BORDER GATEWAY PROTOCOL

Lab 4: Configure and Verify EBGP

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"CyberTraining CIP: Cyberinfrastructure Expertise on High-throughput Networks for Big Science Data Transfers"

Contents

Overview

This lab presents Border Gateway Protocol (BGP) and describes the steps to configure and verify the operation of External BGP (EBGP) between two Autonomous Systems (ASes), and Open Shortest Path First (OSPF) protocol within an AS. The focus in this lab is to integrate BGP and OSPF routing protocols by using route redistribution. In this lab, the terms BGP and EBGP will be used interchangeably since they will only be running between ASes.

Objectives

By the end of this lab, students should be able to:

1. Explain the concept of BGP.
2. Configure and verify EBGP between two ASes.
3. Enable OSPF redistribution to advertise BGP routes.
4. Enable BGP redistribution to advertise OSPF routes.

Lab settings

The information in Table 1 provides the credentials to access Client1 machine.

Table 1. Credentials to access Client1 machine.

Device	Account	Password
Client1	admin	password

Lab roadmap

This lab is organized as follows:

1. Section 1: Introduction.
2. Section 2: Lab topology.
3. Section 3: Configure OSPF on router r3 and router r4.
4. Section 4: Configure BGP on all routers.
5. Section 5: Redistribute routes on router r3 and router r4.
6. Section 6: Verify connections.

1. Introduction

1.1. Intradomain and Interdomain routing protocols

The Internet consists of many independent administrative domains, referred to as ASes. ASes are operated by different organizations, which can run their own internal routing protocols. A routing protocol that runs within an AS is referred to as intradomain routing protocol. One of the most widely used intradomain protocols is OSPF. Since an AS may be large and nontrivial to manage, OSPF allows an AS to be divided into numbered areas[1]. An area is a logical collection of networks, routers, and links. All routers in the same area have detailed information of the topology within their area[2].

A routing protocol that runs between ASes is referred to as interdomain routing protocol. ASes may use different intradomain routing protocols; however, they must use the same interdomain routing protocol, i.e., BGP. Routers in different ASes exchange information using EBGP. BGP allows the enforcement of different routing policies on the traffic from one AS to another. For example, a security policy can prevent the dissemination of routing information from one AS to another[1].

Consider Figure 1. Routers within AS 1 exchange routing information using OSPF. On the other hand, routers in different ASes exchange routing information using EBGP.

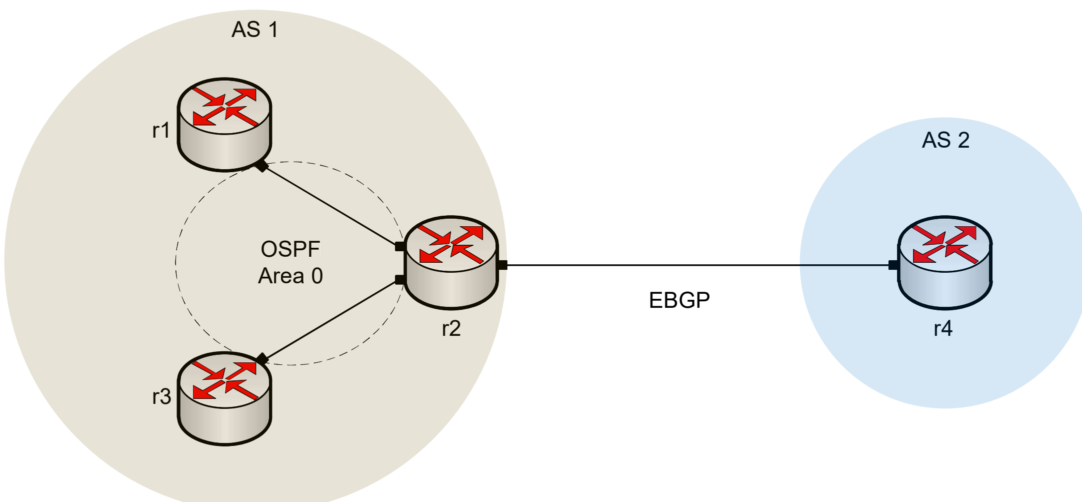


Figure 1. Routers r1, r2, and r3 within AS 1 run OSPF, while routers r2 and r4 in AS 1 and AS 2, respectively, run EBGP.

1.2. Multiprotocol routing and redistribution of protocols

Multi-protocol routing is when two or more routing protocols run in the same router.

The use of a routing protocol to advertise routes that are learned by another routing protocol is called route redistribution[3]. In Figure 2, router r2 receives routing information from router r1 via EBGP. By using redistribution, this information can then be advertised to AS 2 via OSPF. Similarly, routing information received via OSPF can then be advertised to AS1 via EBGP.

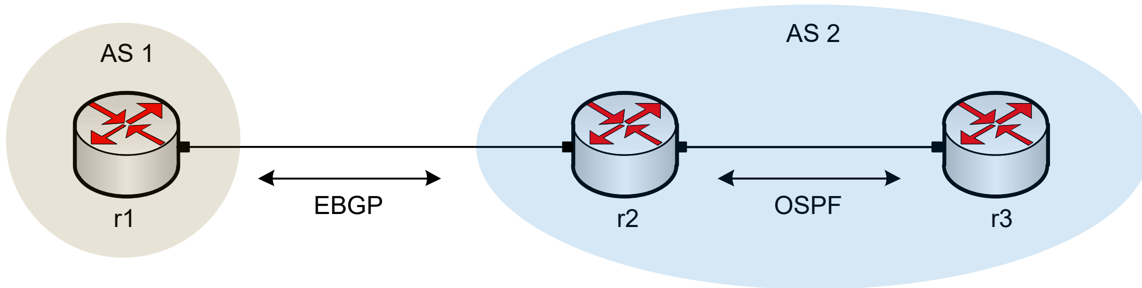


Figure 2. Router r2 redistributes routes between AS1 and AS2.

2. Lab topology

Consider Figure 3. The lab topology consists of three ASes, each identified by an Autonomous System Number (ASN). The ASNs assigned to Campus-1, Campus-2, and the Internet Service Provider (ISP) are 100, 200, and 300, respectively. Campus-1 must exchange routes with Campus-2 using the ISP, which routes the traffic from one AS to another. The communication between ASes is established via EBGP, whereas the communication inside AS 300, i.e., between routers r3 and r4, is established using OSPF.

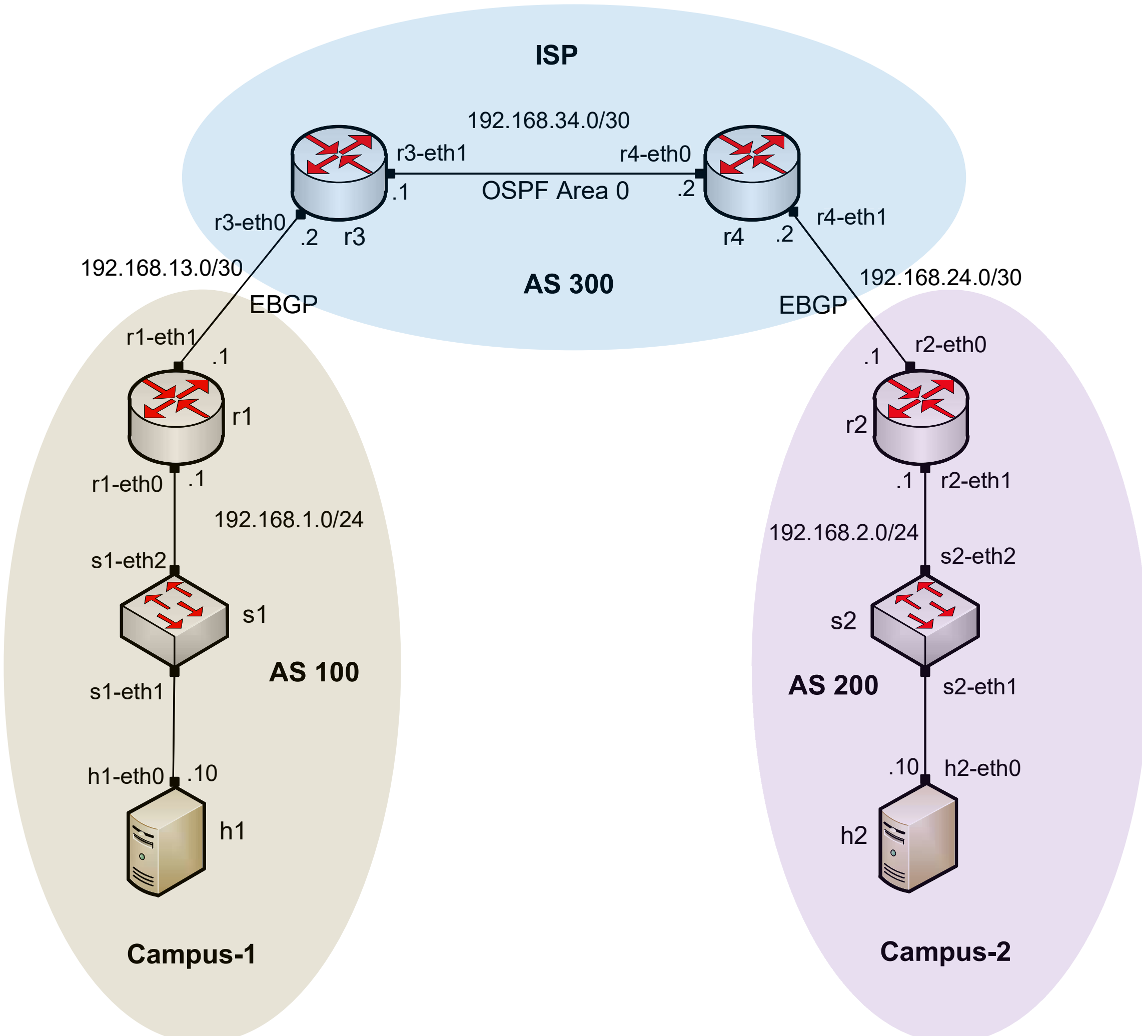


Figure 3. Lab topology.

2.1. Lab settings

Routers and hosts are already configured according to the IP addresses shown in Table 2.

Table 2. Topology information.

Device	Interface	IPV4 Address	Subnet	Default gateway
r1 (Campus-1)	r1-eth0	192.168.1.1	/24	N/A
	r1-eth1	192.168.13.1	/30	N/A
r2 (Campus-2)	r2-eth0	192.168.2.1	/24	N/A
	r2-eth1	192.168.24.1	/30	N/A
r3 (ISP)	r3-eth0	192.168.13.2	/30	N/A
	r3-eth1	192.168.34.1	/30	N/A

r4 (ISP)	r4-eth0	192.168.34.2	/30	N/A
	r4-eth1	192.168.24.2	/30	N/A
h1	h1-eth0	192.168.1.10	/24	192.168.1.1
h2	h2-eth0	192.168.2.10	/24	192.168.2.1

2.2. Open the topology

Step 1. Start by launching Miniedit by clicking on Desktop's shortcut. When prompted for a password, type `password`.

Figure 4. MiniEdit shortcut.

Step 2. On Miniedit's menu bar, click on *File* then *open* to load the lab's topology. Open the *Lab4.mn* topology file stored in the default directory, */home/frr/BGP_Labs/lab4* and click on *Open*.

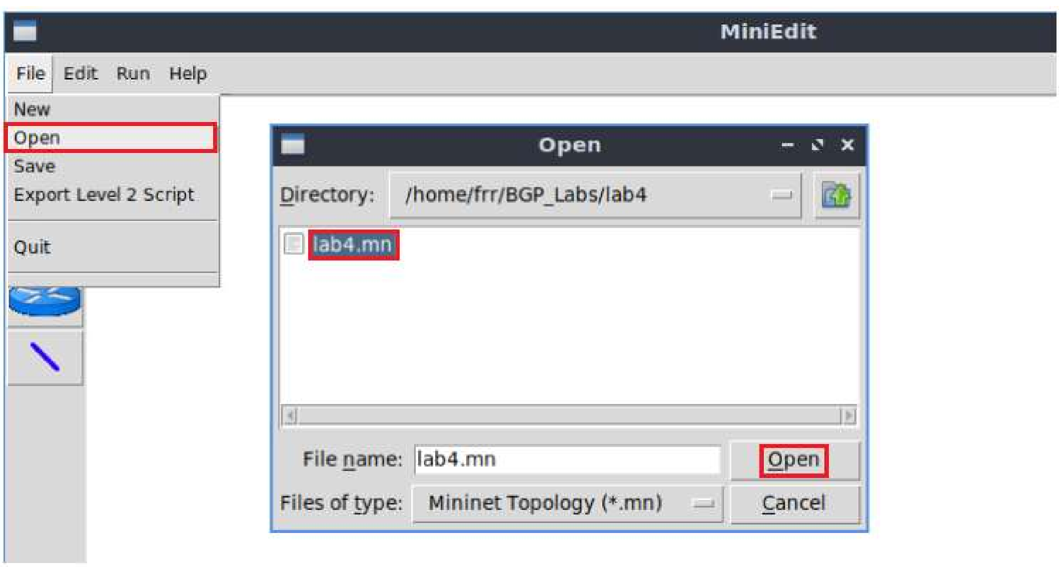


Figure 5. MiniEdit's open dialog.

At this point the topology is loaded with all the required network components. You will execute a script that will load the configuration of the routers.

Step 3. Open the Linux terminal.

Figure 6. Opening Linux terminal.

Step 4. Click on the Linux's terminal and navigate into *BGP_Labs/lab4* directory by issuing the following command. This folder contains a configuration file and the script responsible for loading the configuration. The configuration file will assign the IP addresses to the routers' interfaces. The `cd` command is short for change directory followed by an argument that specifies the destination directory.

```
cd BGP_Labs/lab4
```

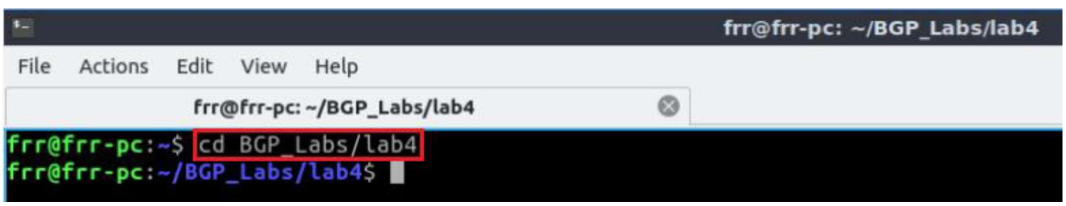


Figure 7. Entering the *BGP_Labs/lab4* directory.

Step 5. To execute the shell script, type the following command. The argument of the program corresponds to the configuration zip file that will be loaded in all the routers in the topology.

```
./config_loader.sh lab4_conf.zip
```

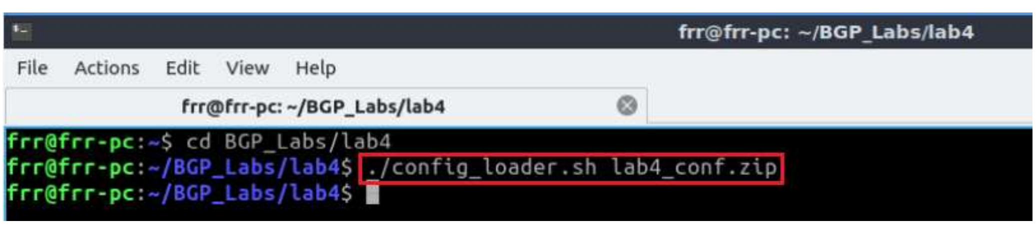


Figure 8. Executing the shell script to load the configuration.

Step 6. Type the following command to exit the Linux terminal.

```
exit
```

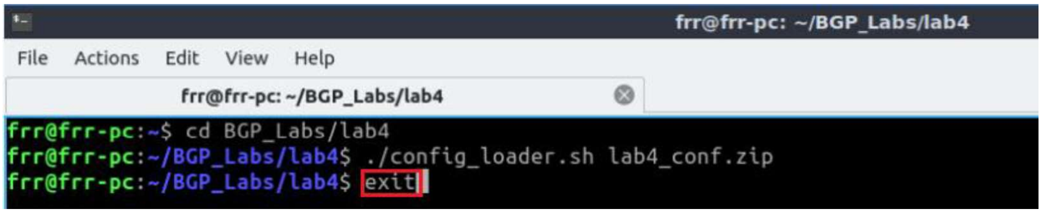


Figure 9. Exiting from the terminal.

Step 7. At this point hosts h1 and h2 interfaces are configured. To proceed with the emulation, click on the *Run* button located in lower left-hand side.

Figure 10. Starting the emulation.

Step 8. Click on Mininet's terminal, i.e., the one launched when MiniEdit was started.

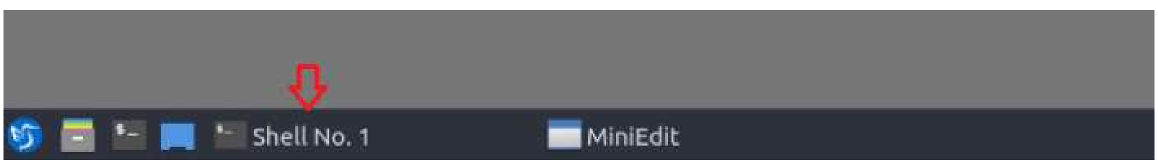


Figure 3. Opening Mininet's terminal.

Step 9. Issue the following command to display the interface names and connections.

```
links
```

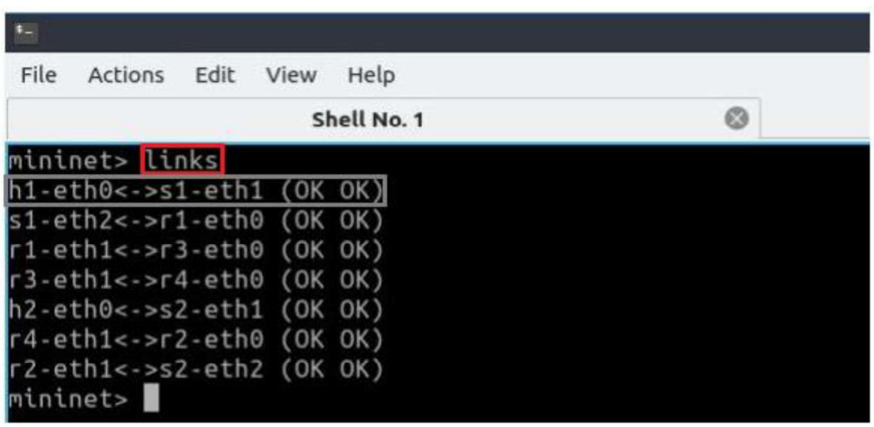


Figure 12. Displaying network interfaces.

In Figure 12, the link displayed within the gray box indicates that interface *eth0* of host h1 connects to interface *eth1* of switch s1 (i.e., *h1-eth0<->s1-eth1*).

2.3. Load zebra daemon and verify configuration

You will verify that the IP addresses listed in Table 2 and inspect the routing table of routers r1, r2, r3, and r4.

Step 1. Hold right-click on host h1 and select *Terminal*. This opens the terminal of host h1 and allows the execution of commands in that host.

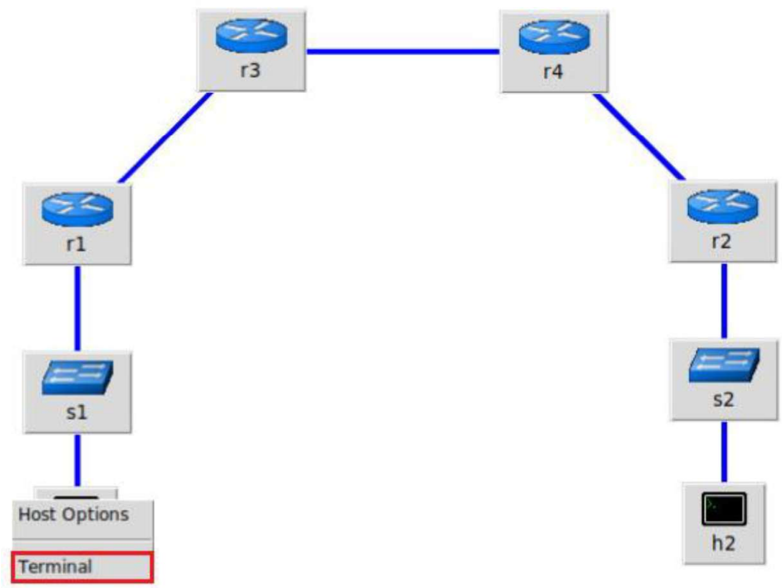


Figure 13. Opening terminal on host h1.

Step 2. On h1 terminal, type the command shown below to verify that the IP address was assigned successfully. You will verify that host h1 has two interfaces, *h1-eth0* configured with the IP address 192.168.1.10 and the subnet mask 255.255.255.0.

```
ifconfig
```

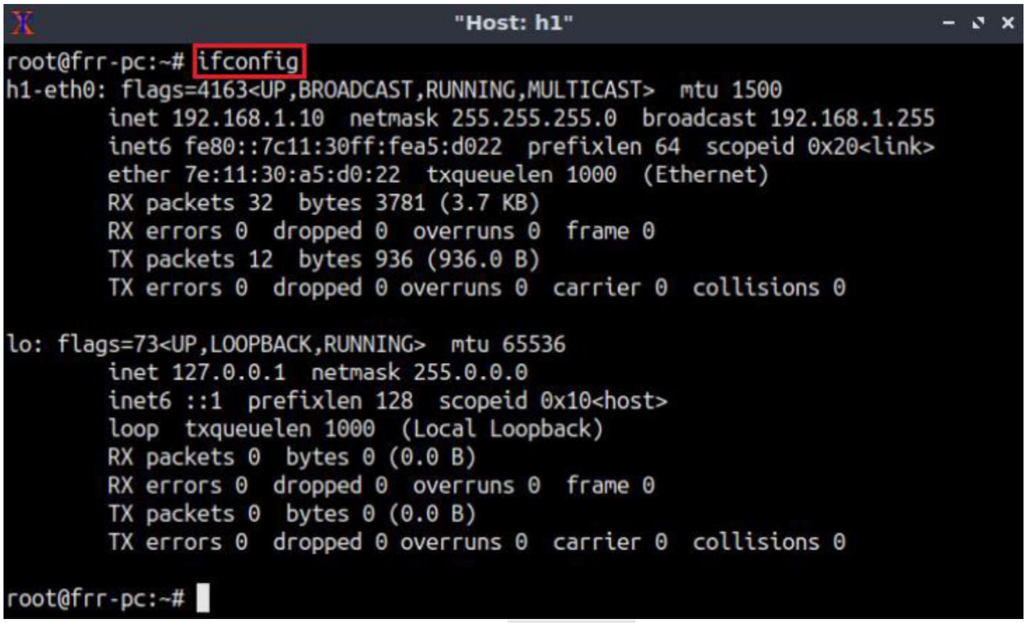


Figure 14. Output of `ifconfig` command.

Step 3. On host h1 terminal, type the command shown below to verify that the default gateway IP address is 192.168.1.1.

```
route
```

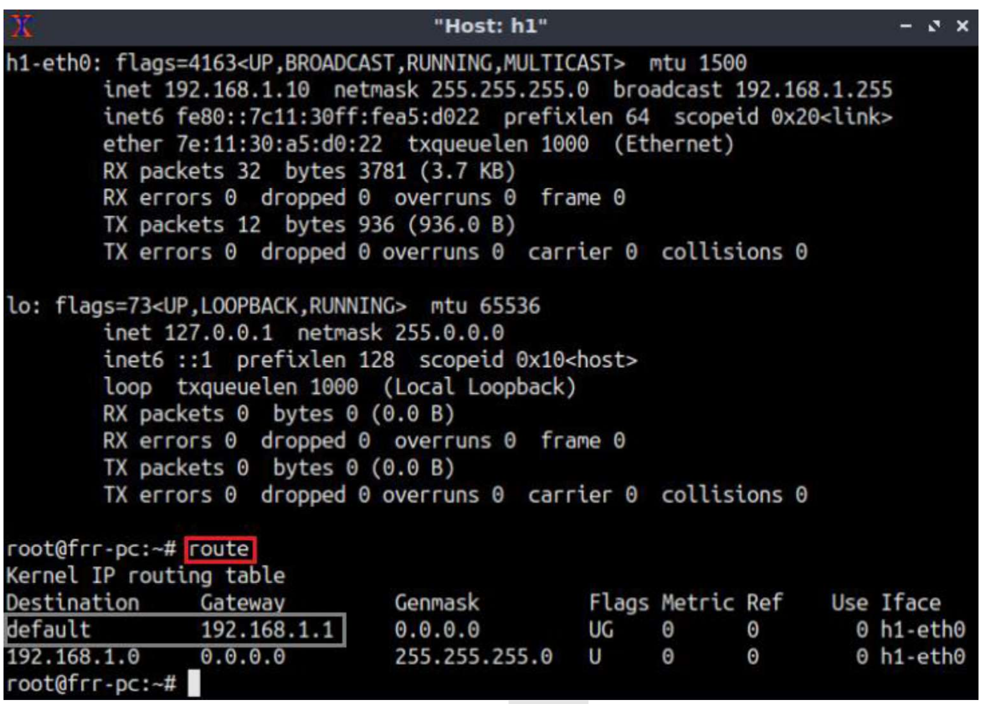


Figure 15. Output of `route` command.

Step 4. In order to verify host h2, proceed similarly by repeating from step 1 to step 3 in host h2 terminal. Similar results should be observed.

Step 5. You will validate that the router interfaces are configured correctly according to Table 2. To proceed, hold right-click on router r1 and select *Terminal*.

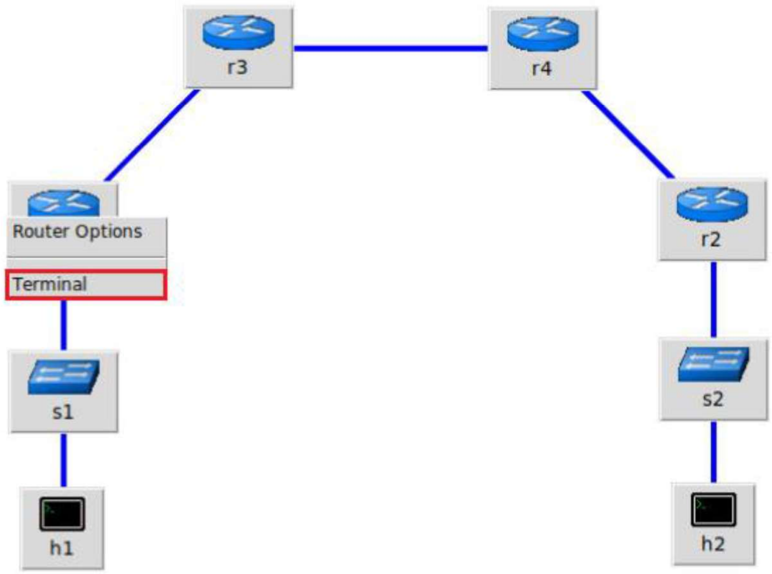


Figure 16. Opening terminal on router r1.

Step 6. In this step, you will start zebra daemon, which is a multi-server routing software that provides TCP/IP based routing protocols. The configuration will not be working if you do not enable zebra daemon initially. In order to start the zebra, type the following command:

```
zebra
```

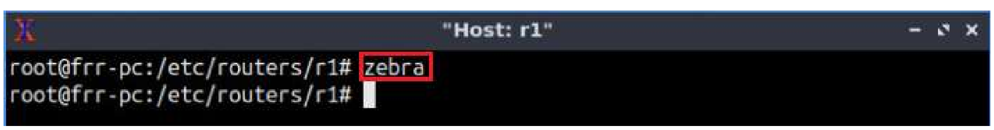


Figure 17. Starting zebra daemon.

Step 7. After initializing zebra, vtysh should be started in order to provide all the CLI commands defined by the daemons. To proceed, issue the following command:

```
vtysh
```

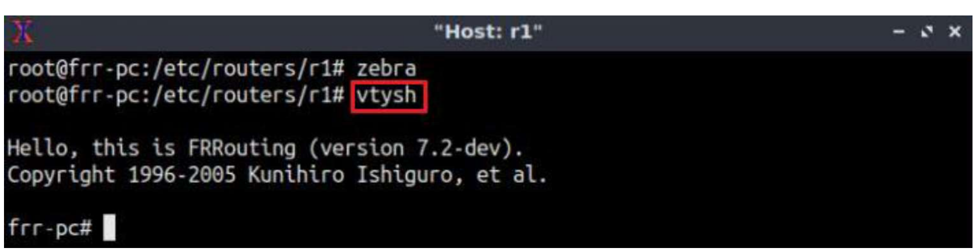


Figure 18. Starting vtysh in router r1.

Step 8. Type the following command on router r1 terminal to verify the routing table of router r1. It will list all the directly connected networks. The routing table of router r1 does not contain any route to the network attached to router r2 (192.168.2.0/24) and router r4 (192.168.24.0/30, 192.168.34.0/30) as there is no routing protocol configured yet.

```
show ip route
```

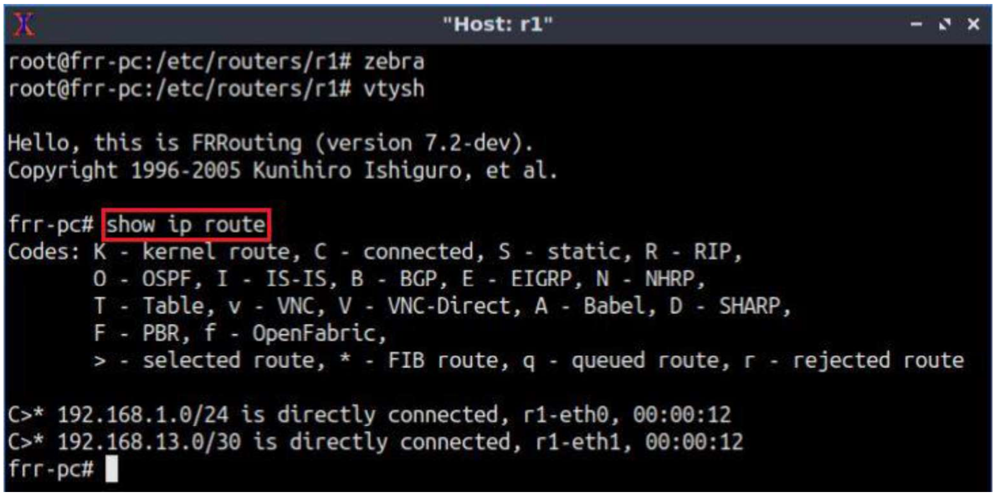


Figure 19. Displaying routing table of router r1.

Step 9. Router r2 is configured similarly to router r1 but, with different IP addresses (see Table 2). Those steps are summarized in the following figure. To proceed, in router r2 terminal issue the commands depicted below. At the end, you will verify all the directly connected networks of router r2.

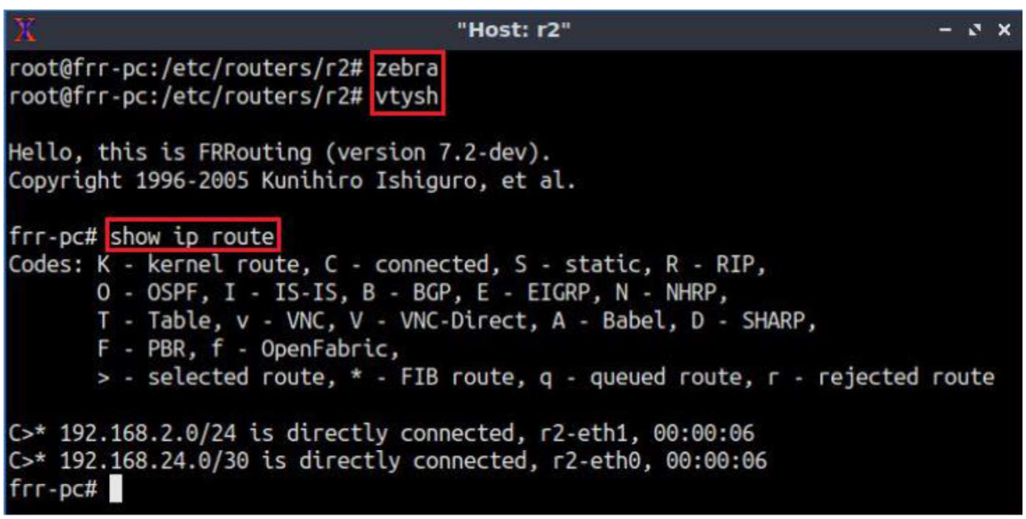


Figure 20. Displaying routing table of router r2.

Step 10. Router r3 is configured similarly to router r1 but, with different IP addresses (see Table 2). Those steps are summarized in the following figure. To proceed, in router r3 terminal, issue the commands depicted below. At the end, you verify all the directly connected networks of router r3.

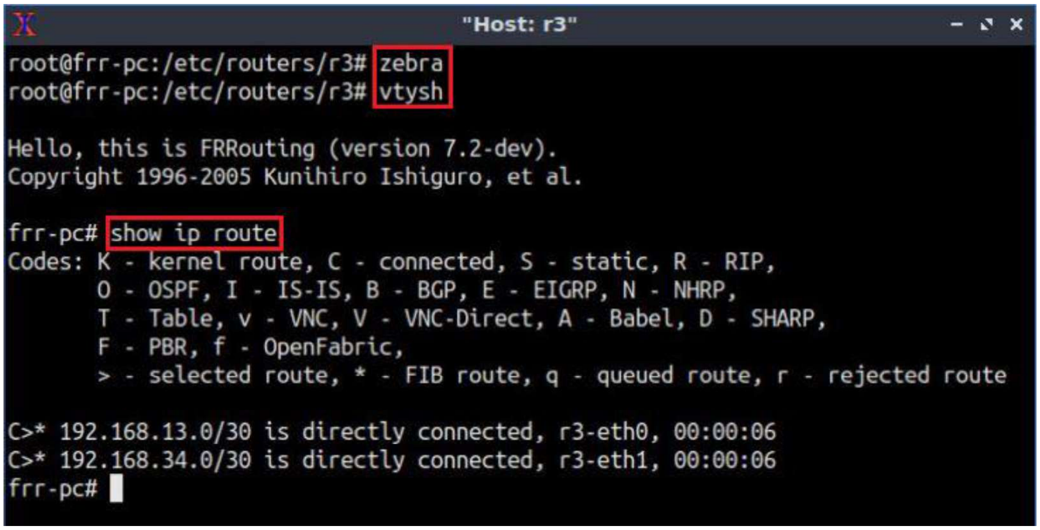


Figure 21. Displaying routing table of router r3.

Step 11. Router r4 is configured similarly to router r1 but, with different IP addresses (see Table 2). Those steps are summarized in the following figure. To proceed, in router r4 terminal, issue the commands depicted below. At the end, you verify all the directly connected networks of router r4.

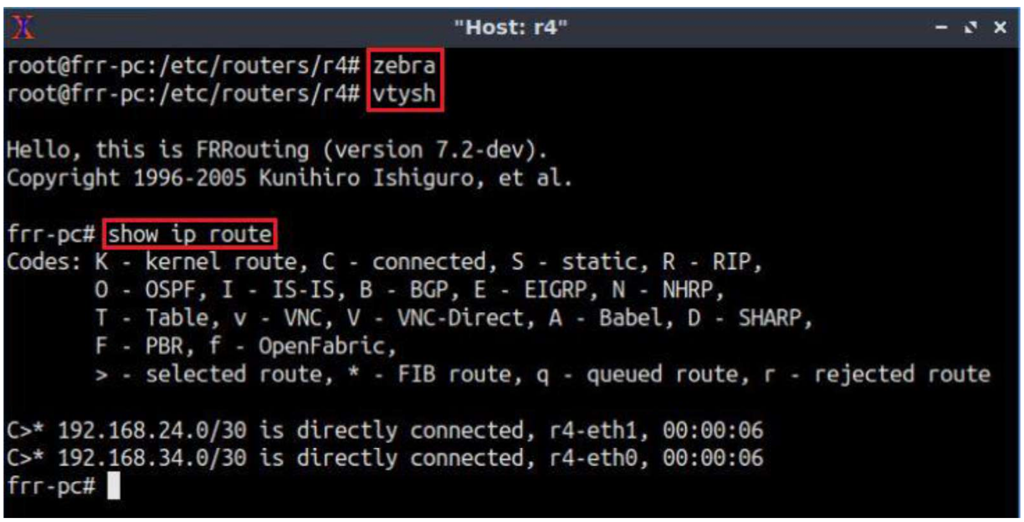


Figure 22. Displaying routing table of router r4.

3. Configure OSPF on router r3 and router r4

In this section, you will configure OSPF routing protocol in router r3 and router r4. First, you will enable the OSPF daemon router r3 and router r4. Second, you will a establish single area OSPF, which is classified as area 0 or backbone area. Finally, all the connected networks are advertised.

Step 1. To configure OSPF routing protocol, you need to enable the OSPF daemon first. In router r3, type the following command to exit the vtysh session:

```
exit
```

Figure 23. Exiting the vtysh session.

Step 2. Type the following command on router r3 terminal to enable OSPF daemon.

```
ospfd
```

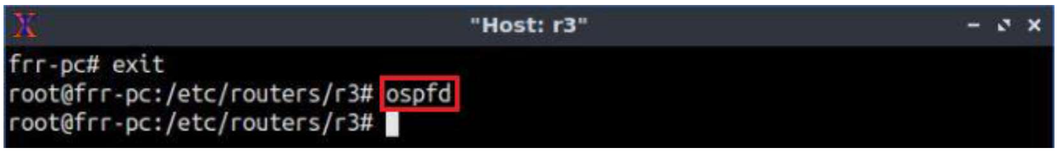


Figure 24. Starting OSPF daemon.

Step 3. In order to enter to router r3 terminal, issue the following command:

```
vtysh
```

Figure 25. Starting vtysh on router r3.

Step 4. To enable router r3 configuration mode, issue the following command:

```
configure terminal
```

Figure 26. Enabling configuration mode on router r3.

Step 5. In order to configure OSPF routing protocol, type the command shown below. This command enables OSPF configuration mode where you advertise the networks directly connected to router r3.

```
router ospf
```

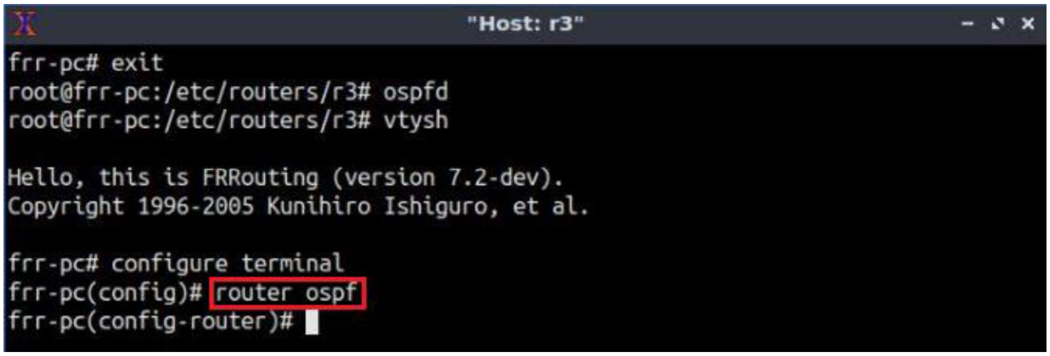


Figure 27. Configuring OSPF on router r3.

Step 6. In this step, type the following command to enable the interface *r3-eth0*, corresponding to the network 192.168.13.0/30, to participate in the routing process. This network is associated with area 0.

```
network 192.168.13.0/30 area 0
```

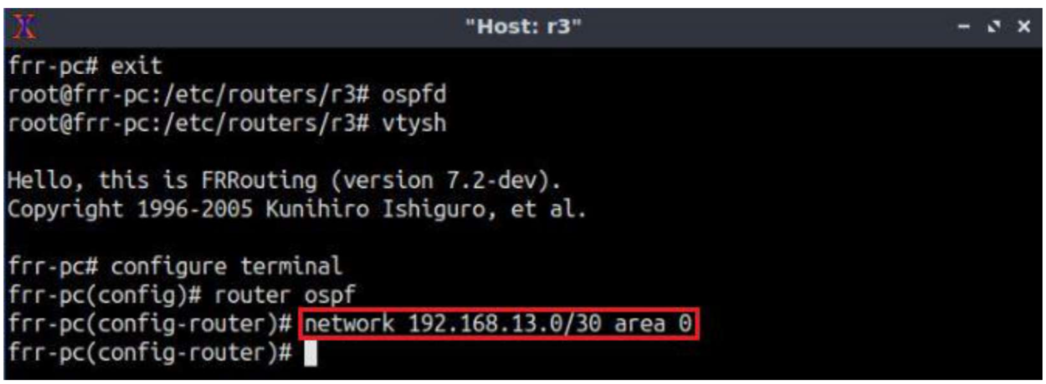


Figure 28. Enabling the interface corresponding to the network 192.168.13.0/30 to participate in the OSPF routing process.

Step 7. Similarly, type the following command on router r3 terminal to enable the interface *r3-eth1* to participate in the OSPF routing process.

```
network 192.168.34.0/30 area 0
```

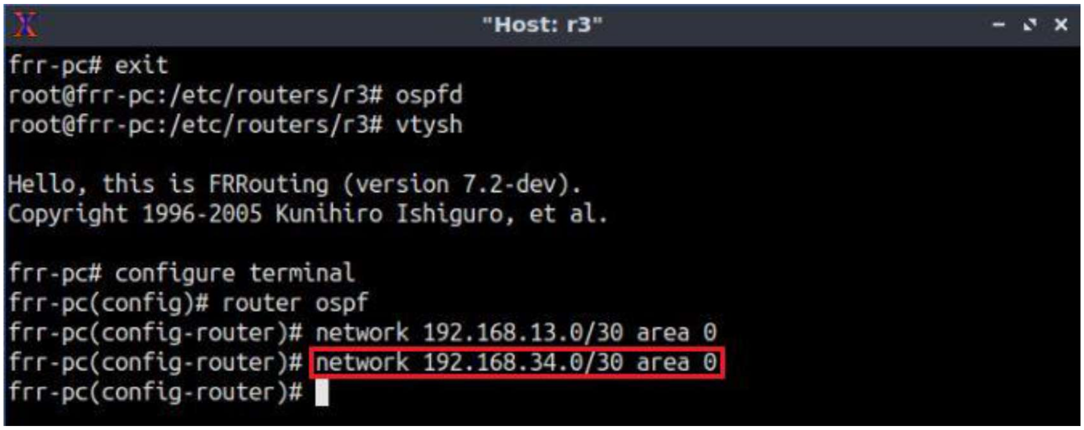


Figure 29. Enabling the interface corresponding to 192.168.34.0/30 to participate in the OSPF routing process.

Step 8. Type the following command to exit from the configuration mode.

```
end
```

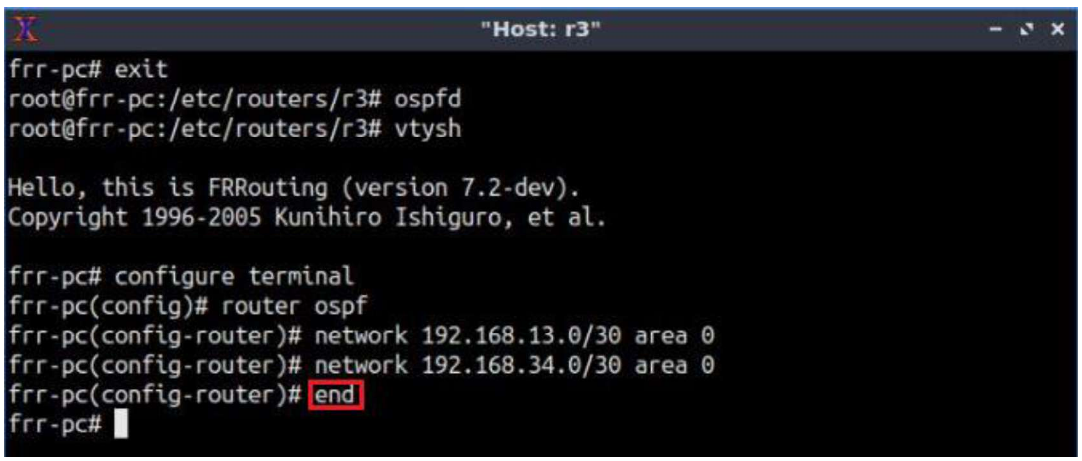


Figure 30. Exiting from configuration mode.

Step 9. Router r4 is configured similarly to router r3 but, with different IP addresses (see Table 2). Those steps are summarized in the following figure. To proceed, on router r4 terminal, issue the commands depicted below.

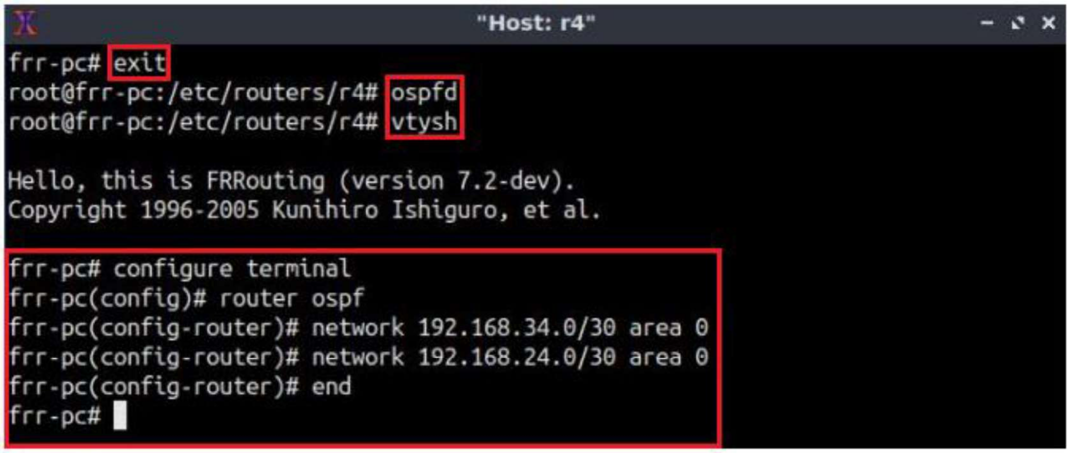


Figure 31. Configuring OSPF on router r4.

Step 10. Type the following command to verify the routing table of router r4.

```
show ip route
```

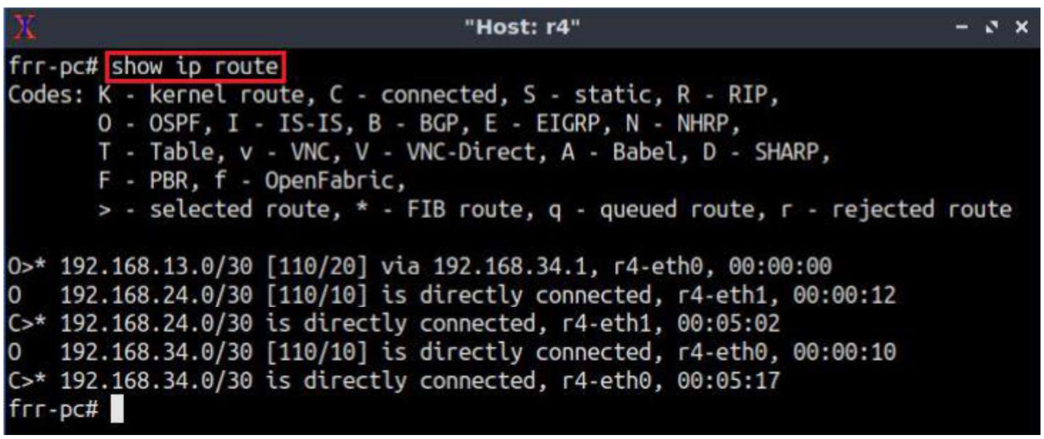


Figure 32. Verifying the routing table of router r4.

Consider Figure 32. Three additional networks (192.168.13.0/30, 192.168.24.0/30 and 192.168.34.0/30) advertised by OSPF. Router r4 reaches the network 192.168.13.0/30 via the IP address 192.168.34.1. Networks 192.168.24.0/30 and 192.168.34.0/30 have two available paths from router r4. The Administrative Distance (AD) of the paths advertised through OSPF is 110. The AD is a value used by routers to select the best path when there are multiple available routes to the same destination. A smaller AD is always preferable to the routers. The characters `>*` indicates that the following path is used to reach a specific network. Router r4 prefers directly connected networks over OSPF since the former has a lower AD than the latter.

Step 11. In router r3 terminal, test the connectivity between routers r3 and r4 using the `ping` command. Router r3 should ping the IP address 192.168.24.2 after configuring the OSPF routing protocol. To stop the test, press `Ctrl+c`. The figure below shows a successful connectivity test.

```
ping 192.168.24.2
```

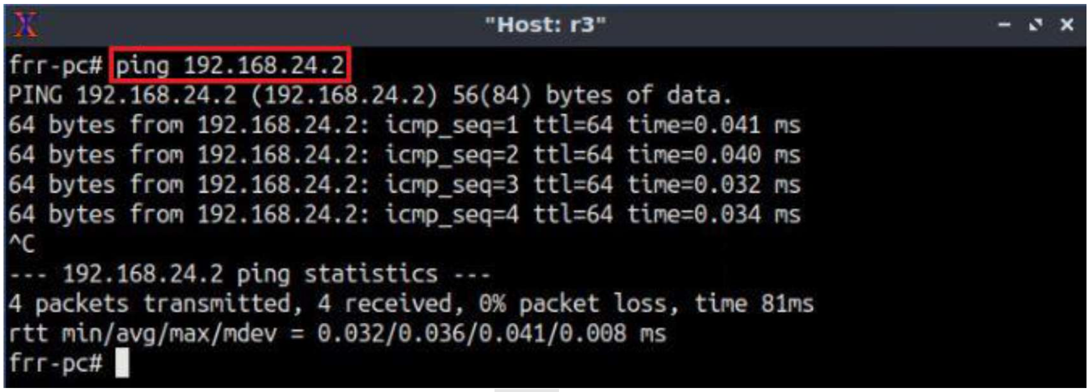


Figure 33. Output of `ping` command on router r3.

4. Configure BGP on all routers

In this section, you will configure EBGP in the routers that are hosted in different ASes. You will assign BGP neighbors to allow the routers to exchange BGP routes. Furthermore, routers r1 and r2 will advertise their LANs via BGP. Therefore, router r3 and router r4 will receive route information about LAN 192.168.1.0/24 and 192.168.2.0/24, respectively.

Step 1. To configure BGP routing protocol, you need to enable the BGP daemon first. In router r1, type the following command to exit the vtysh session:

```
exit
```

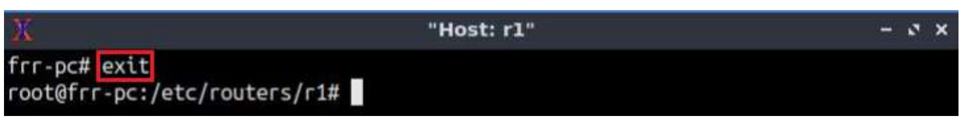


Figure 34. Exiting the vtysh session.

Step 2. Type the following command on router r1 terminal to enable and to start BGP routing protocol.

```
bgpd
```

Figure 35. Starting BGP daemon.

Step 3. In order to enter to router r1 terminal, type the following command:

```
vtysh
```

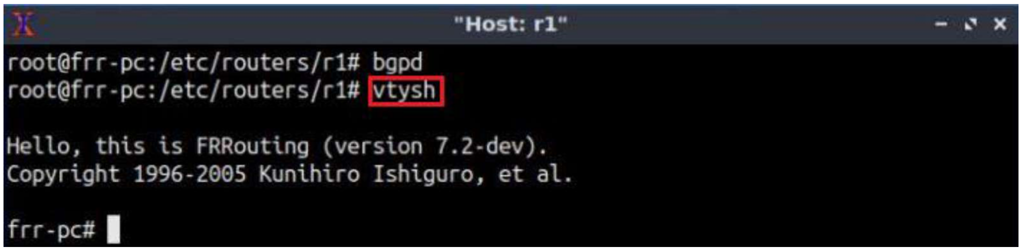


Figure 36. Starting vtysh on router r1.

Step 4. To enable router r1 configuration mode, issue the following command:

```
configure terminal
```

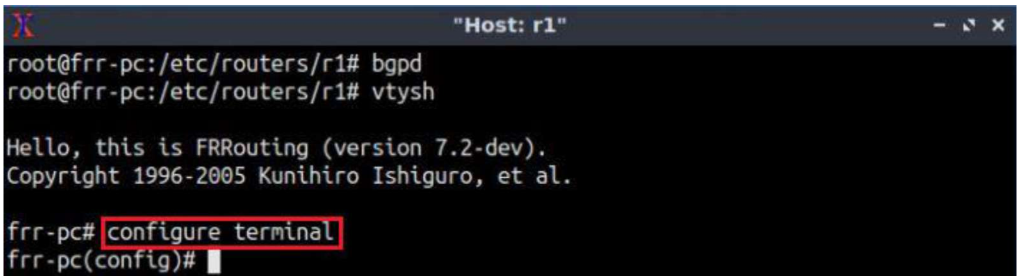


Figure 37. Enabling configuration mode on router r1.

Step 5. The ASN assigned for router r1 is 100. In order to configure BGP, type the following command:

```
router bgp 100
```

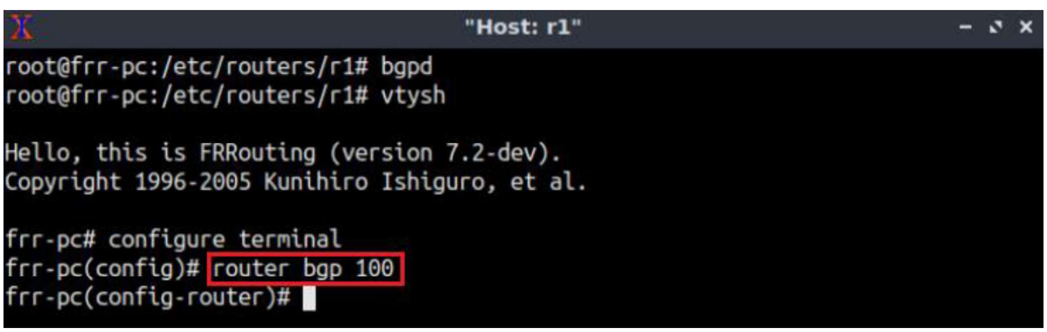


Figure 38. Configuring BGP on router r1.

Step 6. To configure a BGP neighbor to router r1 (AS 100), type the command shown below. This command specifies the neighbor IP address (192.168.13.2) and ASN of the remote BGP peer (AS 300).

```
neighbor 192.168.13.2 remote-as 300
```

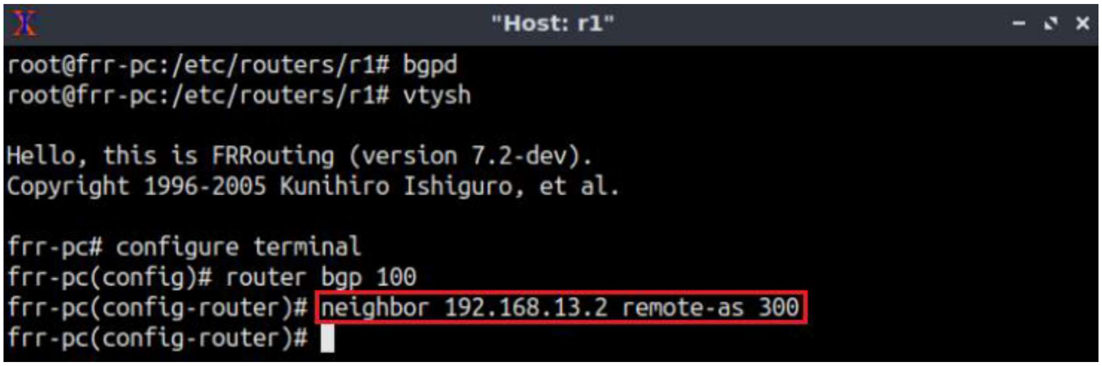


Figure 39. Assigning BGP neighbor to router r1.

Step 7. In this step, router r1 will advertise the Local Area Network (LAN) 192.168.1.0/24 to router r3 through EBGP. To do so, issue the following command:

```
network 192.168.1.0/24
```

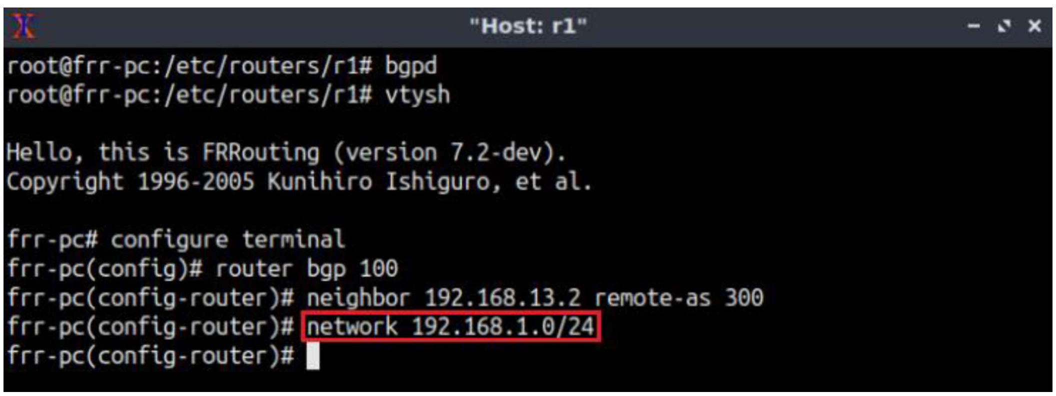


Figure 40. Advertising a network on router r1.

Step 8. Type the following command to exit from the configuration mode.

```
end
```

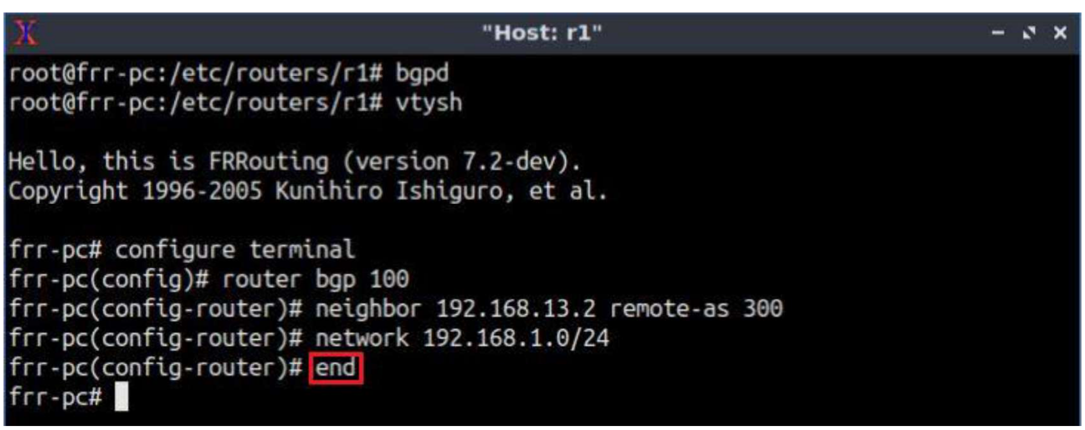


Figure 41. Exiting from configuration mode.

Step 9. Type the following command to verify BGP networks. You will observe the LAN network of router r1.

```
show ip bgp
```

```
"Host: r1"
frr-pc# show ip bgp
BGP table version is 1, local router ID is 192.168.13.1, vrf id 0
Default local pref 100, local AS 100
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 192.168.1.0/24   0.0.0.0                  0         32768 i

Displayed  1 routes and 1 total paths
frr-pc#
```

Figure 42. Verifying BGP networks on router r1.

Step 10. Type the following command to verify BGP neighbors. You will verify that the neighbor IP address is 192.168.13.2. The corresponding ASN is 300.

```
show ip bgp neighbors
```

```
"Host: r1"
frr-pc# show ip bgp neighbors
BGP neighbor is 192.168.13.2, remote AS 300, local AS 100, external link
Hostname: frr-pc
  BGP version 4, remote router ID 192.168.34.1, local router ID 192.168.13.1
  BGP state = Established, up for 00:04:11
  Last read 00:00:11, Last write 00:00:11
  Hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    4 Byte AS: advertised and received
    AddPath:
      IPv4 Unicast: RX advertised IPv4 Unicast and received
    Route refresh: advertised and received(old & new)
    Address Family IPv4 Unicast: advertised and received
    Hostname Capability: advertised (name: frr-pc,domain name: n/a) received (na
me: frr-pc,domain name: n/a)
    Graceful Restart Capabilty: advertised and received
      Remote Restart timer is 120 seconds
      Address families by peer:
        none
  Graceful restart information:
    End-of-RIB send: IPv4 Unicast
    End-of-RIB received: IPv4 Unicast
  Message statistics:
    Inq depth is 0
```

Figure 43. Verifying BGP neighbors on router r1.

Step 11. Follow from step 1 to step 8 but with different metrics in order to configure BGP in router r2. All these steps are summarized in the following figure.

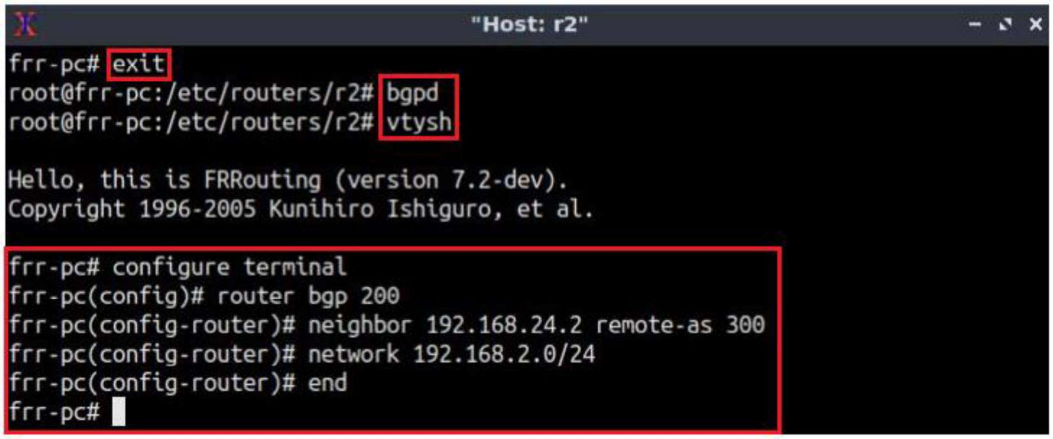


Figure 44. Configuring BGP on router r2.

Step 12. To configure BGP on router r3, you will add the neighbor router r1 so that router r3 receives router r1 advertised routes. To do so, type all the commands summarized in the following figure.

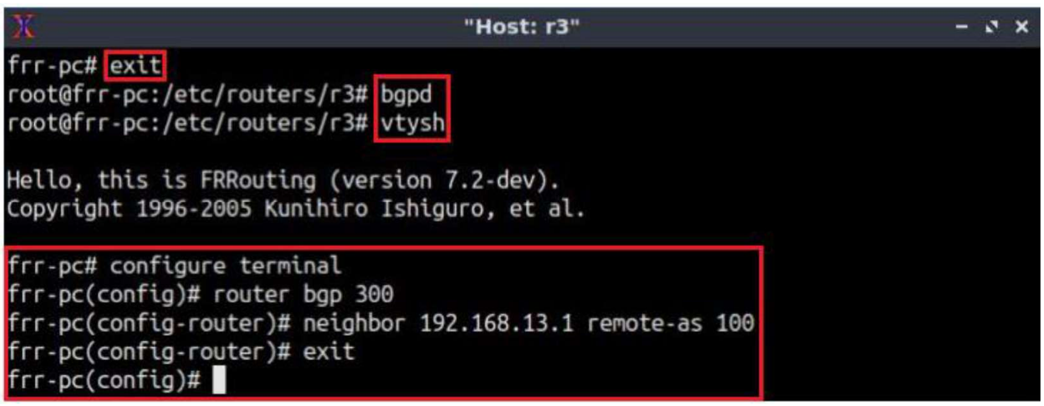


Figure 45. Configuring BGP on router r3.

Step 13. To configure BGP on router r4, you will add the neighbor router r2 so that router r4 receives the network address of router r2. To do so, type all the commands summarized in the following figure.

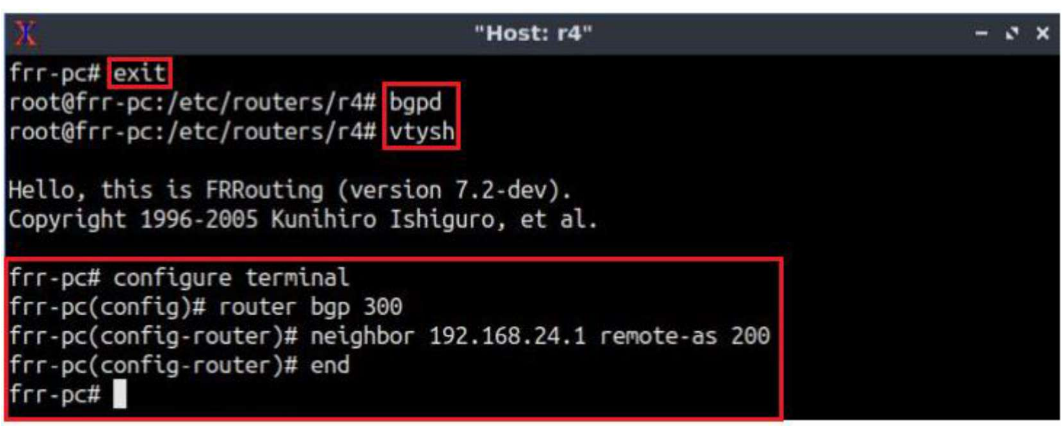


Figure 46. Configuring BGP on router r4.

Step 14. Type the following command to verify the routing table of router r4. The LAN of router r2 network (192.168.2.0/24) is advertised to router r4 through EBGP.

```
show ip route
```

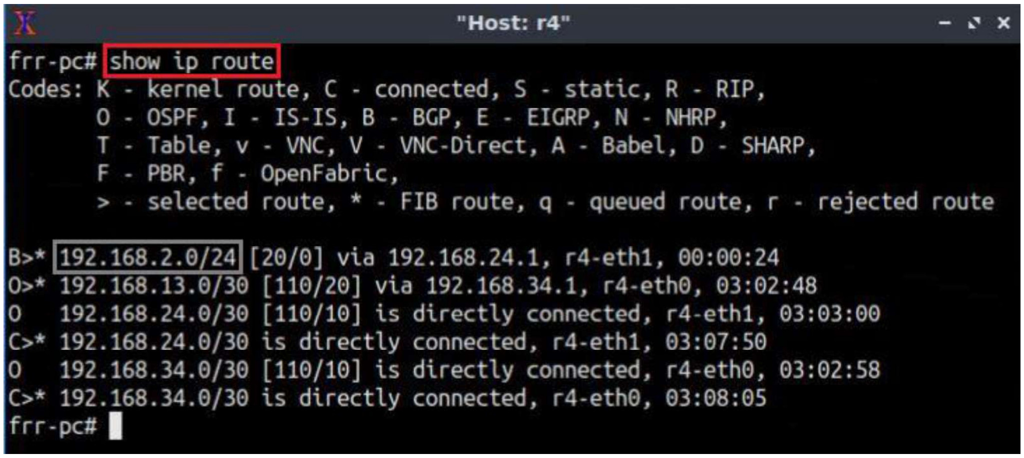


Figure 47. Verifying the routing table of router r4.

Step 15. Type the following command to verify the BGP table of router r4. The network address 192.168.2.0/24 of the LAN connected to router r2 is present in router r4 BGP table. The table also shows the next hop to reach the network, which is the IP address of the neighbor router r4.

```
show ip bgp
```

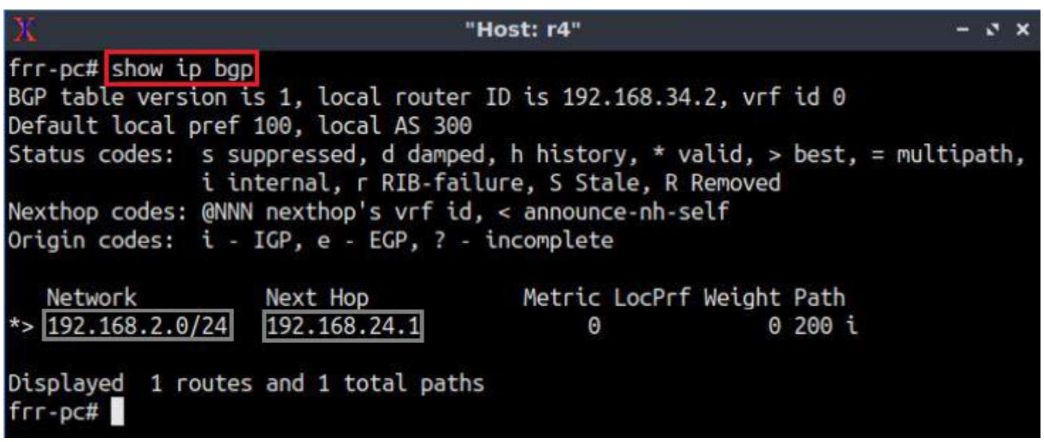


Figure 48. Verifying the BGP table of router r4.

5. Redistribute routes on router r3 and router r4

In this section, you will configure redistribution in routers running multiple routing protocols (OSPF, BGP), i.e., routers r3 and r4. At this point, routing protocols do not share their learned routes with each other. Thus, you will redistribute the routes of each routing protocol so that routers r3 and r4 share all the routes with each other. In section 5.1, you will redistribute BGP routes into OSPF routing protocol with a default metric. Then, in section 5.2, OSPF and directly connected routes will be redistributed into BGP routing protocol.

5.1. Inject BGP routes into OSPF

Step 1. Router r3 received the network 192.168.1.0/24 through EBGP. By doing the redistribution, r3 will share the network with router r4 via OSPF. In this step, you will enable OSPF configuration mode so that you can redistribute the BGP route into OSPF. To enable OSPF configuration mode, type the following command in router r3 terminal:

```
router ospf
```

Figure 49. Enabling OSPF configuration.

Step 2. Type the command shown below to display all the options available for route redistribution. Then, the option `bgp` will be listed.

```
redistribute ?
```

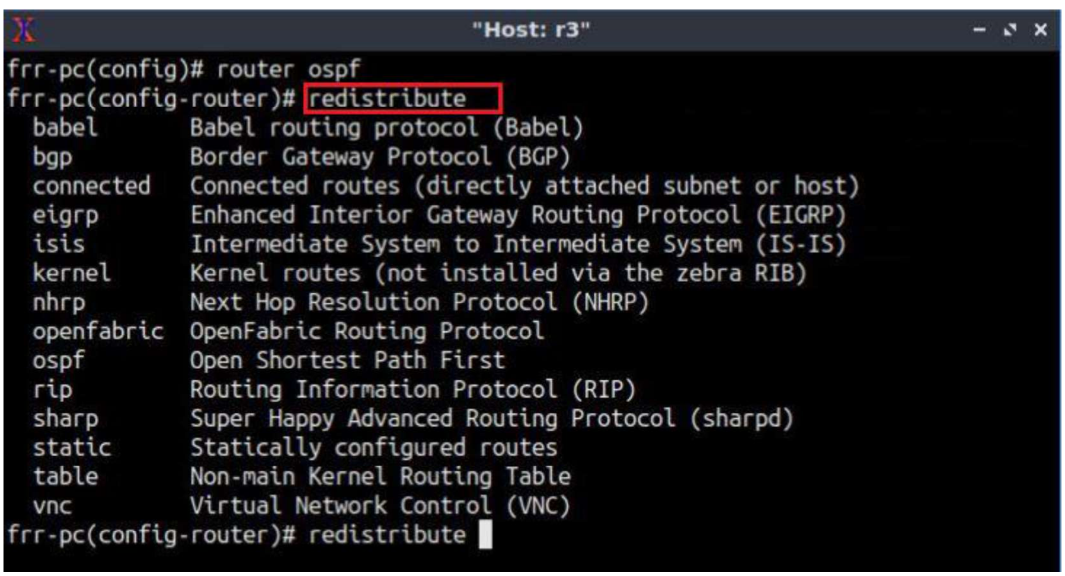


Figure 50. Listing all the redistribution options.

Notice that the character `?` will not be displayed in the command prompt, it will display a list of the commands you can use after the word *redistribution* instead.

Step 3. To list the BGP options, type the command.

```
bgp ?
```

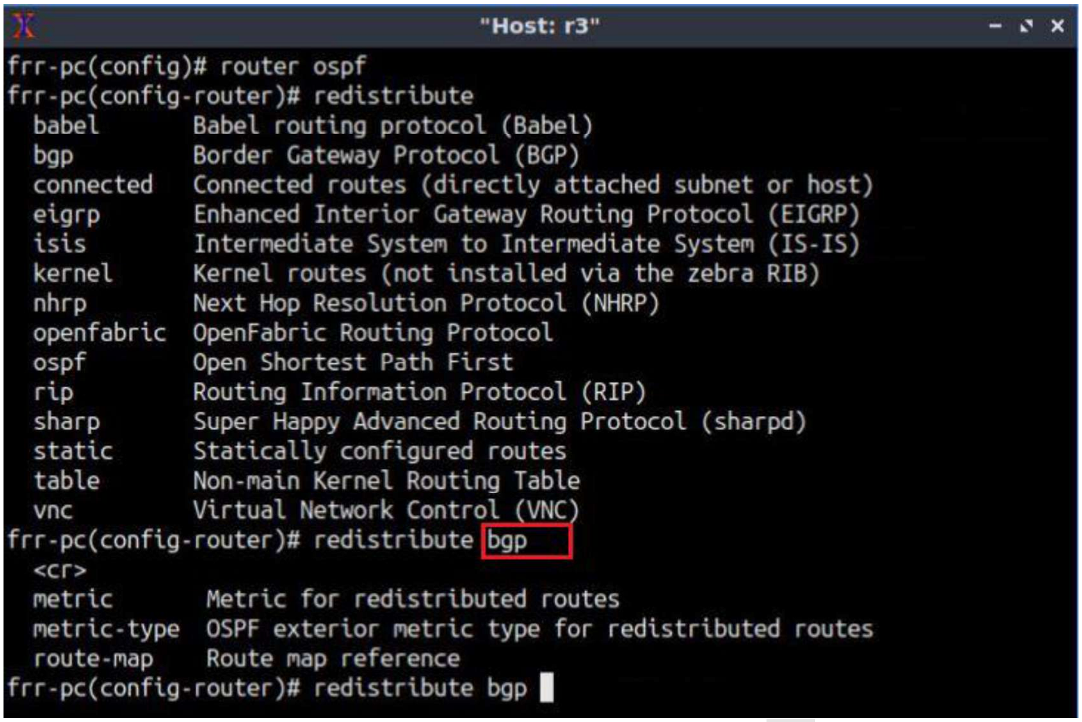
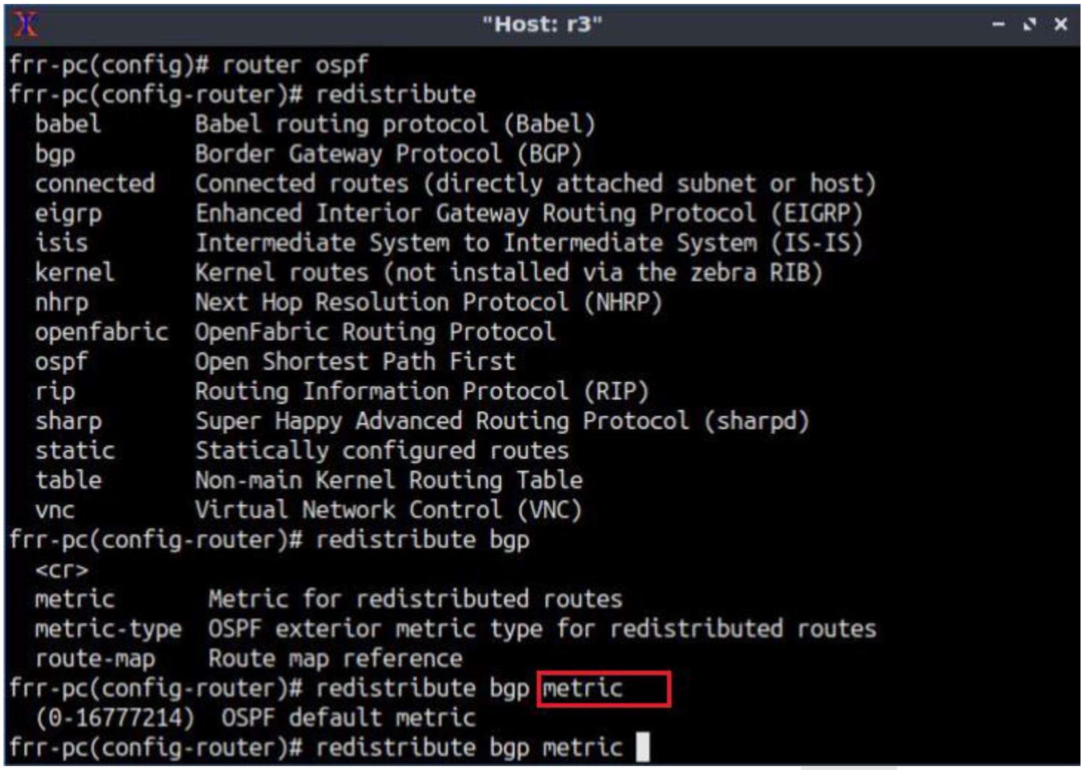


Figure 51. Listing the options available for `bgp`.

Notice that the bgp `?` will not be displayed in the command prompt instead, you will get a list of options that you can use with `bgp` command.

Step 4. Type the following command to configure the default metric. Notice that the character `?` will not be displayed in the command prompt instead, you will get the range of number that `metric` can adopt. You can choose any number within the range in order to configure the default metric.

```
metric ?
```



```
"Host: r3"
frr-pc(config)# router ospf
frr-pc(config-router)# redistribute
  babel        Babel routing protocol (Babel)
  bgp          Border Gateway Protocol (BGP)
  connected    Connected routes (directly attached subnet or host)
  eigrp        Enhanced Interior Gateway Routing Protocol (EIGRP)
  isis         Intermediate System to Intermediate System (IS-IS)
  kernel       Kernel routes (not installed via the zebra RIB)
  nhrp         Next Hop Resolution Protocol (NHRP)
  openfabric   OpenFabric Routing Protocol
  ospf         Open Shortest Path First
  rip          Routing Information Protocol (RIP)
  sharp        Super Happy Advanced Routing Protocol (sharpd)
  static       Statically configured routes
  table        Non-main Kernel Routing Table
  vnc          Virtual Network Control (VNC)
frr-pc(config-router)# redistribute bgp
  <cr>
  metric        Metric for redistributed routes
  metric-type   OSPF exterior metric type for redistributed routes
  route-map     Route map reference
frr-pc(config-router)# redistribute bgp metric
  (0-16777214)  OSPF default metric
frr-pc(config-router)# redistribute bgp metric
```

Figure 52. Showing the range of values available for `metric`.

Step 5. In order to redistribute BGP routes, a specific metric is required. For the purpose of this lab, you will specify the metric `12`. Type the following command to assign a BGP metric.

```
12
```

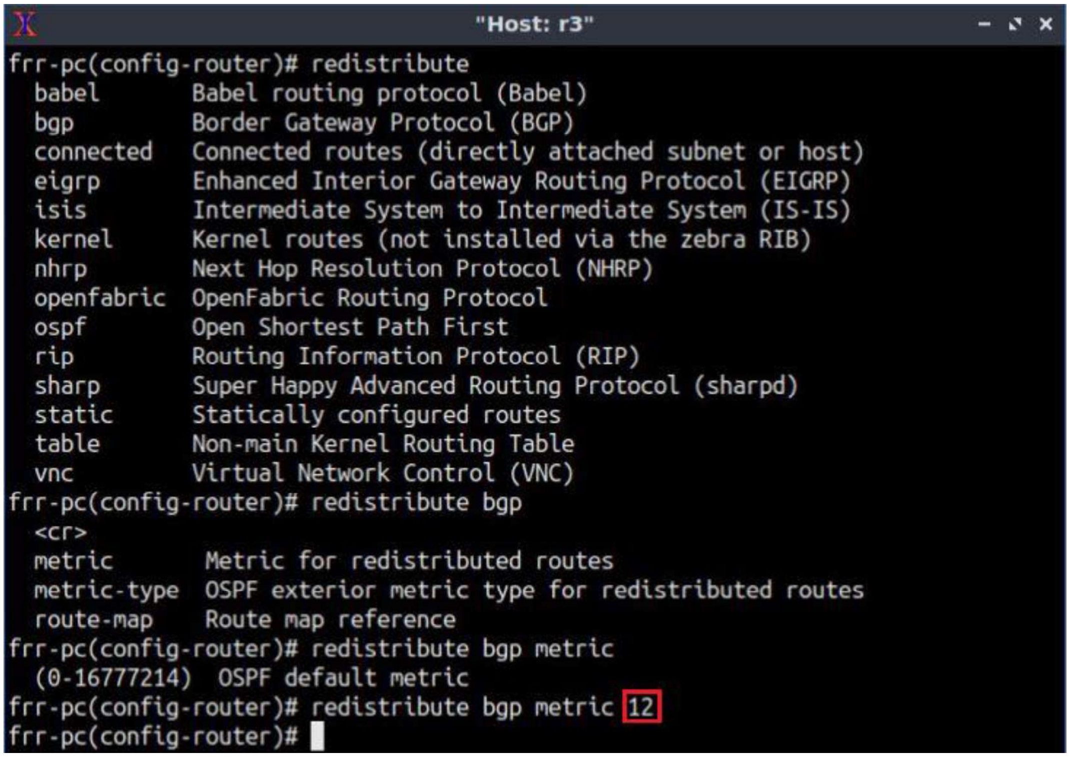


Figure 53. Setting the metric number to redistribute BGP routes.

Step 6. At this point, you injected BGP routes into OSPF routing protocol. To proceed, type the following command to exit from configuration mode.

```
end
```

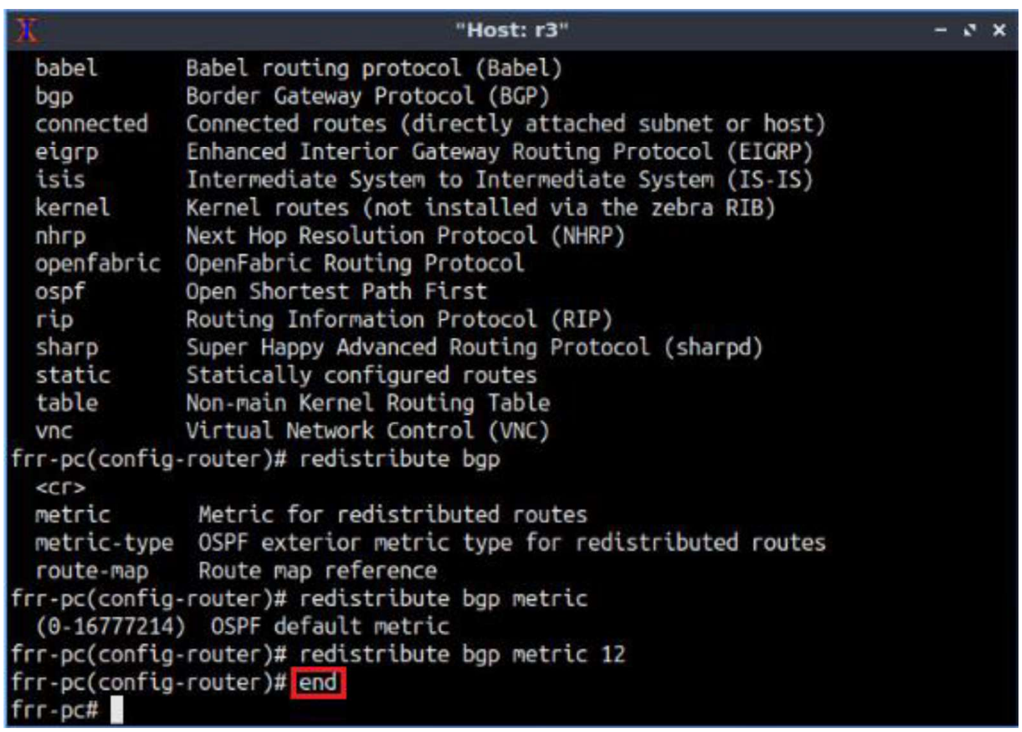


Figure 54. Exiting from configuration mode.

Step 7. In router r4 terminal, type the following command to enable the configuration mode.

```
configure terminal
```

Figure 55. Enabling configuration mode on router r4.

Step 8. Router r4 received the network 192.168.2.0/24 through EBGP. By doing the redistribution, r4 will be sharing the network with router r3 via OSPF. In order to redistribute BGP routes in router r4, repeat from step 1 to step 6. All the commands are summarized in the figure below.

Figure 56. Redistributing BGP routes on router r4.

Step 9. In order to verify the routing table of router r4, type the following command. You will verify that the network 192.168.1.0/24 is added to the routing table of router r4. Additionally, this network is reachable via the IP address 192.168.34.1 using OSPF routing protocol.

```
show ip route
```

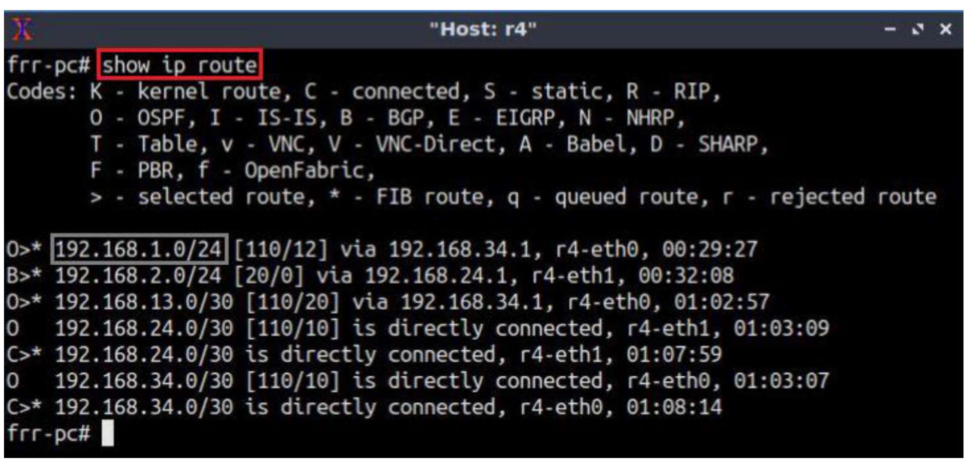


Figure 57. Verifying routing table of router r4.

5.2. Inject OSPF and directly connected routes into BGP

Step 1. To enable router r3 configuration mode, issue the following command:

```
configure terminal
```

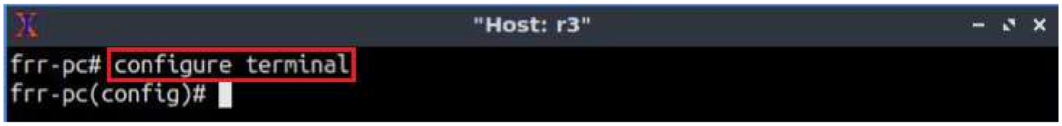


Figure 58. Enabling configuration mode on router r3.

Step 2. In router r3, you will redistribute the OSPF routes (192.168.2.0/24 and 192.168.24.0/30) into BGP so that router r1 can reach the networks. Additionally, you will redistribute the directly connected routes (192.168.13.0/30, 192.168.34.0/30) so that router r1 can learn the paths to reach the networks. Type the following command to enter BGP configuration mode.

```
router bgp 300
```

Figure 59. Entering to BGP Configuration mode.

Step 3. Type the following command to redistribute all the OSPF networks.

```
redistribute ospf
```

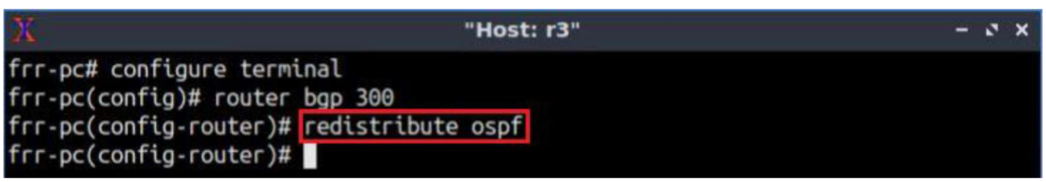


Figure 60. Redistributing OSPF routes on router r3.

Step 4. Type the following command to verify the routing table of router r1. You will notice new networks shared by router r3 (192.168.2.0/24 and 192.168.24.0/30). It also shows that router r1 can reach these networks via the IP address 192.168.13.2 using EBGP.

```
show ip route
```

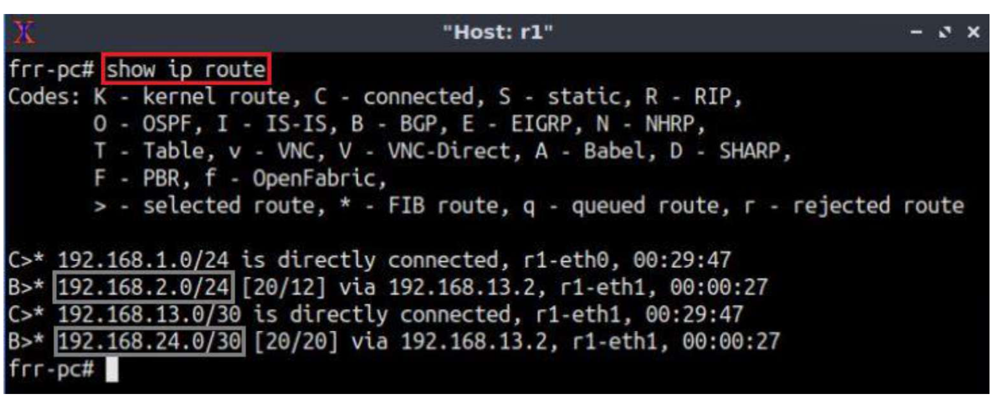


Figure 61. Verifying routing table of router r1.

Step 5. In router r3 terminal, type the following command to redistribute the directly connected networks (192.168.13.0/30, 192.168.34.0/30) into BGP.

```
redistribute connected
```

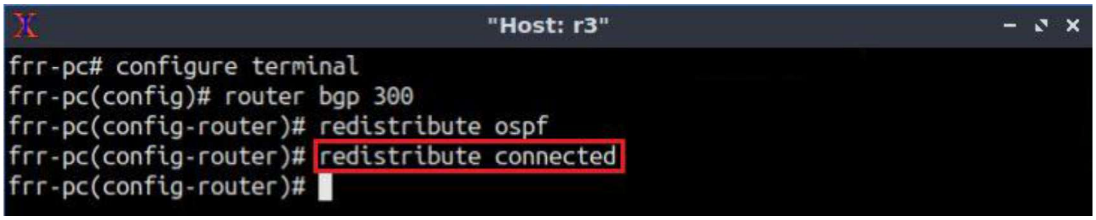


Figure 62. Redistributing connected networks.

Step 6. Type the following command to exit from the configuration mode.

```
end
```

Figure 63. Exiting from configuration mode.

Step 7. Type the following command to verify the routing table of router r1. You will verify additional network in router r1 table. These networks (192.168.13.0/30 and 192.168.34.0/30) are shared by router r3. It is also listed that router r1 can reach these networks via 192.168.13.2 using EBGP.

```
show ip route
```

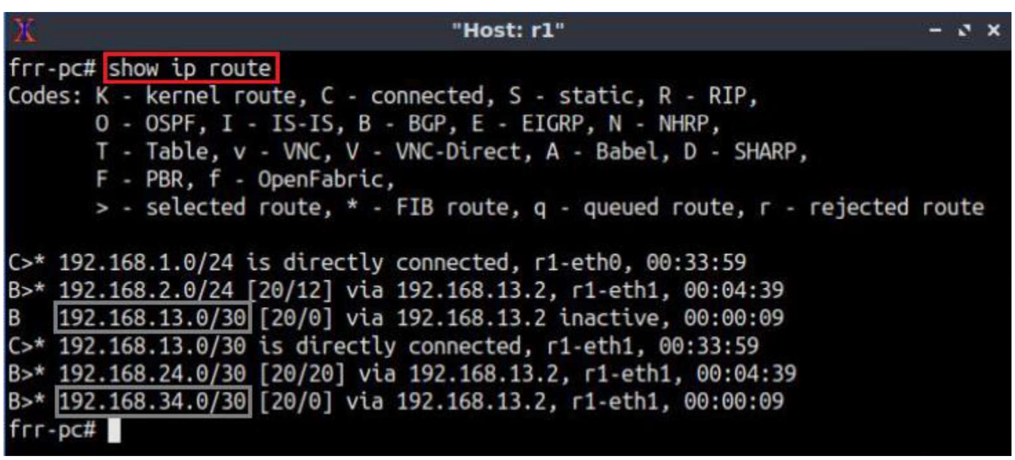


Figure 64. Verifying routing table of router r1.

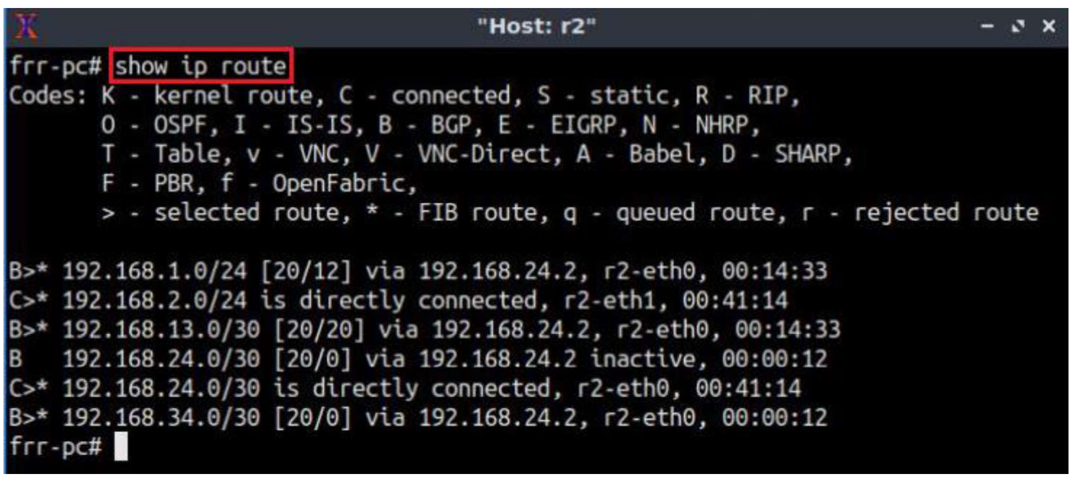
Step 8. In router r4 terminal, type the following command to redistribute the OSPF routes. This directive will allow router r2 to receive routing information from router r4. These routes carry the information about how router r4 reaches the networks 192.168.1.0/24 and 192.168.13.0/30. In addition, you will redistribute the information about how to reach the networks 192.168.24.0/30 and 192.168.34.0/30. The latter are the directly connected networks.

```
"Host: r4"
frr-pc# configure terminal
frr-pc(config)# router bgp 300
frr-pc(config-router)# redistribute ospf
frr-pc(config-router)# redistribute connected
frr-pc(config-router)# end
frr-pc#
```

Figure 65. Redistributing OSPF routes on router r4.

Step 9. Type the following command to verify the routing table of router r2. You will see the networks advertised through OSPF (192.168.1.0/24 and 192.168.13.0/30) and the directly connected networks with router r2 (192.168.24.0/30 and 192.168.34.0/30).

```
show ip route
```



```
"Host: r2"
frr-pc# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,
       F - PBR, f - OpenFabric,
       > - selected route, * - FIB route, q - queued route, r - rejected route

B>* 192.168.1.0/24 [20/12] via 192.168.24.2, r2-eth0, 00:14:33
C>* 192.168.2.0/24 is directly connected, r2-eth1, 00:41:14
B>* 192.168.13.0/30 [20/20] via 192.168.24.2, r2-eth0, 00:14:33
B   192.168.24.0/30 [20/0] via 192.168.24.2 inactive, 00:00:12
C>* 192.168.24.0/30 is directly connected, r2-eth0, 00:41:14
B>* 192.168.34.0/30 [20/0] via 192.168.24.2, r2-eth0, 00:00:12
frr-pc#
```

Figure 66. Verifying the routing table of router r2.

6. Verify connections

In this section, you will verify if the configuration is working correctly. You will also verify that Campus-1 and Campus-2 have properly formed an EBGP adjacency with the ISP.

Step 1. In the lab topology, hold right-click on host h1 and select *Terminal*. This opens the terminal of host h1.

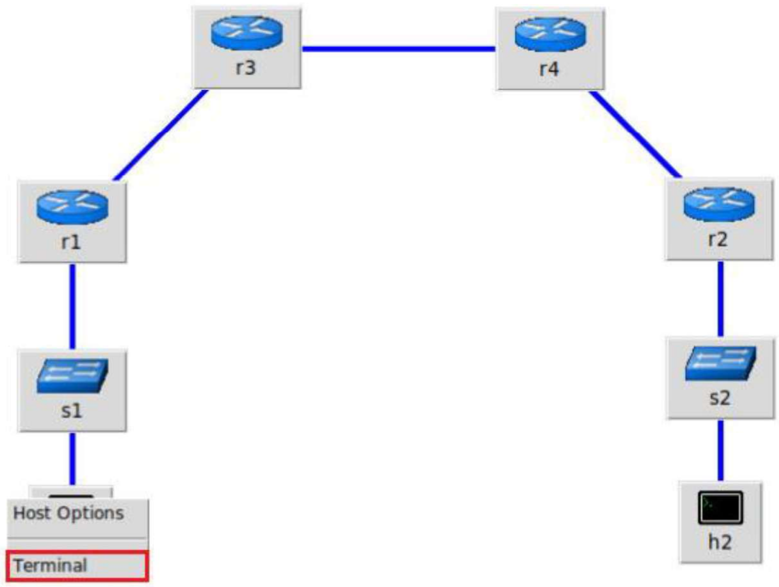


Figure 67. Opening host h1 terminal.

Step 2. Test the connectivity between host h1 and host h2 using the `ping` command. In host h1, type the command specified below. To stop the test, press `Ctrl+c`. The figure below shows a successful connectivity test.

```
ping 192.168.2.10
```

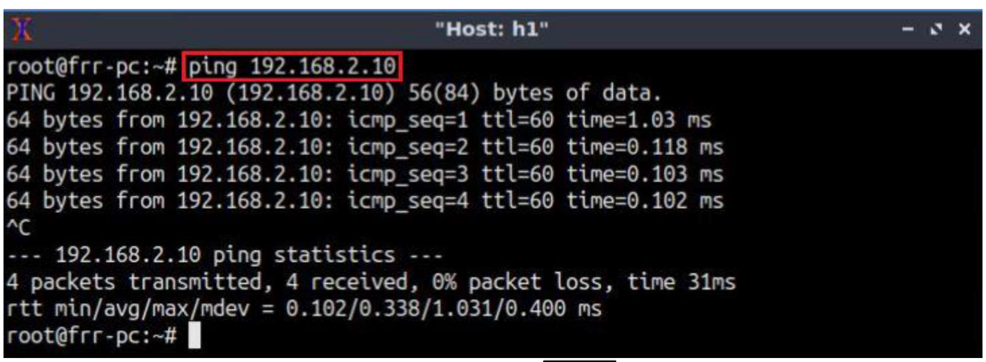


Figure 68. Connectivity test using `ping` command.

Step 3. Similarly, hold right-click on host h2 and select *Terminal*. This opens the terminal of host h2.

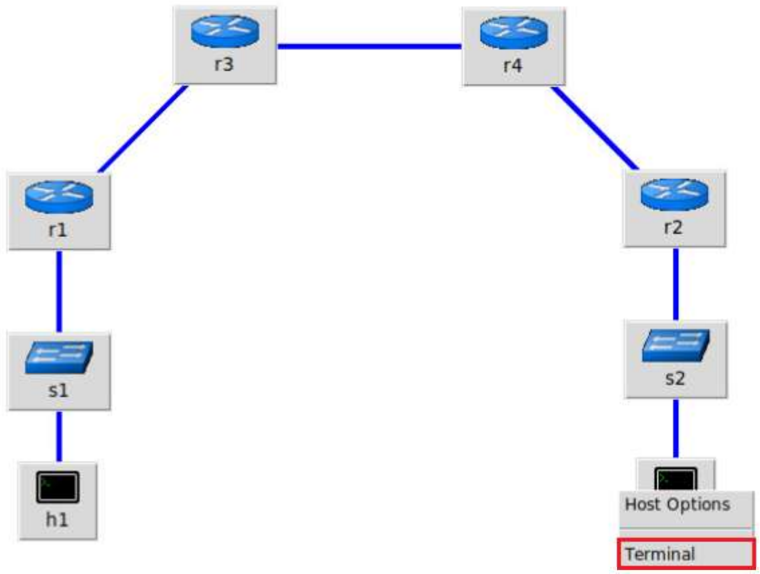


Figure 69. Opening host h2 terminal.

Step 4. Test the connectivity between host h2 and host h1 using the `ping` command. On host h2, type the command specified below. To stop the test, press `Ctrl+c`. The figure below shows a successful connectivity test.

```
ping 192.168.1.10
```

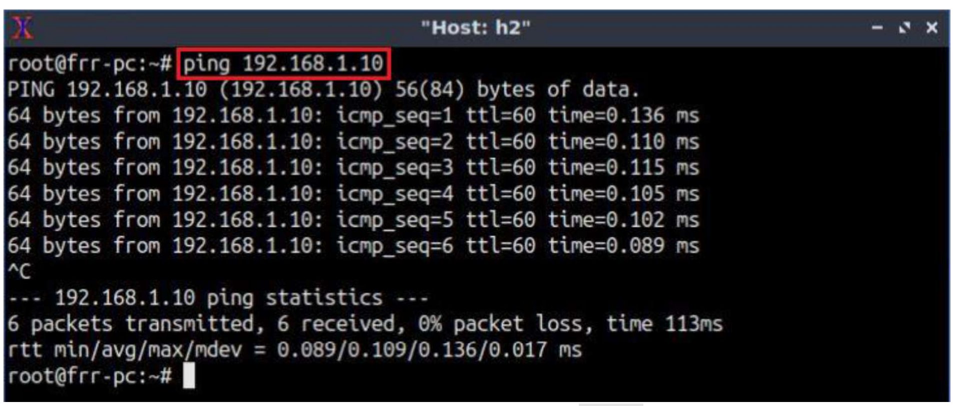


Figure 70. Connectivity test using `ping` command.

This concludes Lab 4. Stop the emulation and then exit out of MiniEdit.

References

1. A. Tanenbaum, D. Wetherall, “Computer networks”, 5th Edition, Pearson, 2012.
2. Cisco, “What are OSPF Areas and virtual links?”, 2016. [Online]. Available: https://www.cisco.com/c/en/us/support/docs/ip/open-shortest-path-first-ospf/13703-8.html
3. Cisco, “Redistributing routing protocols”, 2012. [Online]. Available: https://www.cisco.com/c/en/us/support/docs/ip/enhanced-interior-gateway-routing-protocol-eigrp/8606-redist.html

4. Linux foundation collaborative projects, “FRR routing documentation”, 2017. [Online]. Available: http://docs.frrouting.org/en/latest/
5. D. Teare, B. Vachon, R. Graziani, “Implementing cisco IP Routing (Route), foundation learning guide”, CCNP ROUTE 300-101.