise .pdf specify the following commands that should be used for BGP config:

```
router bgp <AS number>
```

Where AS number is the number of the AS that is configured on a given router. This command enters the config sub-mode for the BGP.

```
neighbor <ip address> remote-as <AS number>
```

This command sets BGP neighbors (there is no automatic discovery. Administrator needs to set-up this themselves). This command is used only in BGP sub-mode.
<ip address> is the IP address for the neighboring router; <AS number> is the AS number the router is located in. If we configure iBGP, the AS num is the same as the AS we are configuring.

```
neighbor <ip address> update-source <interface>
```

Is used to explicitly define the interface that will be used as the source IP address for the BGP session in the AS that the command is executed in.
<ip address> parameter is the address of the neighbor router. <interface> specifies the source interface for the BGP session with the neighbor.

R2-R3 iBGP session configuration

The following commands were used to configure the iBGP session for the AS230:

```
config t
router bgp 230
neighbor 3.3.3.3 remote-as 230
exit
exit
show ip bgp neighbors
```

```
config t
router bgp 230
neighbor 3.3.3.3 update-source loopback0
do clear ip bgp 3.3.3.3 soft
exit
exit
show ip bgp neighbors
```

Above-mentioned commands were run on the R2 router.
On R3 router, the following was run (before `update-source` execution on R2):

```
config t
router bgp 230
neighbor 2.2.2.2 remote-as 230
exit
exit
show ip bgp neighbors
```

Also, the `neighbor 2.2.2.2 update-source loopback0` with other necessary commands was run on R3, but it did not change any state of the routers, as R2 has reached R3 and got a response from loopback0 of router R3 before running the above-mentioned command. That was the moment the bgp session was properly established and running. Running of the `update-source` command on R3 was incorrect - although no issues have arisen due to that.

Task C1 - command execution and results

Below we show what commands were run, as well with necessary proof showing that the session was properly established. Note - we forgot to make direct screenshots from the console. The screenshots are from saved console text. Neighbor set-up:

```
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router bgp 230
R3(config-router)#neigh
R3(config-router)#neighbor 2.2
R3(config-router)#neighbor 2.2.2.2 remote-as 230
R3(config-router)#do clear ip bgp 2.2.2.2 soft
R3(config-router)#clear ip bgp 2.2.2
R3(config-router)#clear ip bgp 2.2.2.2 soft
                  ^
% Invalid input detected at '^' marker.

R3(config-router)#exit
R3(config)#exit
```

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router bgp 230
R2(config-router)#neigh
R2(config-router)#neighbor 3.3.3.3 remo
R2(config-router)#neighbor 3.3.3.3 remote
R2(config-router)#neighbor 3.3.3.3 remote-as 230
R2(config-router)#exit
R2(config)#exit
R2#
*Mar  1 00:32:44.899: %SYS-5-CONFIG_I: Configured from console by console
R2#clear ip bgp soft 3.3.3.3 soft
                ^
% Invalid input detected at '^' marker.

R2#clear ip bgp 3.3.3.3 soft
```

Above-mentioned defined bgp neighbors: R2 as R3 neighbor, and vice versa.

After the commands, we run `show ip bgp neighbors`. The output of the command has shown that the existence of 2.2.2.2 (R2 L0 interface) has been acknowledged by R3, and 3.3.3.3 has been acknowledged by R2. But so far, no data has been exchanged between the routers regarding the bgp session. State is only ‘active’:

```
R2#show ip bgp neighbors
BGP neighbor is 3.3.3.3,  remote AS 230, internal link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active
  Last read 00:00:38, last write 00:00:38, hold time is
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                     Sent       Rcvd
    Opens:              0          0
    Notifications:      0          0
    Updates:            0          0
    Keepalives:         0          0
    Route Refresh:      0          0
    Total:              0          0
```

0 messages sent. Furthermore:

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

0 established connections; no active TCP connection.

Similar output is observed for R3. BGP neighbor of course being 2.2.2.2 instead:

```
R3#show ip bgp neighbors
BGP neighbor is 2.2.2.2,  remote AS 230, internal link
  BGP version 4, remote router ID 0.0.0.0
  BGP state = Active
  Last read 00:07:46, last write 00:07:46, hold time is
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                     Sent       Rcvd
    Opens:              0          0
    Notifications:      0          0
    Updates:            0          0
    Keepalives:         0          0
    Route Refresh:      0          0
    Total:              0          0
  Connections established 0; dropped 0
  Last reset never
  No active TCP connection
R3#
```

Then, we run the 2nd part of the commands - the `update-source`:

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router bgp 230
R2(config-router)#neigh
R2(config-router)#neighbor 3.3.3.3 udpa
R2(config-router)#neighbor 3.3.3.3 upda
R2(config-router)#neighbor 3.3.3.3 update-source loop
R2(config-router)#neighbor 3.3.3.3 update-source loopback0
R2(config-router)#
*Mar  1 00:42:58.487: %BGP-5-ADJCHANGE: neighbor 3.3.3.3 Up
```

Then note, that at nearly the same timestamp at R3:

```
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router bgp 230
*Mar  1 00:42:58.707: %BGP-5-ADJCHANGE: neighbor 2.2.2.2 Up
```

Behavior during establishment of BGP session - appendix

This `ADJCHANGE` message showed up before running any other commands on R3.
The update-source command on R3 run after the `ADJCHANGE` message showed up yielded no change in the configuration.
This might be because of special behavior of cisco routers, which can be as follows, on the example of the laboratory case:
If router R2 updated the source to be 2.2.2.2, then the following datagram was sent:
BGP source: 2.2.2.2
BGP dest: 3.3.3.3

Then, router R3 at that time, before running the update-source had the following:
BGP source: interface address of f2/0 for R3
BGP dest: 2.2.2.2

So, since the destination of R3 matched the source of R2, the session was established despite the BGP source of R3 still mismatching the destination of R2.
This matter was discussed on MS Teams in private message.

Below we show proof that the iBGP session state is ESTAB:

```
R3(config-router)#do show ip bgp neighbors
BGP neighbor is 2.2.2.2,  remote AS 230, internal link
  BGP version 4, remote router ID 192.168.21.1
  BGP state = Established, up for 00:01:45

 Message statistics:
  InQ depth is 0
  OutQ depth is 0
                    Sent       Rcvd
  Opens:               1          1
  Notifications:       0          0
  Updates:             0          0
  Keepalives:          4          4
  Route Refresh:       1          1
  Total:               6          6

Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 3.3.3.3, Local port: 179
Foreign host: 2.2.2.2, Foreign port: 58698

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

Event Timers (current time is 0x293CE8):
Timer          Starts    Wakeups            Next
Retrans             6          0             0x0
TimeWait            0          0             0x0
AckHold             5          1             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 2460913429  snduna: 2460913593  sndnxt: 2460913593     sndwnd:  16221
irs: 3121127671  rcvnxt: 3121127835  rcvwnd:      16221  delrcvwnd:    163

SRTT: 165 ms, RTTO: 1172 ms, RTV: 1007 ms, KRTT: 0 ms
minRTT: 12 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs
IP Precedence value : 6

Datagrams (max data segment is 536 bytes):
Rcvd: 12 (out of order: 0), with data: 6, total data bytes: 163
Sent: 7 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 5, total data bytes: 163
R3(config-router)#
```

We see states as established and packets being sent. TCP event timers; rcvd and sent count and others are shown.

Now, analogically for R2:

```
R2#show ip bgp neighbors
BGP neighbor is 3.3.3.3,  remote AS 230, internal link
  BGP version 4, remote router ID 192.168.31.1
  BGP state = Established, up for 00:26:33
  Last read 00:00:32, last write 00:00:32, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:            29         29
    Route Refresh:          1          1
    Total:                 31         31
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 2.2.2.2, Local port: 58698
Foreign host: 3.3.3.3, Foreign port: 179

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

Event Timers (current time is 0x405EA4):
Timer          Starts    Wakeups            Next
Retrans            31          0             0x0
TimeWait            0          0             0x0
AckHold            30         28             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0

iss: 3121127671  snduna: 3121128310  sndnxt: 3121128310     sndwnd:  16289
irs: 2460913429  rcvnxt: 2460914068  rcvwnd:      16289  delrcvwnd:     95

SRTT: 295 ms, RTTO: 335 ms, RTV: 40 ms, KRTT: 0 ms
minRTT: 4 ms, maxRTT: 300 ms, ACK hold: 200 ms
Flags: active open, nagle
IP Precedence value : 6

Datagrams (max data segment is 536 bytes):
Rcvd: 33 (out of order: 0), with data: 30, total data bytes: 638
Sent: 62 (retransmit: 0, fastretransmit: 0, partialack: 0, Second Congestion: 0), with data: 31, total data bytes: 638
R2#
```

The iBGP session was properly set up. It went from active state into established after using the `update-source` command. iBGP for AS230 was properly configured.

Task C2 - eBGP configuration between R1 and R2

For this task we will need to configure a single eBGP connection. It will be done with the use of the commands provided earlier in task C1 appendix.
A remark provided in the lab exercise .pdf is to use IP addresses of the direct link between routers R1 and R2, not the loopback addresses!

The used commands were:

```
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router bgp 100
R1(config-router)#neighbor 10.0.12.2 remote-as 230
R1(config-router)#
*Mar  1 00:27:04.531: %BGP-5-ADJCHANGE: neighbor 10.0.12.2 Up
R1(config-router)#end
R1#
```

And for R2:

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router bgp 230
R2(config-router)#neighbor 10.0.12.1 remote-
R2(config-router)#neighbor 10.0.12.1 remote-as 100
R2(config-router)#
*Mar  1 00:45:16.091: %BGP-5-ADJCHANGE: neighbor 10.0.12.1 Up
R2(config-router)#end
R2#
```

We see from ADJCHANGE messages that the BGP session was established. It can be also seen running the commands described in lab .pdf:

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

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.12.2       4   230      25      25        1    0    0 00:21:43        0
```

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

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4   230      74      74        1    0    0 01:11:27        0
10.0.12.1       4   100      31      31        1    0    0 00:27:18        0
```

For router R2 we also see the session to the loopback0 of R3, which was set in the previous task.
To further confirm proper configuration, I show a small excerpt of the `show ip bgp neighbors` command showing BGP state as established. For router R2:

```
BGP neighbor is 10.0.12.1,  remote AS 100, external link
  BGP version 4, remote router ID 192.168.11.1
  BGP state = Established, up for 00:27:41
```

For router R1:

```
R1#show ip bgp neighbors
BGP neighbor is 10.0.12.2,  remote AS 230, external link
  BGP version 4, remote router ID 192.168.21.1
  BGP state = Established, up for 00:35:09
```

Proper remote AS number and BGP state can be seen.
For full command output please refer to saved console logs provided with the report.

Task C3 - prefix advertising

For this task, we need to assign networks to the BGP process, which in other words means to advertise the prefix via the BGP. The following command will be used:

`network <network prefix> mask <mask>`

Network prefix is the network address and mask is the network mask that should be added to the BGP process. Subnets added by this command are going to be propagated by the BGP protocol on the network

More specifically, the task is to add the network represented by the R3 L1 interface and the network represented by the R1 L1 interface to the BGP protocol.

Advertising the prefixes and routing table analysis

We run the following commands to advertise the prefixes in the BGP process. We advertise the L1 address pool for R3 and R1. First - R1:

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.0.12.1       YES NVRAM  up                    up
FastEthernet0/1            unassigned      YES NVRAM  administratively down down
FastEthernet1/0            unassigned      YES NVRAM  administratively down down
FastEthernet2/0            unassigned      YES NVRAM  administratively down down
FastEthernet3/0            unassigned      YES NVRAM  administratively down down
FastEthernet4/0            unassigned      YES NVRAM  administratively down down
Loopback0                  1.1.1.1         YES NVRAM  up                    up
Loopback1                  192.168.11.1    YES NVRAM  up                    up
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router bgp 100
R1(config-router)#network 192.168.11.0 255.255.255.0
                                       ^
% Invalid input detected at '^' marker.

R1(config-router)#network 192.168.11.0 mask 255.255.255.0
R1(config-router)#end
R1#
*Mar  1 00:06:22.883: %SYS-5-CONFIG_I: Configured from console by console
```

R3:

```
R3#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.0.35.1       YES NVRAM  up                    up
FastEthernet0/1            unassigned      YES NVRAM  administratively down down
FastEthernet1/0            unassigned      YES NVRAM  administratively down down
FastEthernet2/0            10.0.23.2       YES NVRAM  up                    up
FastEthernet3/0            10.0.34.1       YES NVRAM  up                    up
FastEthernet4/0            unassigned      YES NVRAM  administratively down down
Loopback0                  3.3.3.3         YES NVRAM  up                    up
Loopback1                  192.168.31.1    YES NVRAM  up                    up
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router bgp 230
R3(config-router)#network 192.168.31.0 255.255.255.0
                                       ^
% Invalid input detected at '^' marker.

R3(config-router)#network 192.168.31.0 mask 255.255.255.0
R3(config-router)#end
```

Now let's analyze the routing tables of R1 and R3:

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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
B    192.168.31.0/24 [20/0] via 10.0.12.2, 00:03:08
C    192.168.11.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.12.0 is directly connected, FastEthernet0/0
```

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

Gateway of last resort is not set

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 10.0.23.1, 00:09:04, FastEthernet2/0
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.23.0 is directly connected, FastEthernet2/0
C       10.0.34.0 is directly connected, FastEthernet3/0
C       10.0.35.0 is directly connected, FastEthernet0/0
```

So in R1 we see that the `192.168.31.0/24` is reachable and advertised on the BGP, as seen by the B next to the network address.
But R3 has no knowledge of the L1 interface of R1. L1 of R1 is unreachable from R3.
Also it is needed per the exercise, to paste the following command result:

```
R1#show ip bgp
BGP table version is 3, local router ID is 192.168.11.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 192.168.11.0     0.0.0.0                  0         32768 i
*> 192.168.31.0     10.0.12.2                              0 230 i
```

```
R3#show ip bgp
BGP table version is 2, local router ID is 192.168.31.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i192.168.11.0     10.0.12.1                0    100      0 100 i
*> 192.168.31.0     0.0.0.0                  0         32768 i
```

Why does R3 have no knowledge about R1 L1?

Since we have configured iBGP on the AS230 to have loopback0 on R2 as source of the iBGP session, then if the loopback0 does not know a route to the f0/0 interface that is used for the BGP connection between AS100 and AS230, the session will not be established.
So to fix this issue, we need to add f0/0 to the OSPF of R2. Then, a route from f0/0 will be created to the loopback0 of R2, which is a source of the iBGP session for AS230.
In general, a good measure would be to add all interfaces to the OSPF during the initial configuration that was done earlier.

R2 router - configuration update

Simply adding the address of f0/0 on R2 will fix the issue:

```
R2#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.0.12.2       YES NVRAM  up                    up
FastEthernet0/1            unassigned      YES NVRAM  administratively down down
FastEthernet1/0            10.0.24.1       YES NVRAM  up                    up
FastEthernet2/0            10.0.23.1       YES NVRAM  up                    up
FastEthernet3/0            unassigned      YES NVRAM  administratively down down
FastEthernet4/0            unassigned      YES NVRAM  administratively down down
Loopback0                  2.2.2.2         YES NVRAM  up                    up
Loopback1                  192.168.21.1    YES NVRAM  up                    up
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router ospf 1
R2(config-router)#network 10.0.12.2 area 0
                                    ^
% Invalid input detected at '^' marker.

R2(config-router)#network 10.0.12.2 0.0.0.0 area 0
```

Now, checking the routing table of R3 again, we see BGP to L1 of R1:

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

Gateway of last resort is not set

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 10.0.23.1, 00:00:06, FastEthernet2/0
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
B    192.168.11.0/24 [200/0] via 10.0.12.1, 00:00:00
     10.0.0.0/30 is subnetted, 4 subnets
O       10.0.12.0 [110/11] via 10.0.23.1, 00:00:06, FastEthernet2/0
C       10.0.23.0 is directly connected, FastEthernet2/0
C       10.0.34.0 is directly connected, FastEthernet3/0
C       10.0.35.0 is directly connected, FastEthernet0/0
```

Confirming the reachability

For this, we run a ping command with specified source:

```
R3#ping 192.168.11.1 source 192.168.31.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.31.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/29/56 ms
```

We ping L1 of R1, with source specified as L1 of R3

Without a source specified, the command fails:

```
R3#ping 192.168.11.1

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

Why does the ping command without a specified source fail?

By default, the source of the ping is the interface appropriately chosen from the routing table. In our case, it will most likely be the interface f2/0
To better show why the ping command does not work, we decided to show a traceroute command with the same arguments:

```
R3#traceroute 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.11.1

  1 10.0.23.1 12 msec 12 msec 8 msec
  2  *  *  *
  3  *  *  *
  4  *  *  *
  5  *  *  *
  6  *  *  *
  7  *  *  *
  8  *  *  *
  9  *  *  *
 10  *  *
R3# traceroute 192.168.11.1 source 192.168.31.1

Type escape sequence to abort.
Tracing the route to 192.168.11.1

  1 10.0.23.1 12 msec 24 msec 20 msec
  2 10.0.12.1 32 msec 40 msec 40 msec
```

Despite the packet reaching the same IP after the first hop, the packet from the interface f2/0 is lost (dropped), but the packet from L1 is properly forwarded to the destination.

Task C4 - remaining eBGP configuration

For this task, we need to configure every remaining eBGP in the network topology. Since we configure eBGP, we need to configure the session on the Fast Ethernet interface addresses, NOT loopback addresses like in iBGP.
Configuration on loopback addresses should be used mostly only in the iBGP.

The following command will be used:

```
neighbor <ip address> remote-as <AS number>
```

Where all the arguments correspond to the remote (neighbor) router. We will need to look at the topology, see what neighbor the router has, and execute neighbor command for every neighbor of a given router.

Below we show an example of a single eBGP session establishment:

```
R3#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.0.35.1       YES NVRAM  up                    up
FastEthernet0/1            unassigned      YES NVRAM  administratively down down
FastEthernet1/0            unassigned      YES NVRAM  administratively down down
FastEthernet2/0            10.0.23.2       YES NVRAM  up                    up
FastEthernet3/0            10.0.34.1       YES NVRAM  up                    up
FastEthernet4/0            unassigned      YES NVRAM  administratively down down
Loopback0                  3.3.3.3         YES NVRAM  up                    up
Loopback1                  192.168.31.1    YES NVRAM  up                    up
R3#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router bgp 230
R3(config-router)#neighbor 10.0.35.2 remote-as 500
R3(config-router)#
*Mar  1 00:04:08.703: %BGP-5-ADJCHANGE: neighbor 10.0.35.2 Up
```

```
R5#show ip interface br
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.0.35.2       YES NVRAM  up                    up
FastEthernet0/1            unassigned      YES NVRAM  administratively down down
FastEthernet1/0            unassigned      YES NVRAM  administratively down down
FastEthernet2/0            10.0.45.2       YES NVRAM  up                    up
FastEthernet3/0            unassigned      YES NVRAM  administratively down down
FastEthernet4/0            unassigned      YES NVRAM  administratively down down
Loopback0                  5.5.5.5         YES NVRAM  up                    up
Loopback1                  192.168.51.1    YES NVRAM  up                    up
R5#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R5(config)#router bgp 500
R5(config-router)#neighbor 10.0.35.1 remote-as 230
R5(config-router)#
*Mar  1 00:03:50.107: %BGP-5-ADJCHANGE: neighbor 10.0.35.1 Up
```

So we see that ADJCHANGE messages have appeared. This means that the session has been established.
This set of commands was executed on every connection between two routers that didn’t have a running bgp session prior to this task. The commands were the same apart from remote-as numbers, IP addresses of neighbors, and the bgp sub-mode. Complete proof by the `show ip route` commands that were executed after the configuration of every connection was done is shown below:

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

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.12.2       4   230      43      43        3    0    0 00:39:54        1
```

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

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4   230      35      35        3    0    0 00:31:12        1
10.0.12.1       4   100      35      35        3    0    0 00:31:40        1
10.0.24.2       4   400      10      10        3    0    0 00:04:45        0
```

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

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
2.2.2.2         4   230      62      62        3    0    0 00:58:24        1
10.0.34.2       4   400      38      40        3    0    0 00:34:45        0
10.0.35.2       4   500      59      61        3    0    0 00:55:19        0
```

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

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.24.1       4   230       9       9        3    0    0 00:03:56        2
10.0.34.1       4   230      12      10        3    0    0 00:06:45        2
10.0.45.2       4   500      11      11        3    0    0 00:05:26        2
```

```
R5#show ip bgp summary
BGP router identifier 192.168.51.1, local AS number 500
BGP table version is 3, main routing table version 3
2 network entries using 234 bytes of memory
4 path entries using 208 bytes of memory
5/2 BGP path/bestpath attribute entries using 620 bytes of memory
4 BGP AS-PATH entries using 96 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 1158 total bytes of memory
BGP activity 2/0 prefixes, 4/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.35.1       4   230      34      32        3    0    0 00:28:20        2
10.0.45.1       4   400      12      12        3    0    0 00:06:28        2
```

So as we can see, all neighbors are in the established state (indicated by up/down showing a time value)
Furthermore, the neighbors are correct in regards to the connections in the network.

Up/Down	The length of time that the BGP session has been in the Established state, or the current status if not in the Established state.

Source: documentation of show ip bgp summary command; table 9
https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute_bgp/command/iproute_bgp-xe-3se-3850-cr-book/iproute_bgp-xe-3se-3850-cr-book_chapter_0100.html#wp1583714062

It might be also noted that R2 and R3 see IP of loopback interfaces rather than FastEthernet, as the iBGP session was established on loopback, not FastEth.

Other entries in the bgp summary command are correct and confirm proper config.

Task C5 - loopback advertisement

For this task we will need to address all L1, L2 and/or L3. It depends on the router whether L1, L2 and/or L3 exists.
To remind:

Router	AS	Interface	Address
R1	AS100	L0	1.1.1.1/32
		L1	192.168.11.1/24
R4	AS400	L0	4.4.4.4/32
		L1	192.168.41.1/24
		L2	192.168.42.1/24
		L3	192.168.43.1/24
R5	AS500	L0	5.5.5.5/32
		L1	192.168.51.1/24
R2	AS230	L0	2.2.2.2/32
		L1	192.168.21.1/24
R3	AS230	L0	3.3.3.3/32
		L1	192.168.31.1/24

So - on only R4 we will need to advertise more than one loopback interface.

Also - to remind the advertising command that will be used:

```
network <network prefix> mask <mask>
```

Network prefix is the network address and mask is the network mask that should be added to the BGP process.

We show an example of the configuration commands on R4:

```
R4#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)#router bgp 400
R4(config-router)#network 192.168.41.0 mask 255.255.255.0
R4(config-router)#network 192.168.42.0 mask 255.255.255.0
R4(config-router)#network 192.168.43.0 mask 255.255.255.0
```

As it can be seen, we configured L1, L2 and L3 to be advertised
Executed commands on different routers were similar, but with different IP used.

The correctness of the advertisement can be established by looking at the output of the show ip route command. If we see the router's own loopbacks connected directly, marked by C, and all loopbacks (except L0) of different routers as B (BGP), then the config is correct. That way it means that the router sees all necessary loopbacks.

Correctness of loopback interfaces advertisement

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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
B    192.168.31.0/24 [20/0] via 10.0.12.2, 01:36:41
B    192.168.42.0/24 [20/0] via 10.0.12.2, 00:09:45
B    192.168.43.0/24 [20/0] via 10.0.12.2, 00:09:45
C    192.168.11.0/24 is directly connected, Loopback1
B    192.168.41.0/24 [20/0] via 10.0.12.2, 00:10:16
B    192.168.21.0/24 [20/0] via 10.0.12.2, 00:11:29
     10.0.0.0/30 is subnetted, 1 subnets
C       10.0.12.0 is directly connected, FastEthernet0/0
B    192.168.51.0/24 [20/0] via 10.0.12.2, 00:10:51
```

```
R2#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
B    192.168.31.0/24 [200/0] via 3.3.3.3, 01:36:51
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/2] via 10.0.23.2, 01:37:34, FastEthernet2/0
B    192.168.42.0/24 [20/0] via 10.0.24.2, 00:09:55
B    192.168.43.0/24 [20/0] via 10.0.24.2, 00:09:55
B    192.168.11.0/24 [20/0] via 10.0.12.1, 01:36:51
B    192.168.41.0/24 [20/0] via 10.0.24.2, 00:10:27
C    192.168.21.0/24 is directly connected, Loopback1
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.12.0 is directly connected, FastEthernet0/0
C       10.0.24.0 is directly connected, FastEthernet1/0
C       10.0.23.0 is directly connected, FastEthernet2/0
B    192.168.51.0/24 [20/0] via 10.0.24.2, 00:11:01
```

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

Gateway of last resort is not set

     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 10.0.23.1, 01:32:20, FastEthernet2/0
C    192.168.31.0/24 is directly connected, Loopback1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
B    192.168.42.0/24 [20/0] via 10.0.34.2, 00:04:41
B    192.168.43.0/24 [20/0] via 10.0.34.2, 00:04:41
B    192.168.11.0/24 [200/0] via 10.0.12.1, 01:31:37
B    192.168.41.0/24 [20/0] via 10.0.34.2, 00:05:11
B    192.168.21.0/24 [200/0] via 2.2.2.2, 00:06:26
     10.0.0.0/30 is subnetted, 4 subnets
O       10.0.12.0 [110/11] via 10.0.23.1, 01:32:21, FastEthernet2/0
C       10.0.23.0 is directly connected, FastEthernet2/0
C       10.0.34.0 is directly connected, FastEthernet3/0
C       10.0.35.0 is directly connected, FastEthernet0/0
B    192.168.51.0/24 [20/0] via 10.0.35.2, 00:05:46
```

```
R4#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

B    192.168.31.0/24 [20/0] via 10.0.34.1, 01:13:52
C    192.168.42.0/24 is directly connected, Loopback2
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
C    192.168.43.0/24 is directly connected, Loopback3
B    192.168.11.0/24 [20/0] via 10.0.34.1, 01:13:52
C    192.168.41.0/24 is directly connected, Loopback1
B    192.168.21.0/24 [20/0] via 10.0.24.1, 00:11:50
     10.0.0.0/30 is subnetted, 3 subnets
C       10.0.24.0 is directly connected, FastEthernet1/0
C       10.0.45.0 is directly connected, FastEthernet2/0
C       10.0.34.0 is directly connected, FastEthernet3/0
B    192.168.51.0/24 [20/0] via 10.0.45.2, 00:11:11
```

```
R5#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

B    192.168.31.0/24 [20/0] via 10.0.35.1, 01:43:11
B    192.168.42.0/24 [20/0] via 10.0.45.1, 00:18:50
B    192.168.43.0/24 [20/0] via 10.0.45.1, 00:18:50
     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
B    192.168.11.0/24 [20/0] via 10.0.35.1, 01:43:11
B    192.168.41.0/24 [20/0] via 10.0.45.1, 00:19:20
B    192.168.21.0/24 [20/0] via 10.0.35.1, 00:20:34
     10.0.0.0/30 is subnetted, 2 subnets
C       10.0.45.0 is directly connected, FastEthernet2/0
C       10.0.35.0 is directly connected, FastEthernet0/0
C    192.168.51.0/24 is directly connected, Loopback1
```

Every router should see 6 interfaces advertised on BGP. R4 is an exception - R4 should see 4 on BGP (because R4 has 3 loopback interfaces that are advertised).

And looking at the command output for every router, the above-mentioned is correct. The advertisement has been done properly, as every advertised interface is seen by every router in the topology.

Task C6 - checking reachability from R1 to R5 L1

After advertising various loopback interfaces, we will again check reachability of some interfaces.

In this task, we need to check if we can ping R5 L1 from R1, and check traceroute.

```
R1#ping 192.168.51.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.51.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

```
R1#ping 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.51.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.11.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/47/64 ms
```

Note that without specifying a source address, the packets are lost.

```
R1#traceroute 192.168.51.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 8 msec 12 msec 4 msec
  2  *  *  *
  3  *  *  *
  4  *  *  *
  5  *  *  *
  6
R1#traceroute 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 8 msec 28 msec 16 msec
  2 10.0.24.2 28 msec 40 msec 48 msec
  3 10.0.45.2 48 msec 60 msec 76 msec
```

Traceroute confirms that the packets are dropped after arriving at R2, IF the source is unspecified.
If the source is set to L1 of R1, the packets travel: R2 f0/0 -> R4 f1/0 -> R5 f2/0

Route modification - advertising R3 as a next-hop router

Since R3 is not advertised as a next-hop from R2, the packet decides to choose the route to R4.
To change that, we need to execute the following commands on the R3 router:

```
R3#config t
Enter configuration commands, one per line.  End
R3(config)#router bgp
% Incomplete command.

R3(config)#router bgp 230
R3(config-router)#neighbor 2.2.2.2 nex
R3(config-router)#neighbor 2.2.2.2 next-hop-se
R3(config-router)#neighbor 2.2.2.2 next-hop-self
```

The last, most important command `neighbor 2.2.2.2 next-hop-self` means that R3 is marked to be itself as the next hop from the neighbor 2.2.2.2.
So if any traffic comes to R2, then it will be directed to R3.

And looking at the following trace, we see the command worked:

```
R1#traceroute 192.168.51.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.51.1

  1 10.0.12.2 16 msec 24 msec 16 msec
  2 10.0.23.2 36 msec 32 msec 32 msec
  3 10.0.35.2 76 msec 52 msec 68 msec
```

The path is now: R2 f0/0 -> R3 f2/0 -> R5 f0/0. As required per task description.

Task C7 - local preference

For this last task, the aim is to configure AS230 in such a way that all traffic that is from R1, being sent to R4, will leave AS230 through R3.

Command background

New commands that will need to be used to achieve above-mentioned are:

```
route-map <name> permit <clause_seqence_num>
```

This command creates a route-map entry of a given name with a set sequence_number. For Cisco routers it is recommended to set the clause sequence numbers as multiple of 10 of positive integers. e.g. 10,20,30 …

```
set local-preference <value>
```

Used within the route-map config sub-mode, sets the local preference of received routers to the specified value.
The higher the value is set, the more preferred is the route.

```
neighbor <neighbor address> route-map <name> in
```

Applies the route-map of a given name to a specified neighbor address.

It should be also noted that clearing the bgp session with the usage of:

```
clear ip bgp * soft
```

Will be performed after setting the route-maps.

Initial route state

Executing a traceroute from R1 L1 to R4 L1 interface yields following results:

```
R1#traceroute 192.168.41.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.41.1

  1 10.0.12.2 8 msec 12 msec 12 msec
  2 10.0.24.2 20 msec 24 msec 32 msec
```

As expected, it goes the following route:
R1 -> f0/0 R2 -> f1/0 R4

Local preference configuration

Reminding - we need to force the traffic going into R4 to go through R3 before reaching R4, rather than going directly from R2.

The following commands were run:

```
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#route-map R2OVERRIDE permit 10
R2(config-route-map)#set local-preference 1000
R2(config-route-map)#exit
R2(config)#router bgp 230
R2(config-router)#neighb
R2(config-router)#neighbor 3.3.3.3 route-map R2OVERRIDE
% Incomplete command.

R2(config-router)#neighbor 3.3.3.3 route-map R2OVERRIDE in
R2(config-router)#do clear ip bgp * soft
```

Default local-preference is 100, so a local-preference of 1000 will label this route as a better one. We set the route from R2 to R3 as the better route. That way the packets should go from R2 to R3. Then R3 will forward the packet to R5.

The traceroute result after the above-mentioned configuration was done is:

```
R1#traceroute 192.168.41.1 source 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.41.1

  1 10.0.12.2 12 msec 20 msec 24 msec
  2 10.0.23.2 32 msec 28 msec 36 msec
  3 10.0.34.2 44 msec 40 msec 32 msec
R1#
```

Which indicates the following path: R1 -> f0/0 R2 -> f2/0 R3 -> f3/0 R4

The traceroute now shows a path that was given in the task description.
Local-preference configuration change was done properly.

Closing remarks

Every necessary console output was saved and is attached in the .tar.gz archive.
Sources: BGP lab .pdf.
Command syntaxes and information taken from various cisco documentation sites.

End