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Open Shortest Path First (OSPF)

Instruction

In this lab, we will implement the OSPF routing protocol. If you recall from the first IP Interfaces lab, only R1 has a direct interface outside of the network. Your goal is to configure each router to communicate with the Internet.

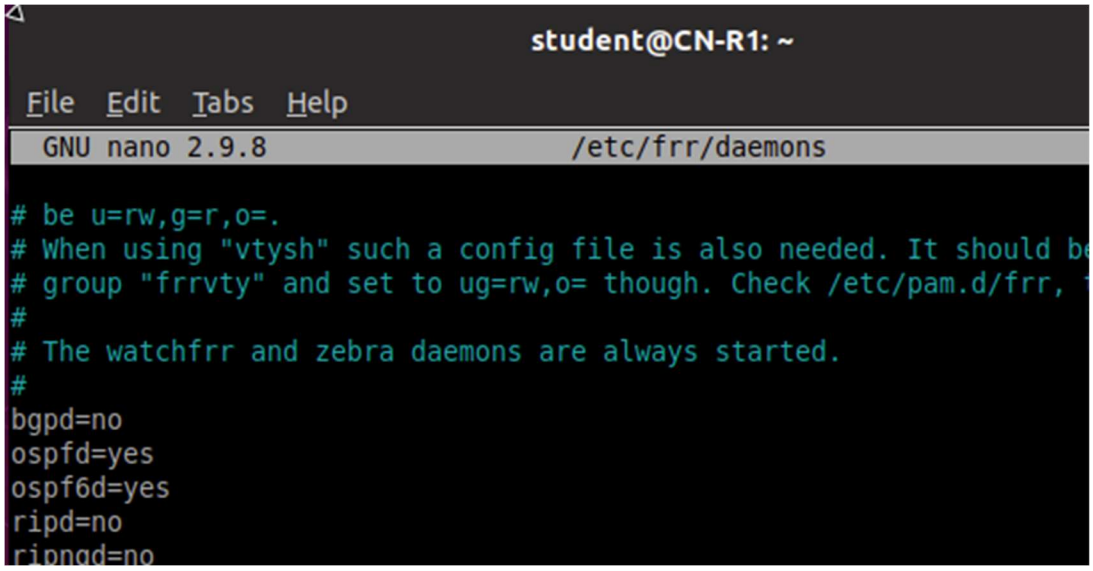
Part 1: Enable the OSPF daemon

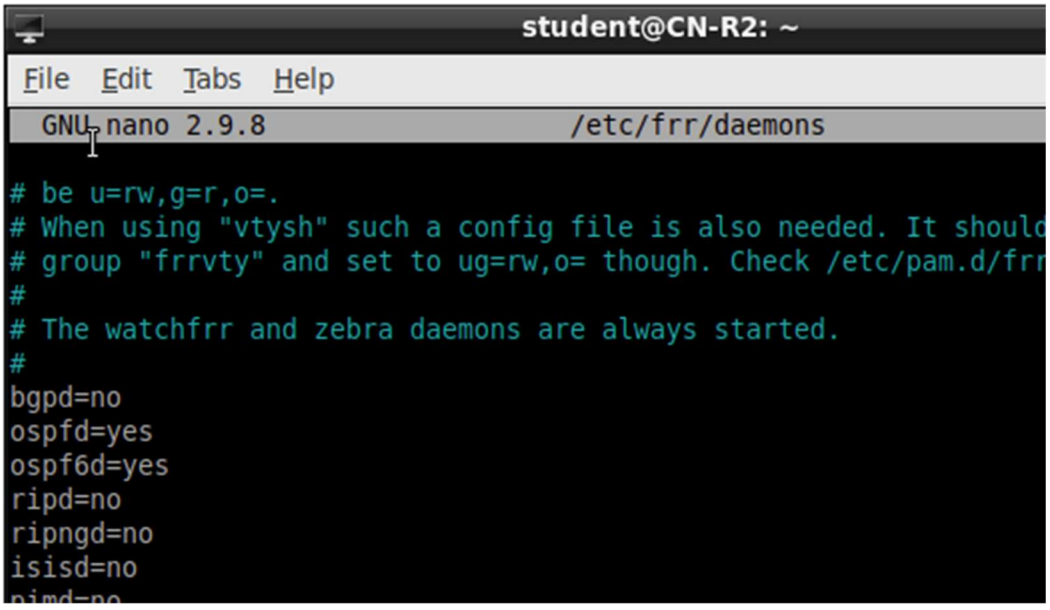
Beginning with R1, edit /etc/frr/daemons to enable OSPF.

Restart frrouting by executing:

> systemctl restart frr

Repeat the steps in Part 1 in order to enable OSPF on R2, R3, and R4.





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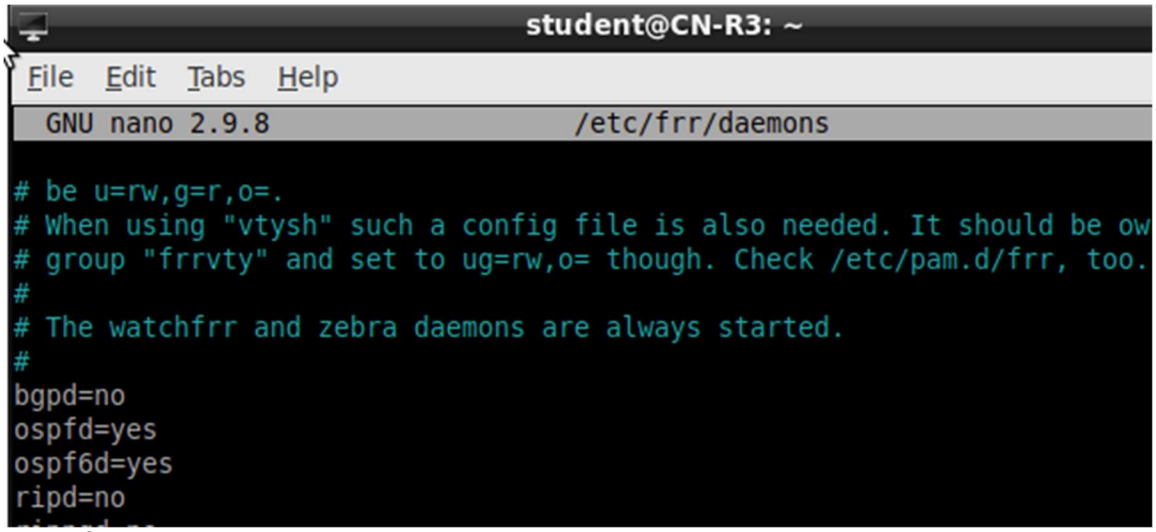
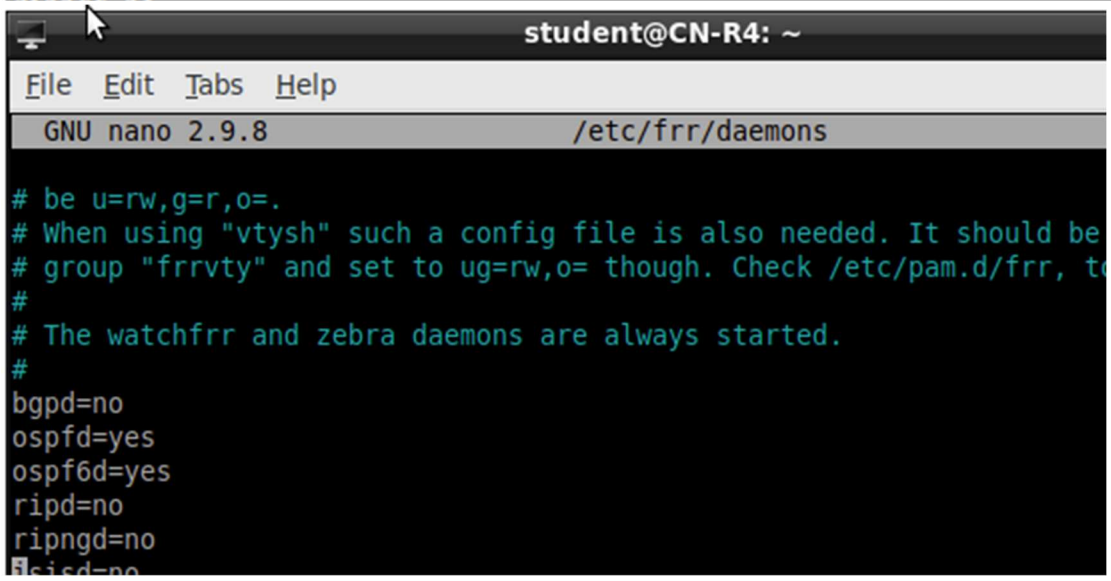

student@CN-R3: ~
File Edit Tabs Help
GNU nano 2.9.8 /etc/frr/daemons
be u=rw,g=r,o=.
When using "vtysh" such a config file is also needed. It should be ow
group "frrvty" and set to ug=rw,o= though. Check /etc/pam.d/frr, too.
#
The watchfrr and zebra daemons are always started.
#
bgpd=no
ospfd=yes
ospf6d=yes
ripd=no


student@CN-R4: ~
File Edit Tabs Help
GNU nano 2.9.8 /etc/frr/daemons
be u=rw,g=r,o=.
When using "vtysh" such a config file is also needed. It should be
group "frrvty" and set to ug=rw,o= though. Check /etc/pam.d/frr, t
#
The watchfrr and zebra daemons are always started.
#
bgpd=no
ospfd=yes
ospf6d=yes
ripd=no
ripngd=no

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Part 2:

Now that we have enabled OSPF, we will need to use vtysh to configure R1 such that it advertises its routable networks. In vtysh, execute the following commands:

> configure terminal

> router ospf

specify the network(s) and areas advertised by R1 (use CIDR notation)

Hint: Run ifconfig and examine the interfaces to determine which network addresses to use.

For additional resources and configuration examples, consult the frrouting guide at:

http://docs.frrouting.org/en/latest/ospfd.html#configuring-ospf

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```
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.20.1.142  netmask 255.255.255.0  broadcast 10.20.1.255
        inet6 fe80::1d:7ff:fe00:1001  prefixlen 64  scopeid 0x20<link>
```

```
student@CN-R1:~$ sudo vtysh

Hello, this is FRRouting (version 7.1-g53f430e).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

This is a git build of frr-7.1-11-g6453f430e
Associated branch(es):
        local:stable/7.1
        github/FRRouting/frr.git/stable/7.1

CN-R1# configure terminal
CN-R1(config)# router ospf
CN-R1(config-router)# network 10.10.10.1/29 area 0
CN-R1(config-router)# end
CN-R1# write
Note: this version of vtysh never writes vtysh.conf
Building Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
CN-R1# exit
student@CN-R1:~$
```

```
student@CN-R1:~$ sudo vtysh

Hello, this is FRRouting (version 7.1-g53f430e).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

This is a git build of frr-7.1-11-g6453f430e
Associated branch(es):
        local:stable/7.1
        github/FRRouting/frr.git/stable/7.1

CN-R1# configure terminal
CN-R1(config)# router ospf
CN-R1(config-router)# network 10.20.1.142/24 area 0
CN-R1(config-router)# end
CN-R1# write
Note: this version of vtysh never writes vtysh.conf
eBuilding Configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
CN-R1# exit
```

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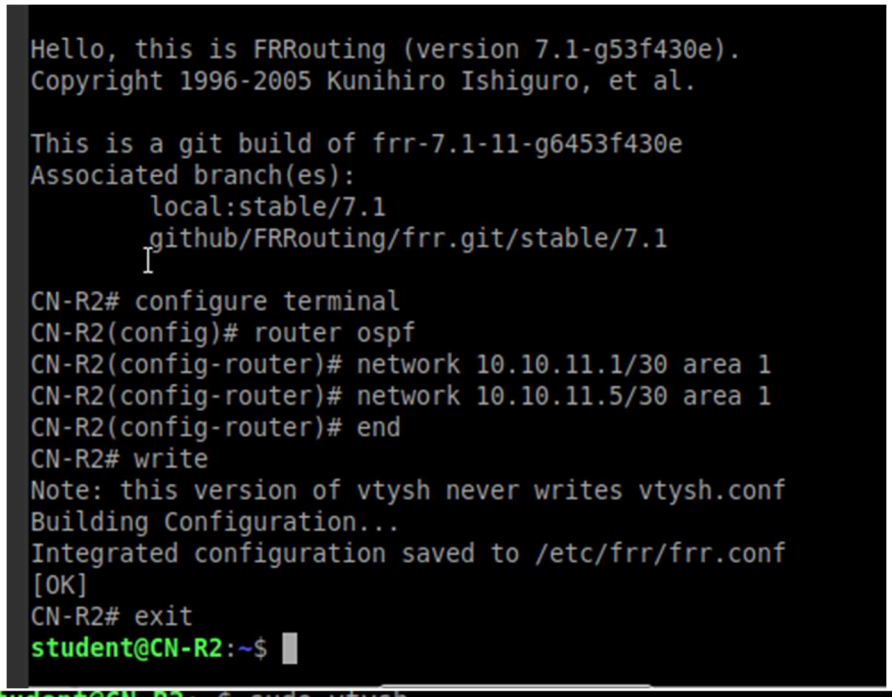
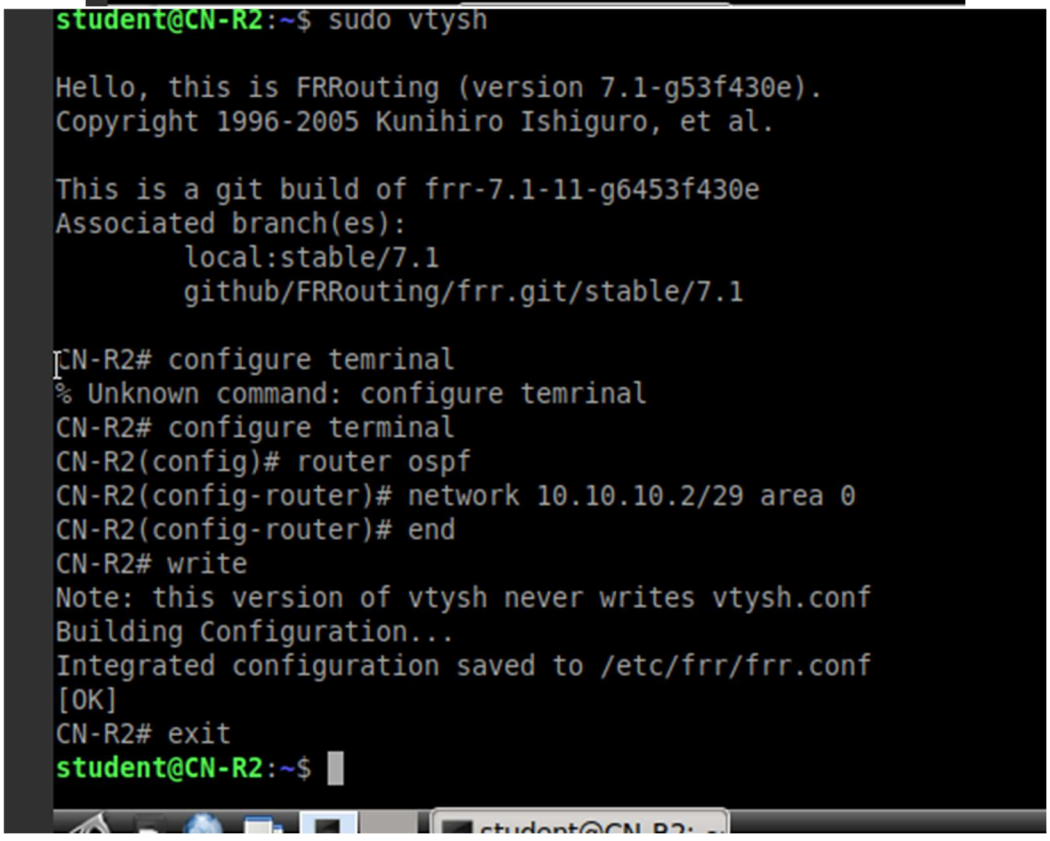
Part 3:

We will follow the same steps to configure each router in Area 1. *Please note that we will not run OSPF on R4 (eth2) since this interface points to a terminal node (see passive-interface).

R2





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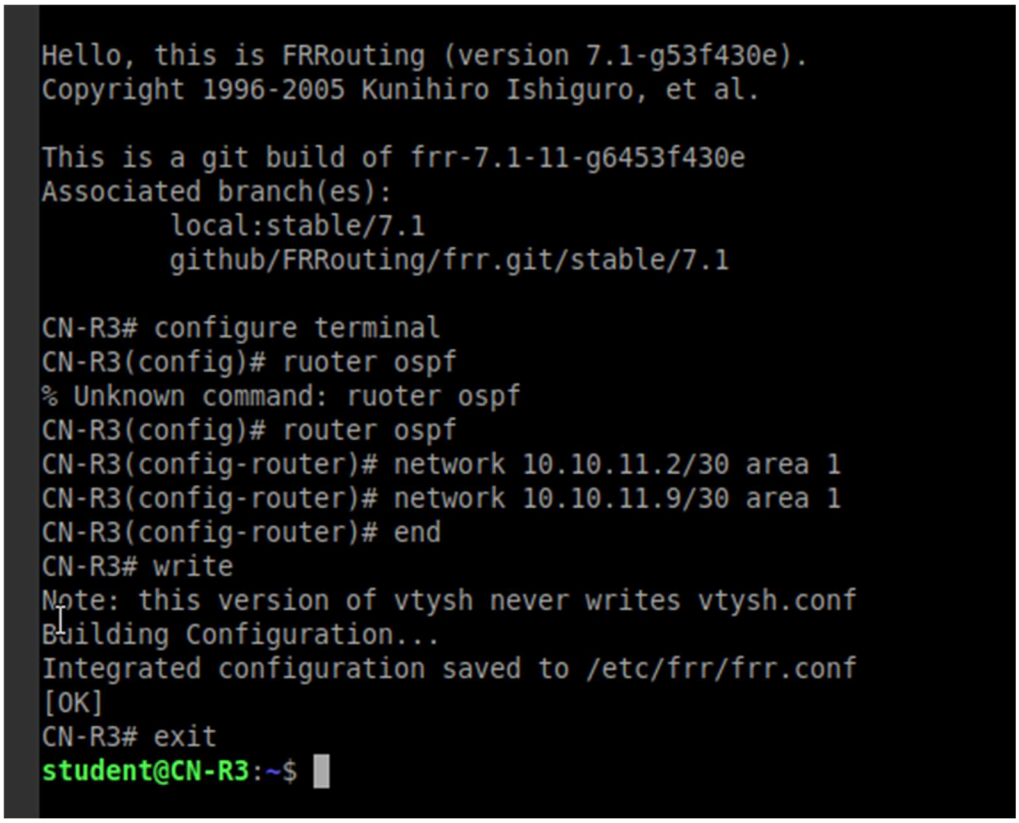
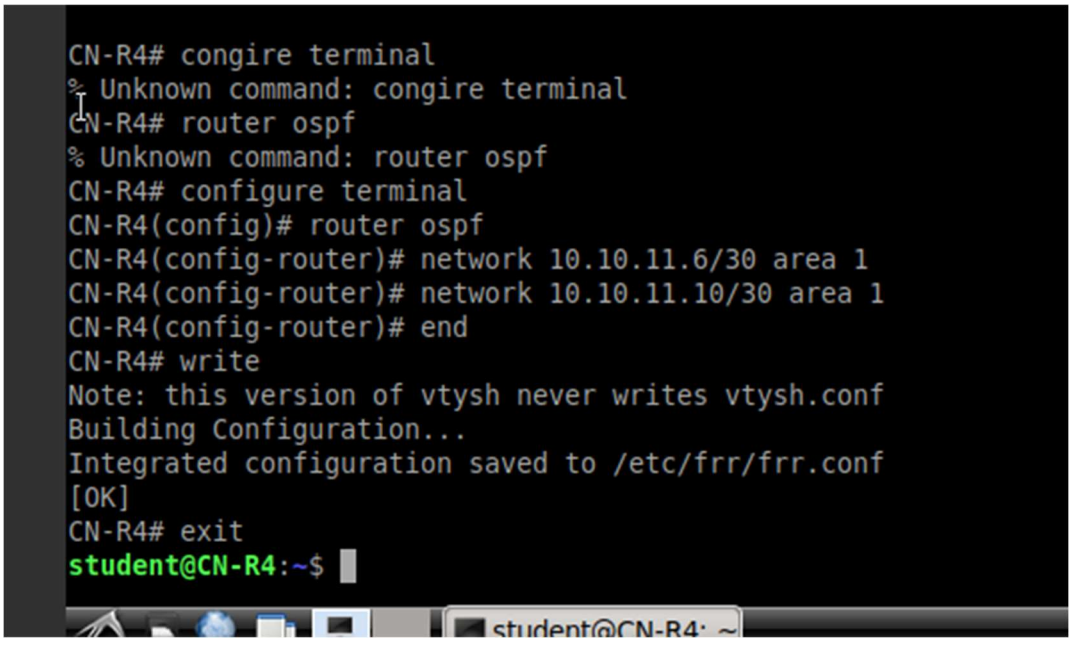
R3



R4

- R4's eth2 ip address will not be written into the ospf network because we're not using that interface for the ospf layout.



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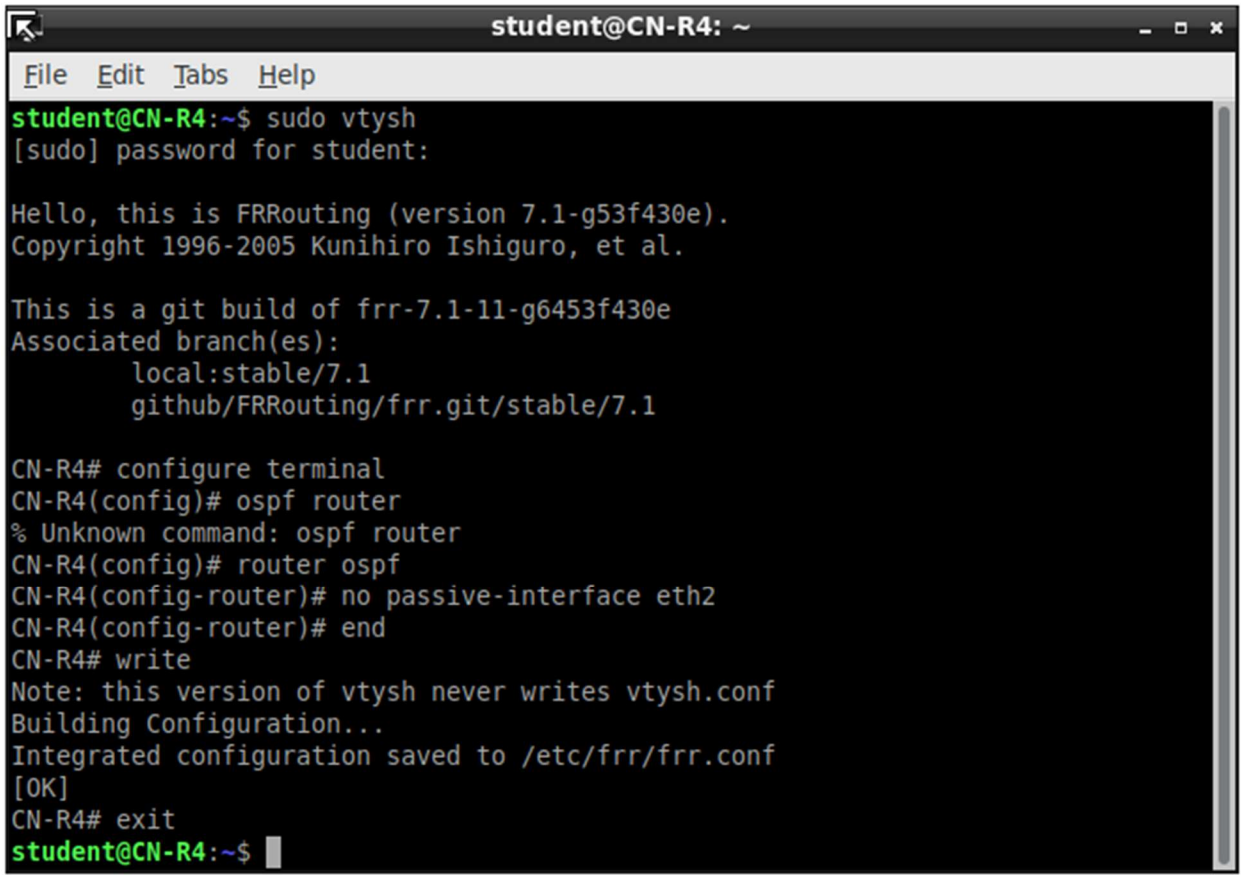
Disabling passive interface on R4 eth2



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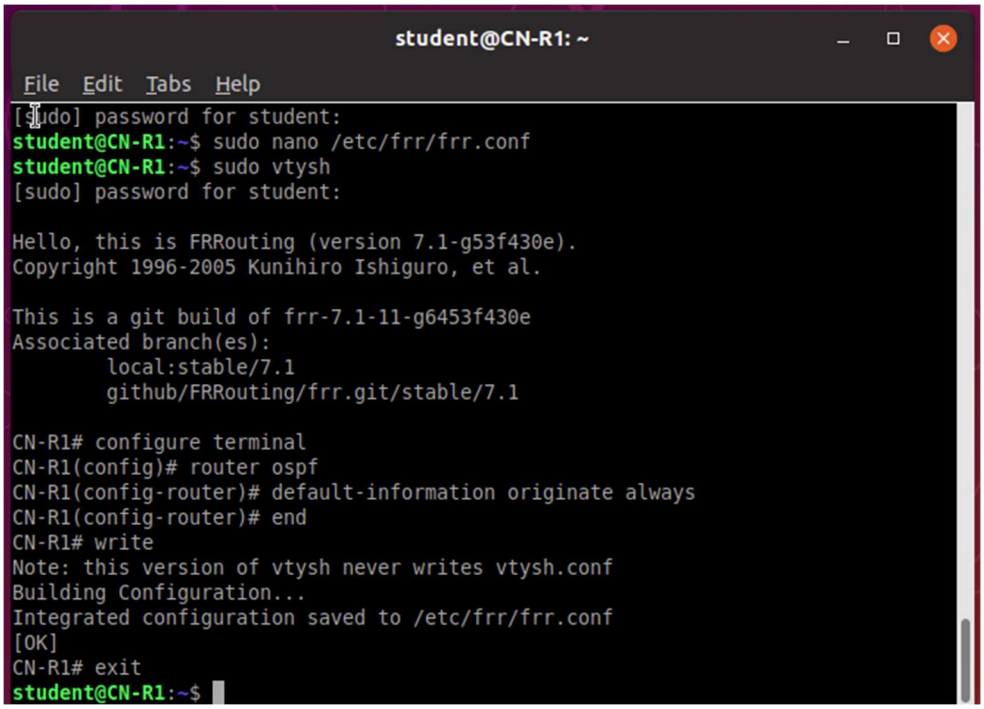
Part 4

The last step is to set the default IP route on R2, R3, and R4 so that they will go through R1 to access the Internet (i.e. all IP addresses outside of our network). You will have to browse through the FRR documentation to find the exact command.

You may verify that your configuration is correct by successfully pinging the SFTP server (128.238.77.36) from routers R2, R3, and R4

- The frrrouting command **default-informaiton originate always** forces the router to create a default ip address if there is no default route present. Putting this in R1 causes it to broadcast a default route to the network.
- An alternative is to assign the ip route of 0.0.0.0/0 to R1's IP address of 10.10.10.1



When sending these ping messages over the network, the packet sometimes gets lost in transmit.

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```
Building configuration...
Integrated configuration saved to /etc/frr/frr.conf
[OK]
CN-R2# exit
student@CN-R2:~$ ping 128.238.77.36
PING 128.238.77.36 (128.238.77.36) 56(84) bytes of data.
64 bytes from 128.238.77.36: icmp_seq=1 ttl=62 time=1.14 ms
64 bytes from 128.238.77.36: icmp_seq=2 ttl=62 time=9.88 ms
64 bytes from 128.238.77.36: icmp_seq=3 ttl=62 time=3.03 ms
64 bytes from 128.238.77.36: icmp_seq=4 ttl=62 time=0.865 ms
64 bytes from 128.238.77.36: icmp_seq=5 ttl=62 time=0.934 ms
64 bytes from 128.238.77.36: icmp_seq=6 ttl=62 time=0.936 ms
^C
--- 128.238.77.36 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 24ms
rtt min/avg/max/mdev = 0.865/2.797/9.880/3.257 ms
student@CN-R2:~$
```

student@CN-R2: ~

```
student@CN-R3:~$ ping 128.238.77.36
PING 128.238.77.36 (128.238.77.36) 56(84) bytes of data.
64 bytes from 128.238.77.36: icmp_seq=4 ttl=61 time=1.25 ms
64 bytes from 128.238.77.36: icmp_seq=5 ttl=61 time=1.11 ms
64 bytes from 128.238.77.36: icmp_seq=6 ttl=61 time=1.27 ms
64 bytes from 128.238.77.36: icmp_seq=7 ttl=61 time=1.17 ms
64 bytes from 128.238.77.36: icmp_seq=8 ttl=61 time=1.31 ms
64 bytes from 128.238.77.36: icmp_seq=14 ttl=61 time=1.53 ms
```

student@CN-R4: ~

File Edit Tabs Help

```
student@CN-R4:~$ ping 128.238.77.36
PING 128.238.77.36 (128.238.77.36) 56(84) bytes of data.
64 bytes from 128.238.77.36: icmp_seq=5 ttl=61 time=1.32 ms
64 bytes from 128.238.77.36: icmp_seq=6 ttl=61 time=1.23 ms
64 bytes from 128.238.77.36: icmp_seq=7 ttl=61 time=1.32 ms
64 bytes from 128.238.77.36: icmp_seq=8 ttl=61 time=1.60 ms
64 bytes from 128.238.77.36: icmp_seq=9 ttl=61 time=1.41 ms
64 bytes from 128.238.77.36: icmp_seq=10 ttl=61 time=1.34 ms
64 bytes from 128.238.77.36: icmp_seq=11 ttl=61 time=1.27 ms
64 bytes from 128.238.77.36: icmp_seq=12 ttl=61 time=1.35 ms
64 bytes from 128.238.77.36: icmp_seq=13 ttl=61 time=1.22 ms
^C
--- 128.238.77.36 ping statistics ---
15 packets transmitted, 9 received, 40% packet loss, time 118ms
rtt min/avg/max/mdev = 1.223/1.340/1.597/0.115 ms
student@CN-R4:~$
```

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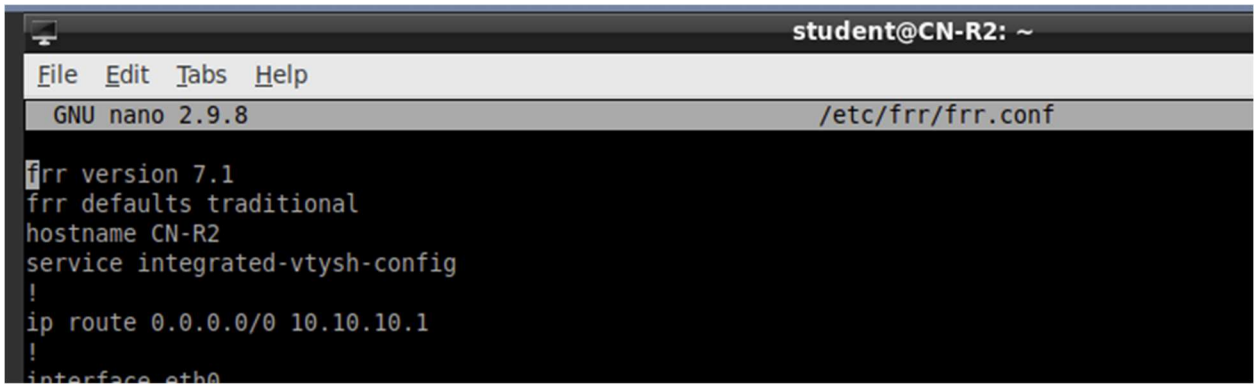
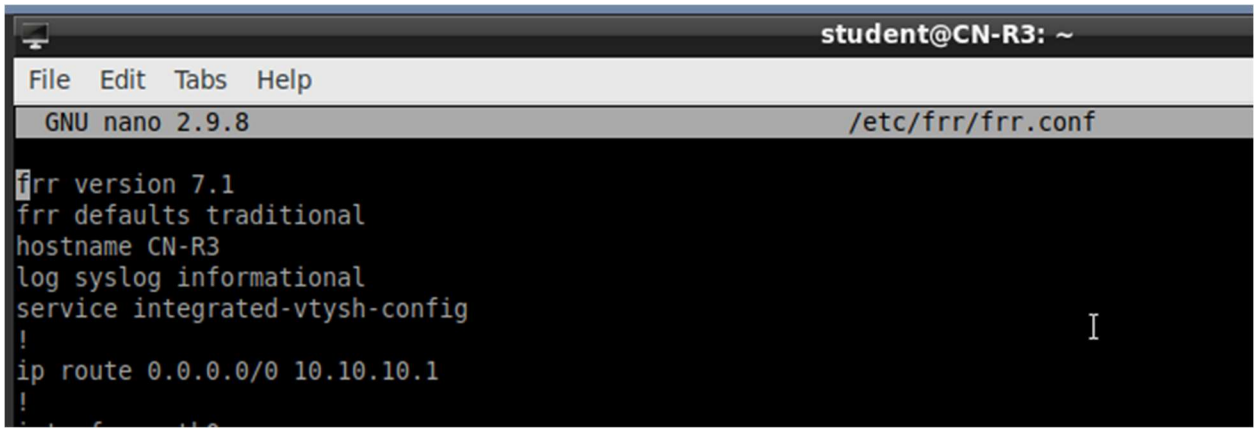
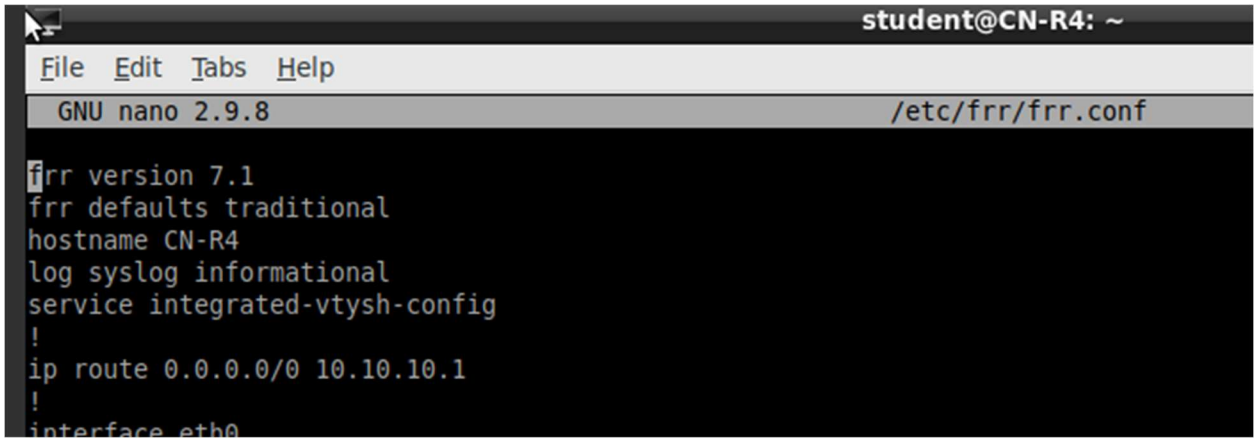
R2, R3, and R4's default routes







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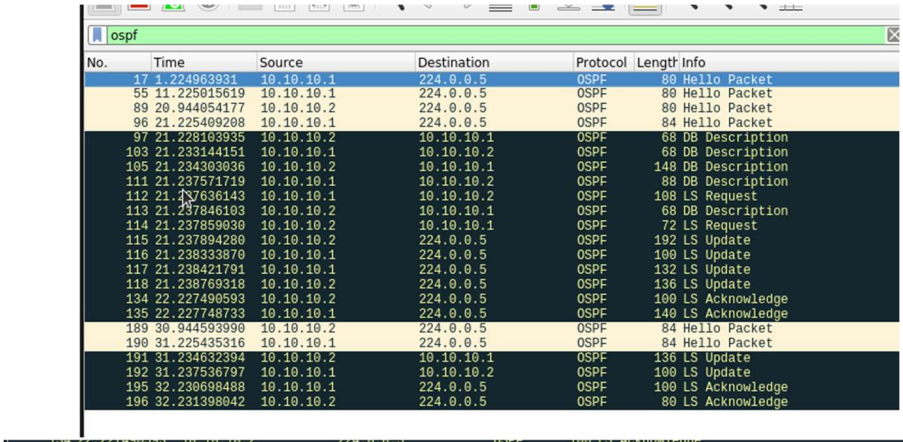
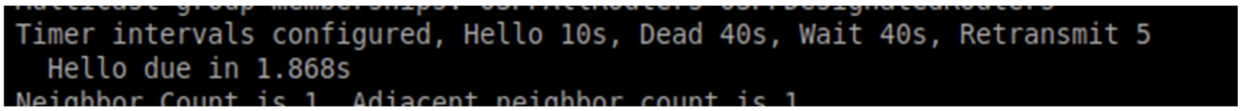
Part 5: Questions

a) Power on all routers and run Wireshark on R1. Apply a filter for OSPF and look at the Hello Packets. How frequently are these packets sent, and why must they be sent periodically?

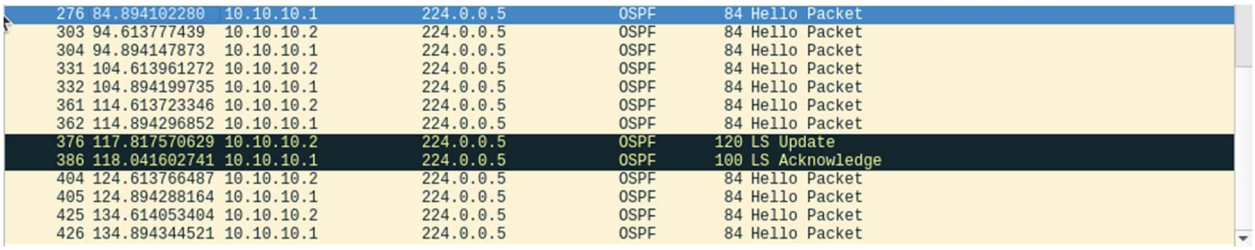




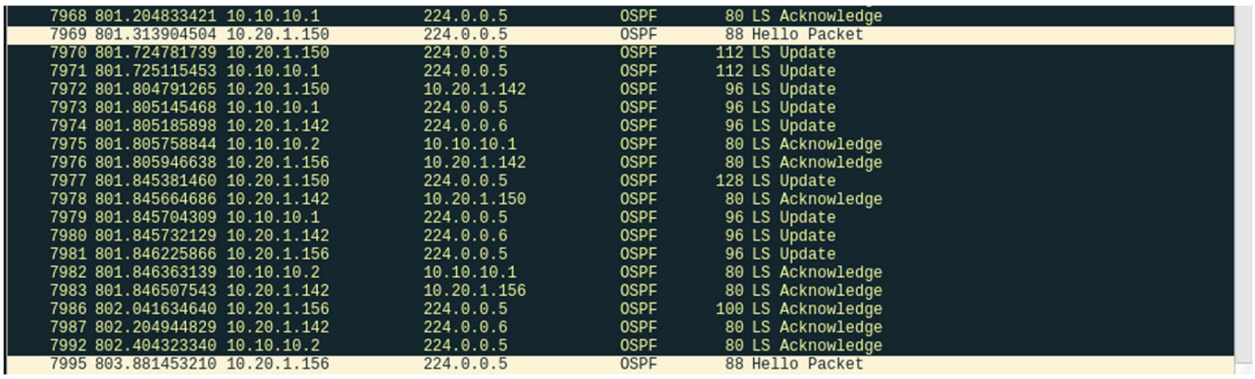
OSPF sends Hello packets at approximately 30-40 second intervals at the multicast IP address. This is to check what routers are still within the network. One router would send out a hello to all its neighbors and receive a reply if the neighbor sees the hello packet. If a router doesn't hear a reply from a neighbor for a while, then it would notice that the router is down and broadcast the alert to the topology. This message has to be broadcasted periodically to keep track of what neighboring routers are still online.

b) Continue running Wireshark and turn off R4. You should now see new OSPF packet types captured on R1. Explain why Hello, Link State Update, and Link State Acknowledgements use the same Destination IP Address

R4 turned off at time 276, prompting an LS Update and an LS Acknowledge packet to be sent out throughout the OSPF network from R2. R2 detects R4 missing from the OSPF network after missed Hello packets and will send out an LS Update to its adjacencies. All Hello, LS Update, and LS Acknowledgements are sent towards the IP Address 224.0.0.5 which will get directed to R1 as well.



276	84.894102280	10.10.10.1	224.0.0.5	OSPF	84 Hello Packet
303	94.613777439	10.10.10.2	224.0.0.5	OSPF	84 Hello Packet
304	94.894147873	10.10.10.1	224.0.0.5	OSPF	84 Hello Packet
331	104.613961272	10.10.10.2	224.0.0.5	OSPF	84 Hello Packet
332	104.894199735	10.10.10.1	224.0.0.5	OSPF	84 Hello Packet
361	114.613723346	10.10.10.2	224.0.0.5	OSPF	84 Hello Packet
362	114.894296852	10.10.10.1	224.0.0.5	OSPF	84 Hello Packet
376	117.817570629	10.10.10.2	224.0.0.5	OSPF	120 LS Update
386	118.041602741	10.10.10.1	224.0.0.5	OSPF	100 LS Acknowledge
404	124.613766487	10.10.10.2	224.0.0.5	OSPF	84 Hello Packet
405	124.894288164	10.10.10.1	224.0.0.5	OSPF	84 Hello Packet
425	134.614053404	10.10.10.2	224.0.0.5	OSPF	84 Hello Packet
426	134.894344521	10.10.10.1	224.0.0.5	OSPF	84 Hello Packet



7968	801.204833421	10.10.10.1	224.0.0.5	OSPF	80 LS Acknowledge
7969	801.313904504	10.20.1.150	224.0.0.5	OSPF	88 Hello Packet
7970	801.724781739	10.20.1.150	224.0.0.5	OSPF	112 LS Update
7971	801.725115453	10.10.10.1	224.0.0.5	OSPF	112 LS Update
7972	801.804791265	10.20.1.150	10.20.1.142	OSPF	96 LS Update
7973	801.805145468	10.10.10.1	224.0.0.5	OSPF	96 LS Update
7974	801.805185898	10.20.1.142	224.0.0.6	OSPF	96 LS Update
7975	801.805758844	10.10.10.2	10.10.10.1	OSPF	80 LS Acknowledge
7976	801.805946638	10.20.1.156	10.20.1.142	OSPF	80 LS Acknowledge
7977	801.845381460	10.20.1.150	224.0.0.5	OSPF	128 LS Update
7978	801.845664686	10.20.1.142	10.20.1.150	OSPF	80 LS Acknowledge
7979	801.845704309	10.10.10.1	224.0.0.5	OSPF	96 LS Update
7980	801.845732129	10.20.1.142	224.0.0.6	OSPF	96 LS Update
7981	801.846225866	10.20.1.156	224.0.0.5	OSPF	96 LS Update
7982	801.846363139	10.10.10.2	10.10.10.1	OSPF	80 LS Acknowledge
7983	801.846507543	10.20.1.142	10.20.1.156	OSPF	80 LS Acknowledge
7986	802.041634640	10.20.1.156	224.0.0.5	OSPF	100 LS Acknowledge
7987	802.204944829	10.20.1.142	224.0.0.6	OSPF	80 LS Acknowledge
7992	802.404323340	10.10.10.2	224.0.0.5	OSPF	80 LS Acknowledge
7995	803.881453210	10.20.1.156	224.0.0.5	OSPF	88 Hello Packet

- The IP Address 224.0.0.5 is the multicast address of all OSPF routers. The router only needs to send the OSPF packets to this IP Address to send it to the rest of the adjacencies which share this multicast address. As a result, R1 only needs to communicate using 224.0.0.5 to communicate with the multicast.

c) Based on the above steps, explain why we do not see DB Descriptions and LS Requests on R1. Is there a situation in which we get all OSPF packet types on R1?

DB Descriptions and LS Request packets are sent only when router adjacencies are being established in order to establish a link and share what adjacencies a neighboring router would have. When R4 turns off, R2 would detect the change in Area 1. R2 would flood the area using LS Update packets to inform the others of the change but not use LS Request or DB Descriptions packets to show the change in topology.

In addition, R1 and R4 are in area 1 and area 0 respectively, they share no adjacency. These two routers aren't directly aware of each other and have to use the Area-Border Router R2 to communicate with each other. R1 and R4 are focused on the state of routers in the same areas. In OSPF, every router maintains a database of its neighbors within the same area[1].

- All OSPF packets are used when R1 is establishing a bidirectional communication with another adjacent router in the same area
- R1 will use all OSPF packets when establishing a connection with a neighboring router. R1 will use all OSPF packets when connecting to R2 for the first time.

[1] https://networkengineering.stackexchange.com/questions/46745/ospf-link-state-advertisement

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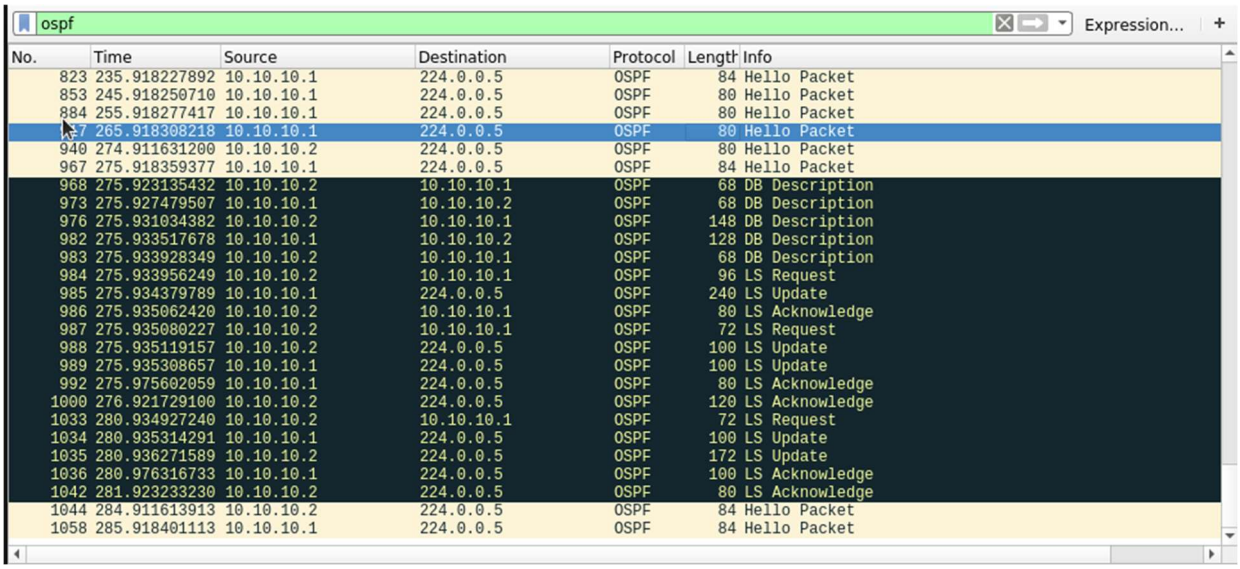
R2 turning on with and establishing a bi-directional communication with R1.



No.	Time	Source	Destination	Protocol	Length	Info
823	235.918227892	10.10.10.1	224.0.0.5	OSPF	84	Hello Packet
853	245.918250710	10.10.10.1	224.0.0.5	OSPF	80	Hello Packet
884	255.918277417	10.10.10.1	224.0.0.5	OSPF	80	Hello Packet
917	265.918308218	10.10.10.1	224.0.0.5	OSPF	80	Hello Packet
940	274.911631200	10.10.10.2	224.0.0.5	OSPF	80	Hello Packet
967	275.918359377	10.10.10.1	224.0.0.5	OSPF	84	Hello Packet
968	275.923135432	10.10.10.2	10.10.10.1	OSPF	68	DB Description
973	275.927479507	10.10.10.1	10.10.10.2	OSPF	68	DB Description
976	275.931034382	10.10.10.2	10.10.10.1	OSPF	148	DB Description
982	275.933517678	10.10.10.1	10.10.10.2	OSPF	128	DB Description
983	275.933928349	10.10.10.2	10.10.10.1	OSPF	68	DB Description
984	275.933956249	10.10.10.2	10.10.10.1	OSPF	96	LS Request
985	275.934379789	10.10.10.1	224.0.0.5	OSPF	240	LS Update
986	275.935062420	10.10.10.2	10.10.10.1	OSPF	80	LS Acknowledge
987	275.935080227	10.10.10.2	10.10.10.1	OSPF	72	LS Request
988	275.935119157	10.10.10.2	224.0.0.5	OSPF	100	LS Update
989	275.935308657	10.10.10.1	224.0.0.5	OSPF	100	LS Update
992	275.975602059	10.10.10.1	224.0.0.5	OSPF	80	LS Acknowledge
1000	276.921729100	10.10.10.2	224.0.0.5	OSPF	120	LS Acknowledge
1033	280.934927240	10.10.10.2	10.10.10.1	OSPF	72	LS Request
1034	280.935314291	10.10.10.1	224.0.0.5	OSPF	100	LS Update
1035	280.936271589	10.10.10.2	224.0.0.5	OSPF	172	LS Update
1036	280.976316733	10.10.10.1	224.0.0.5	OSPF	100	LS Acknowledge
1042	281.923233230	10.10.10.2	224.0.0.5	OSPF	80	LS Acknowledge
1044	284.911613913	10.10.10.2	224.0.0.5	OSPF	84	Hello Packet
1058	285.918401113	10.10.10.1	224.0.0.5	OSPF	84	Hello Packet

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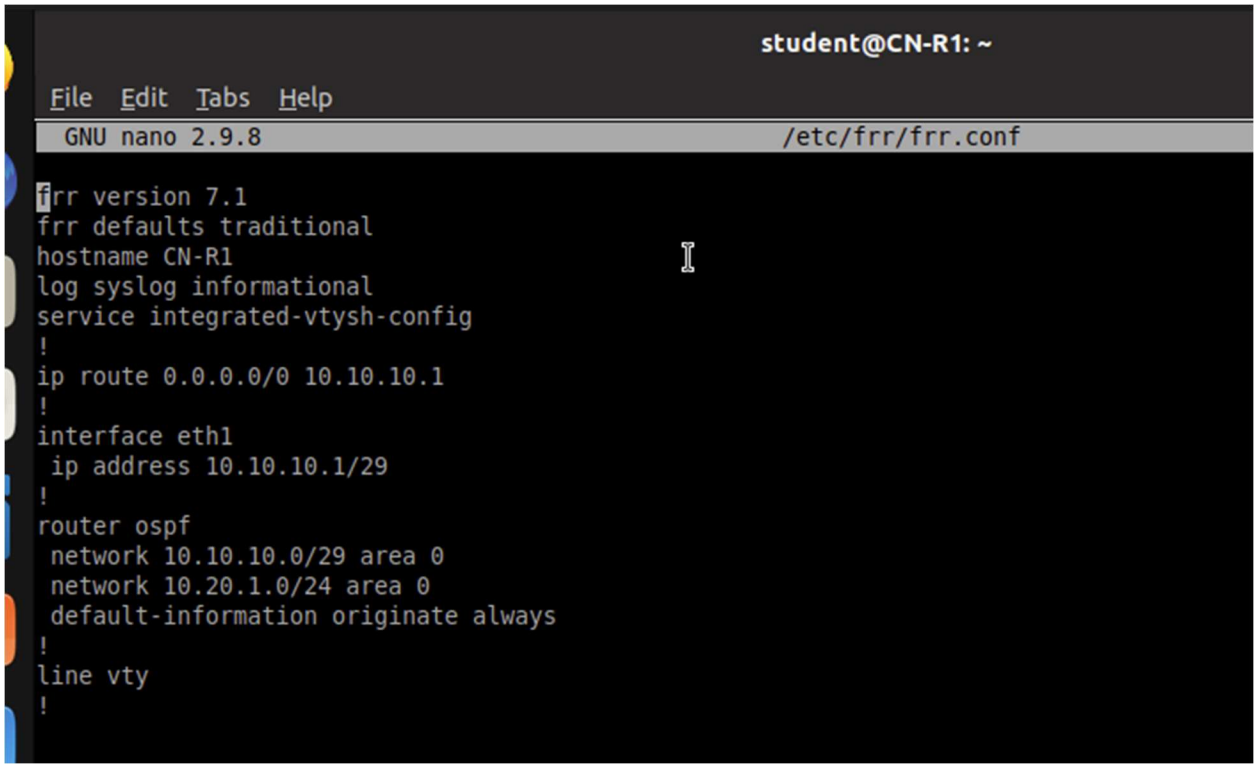
Submissions

[20 points] Screenshot configurations of R1, R2, R3, and R4

R1



R2

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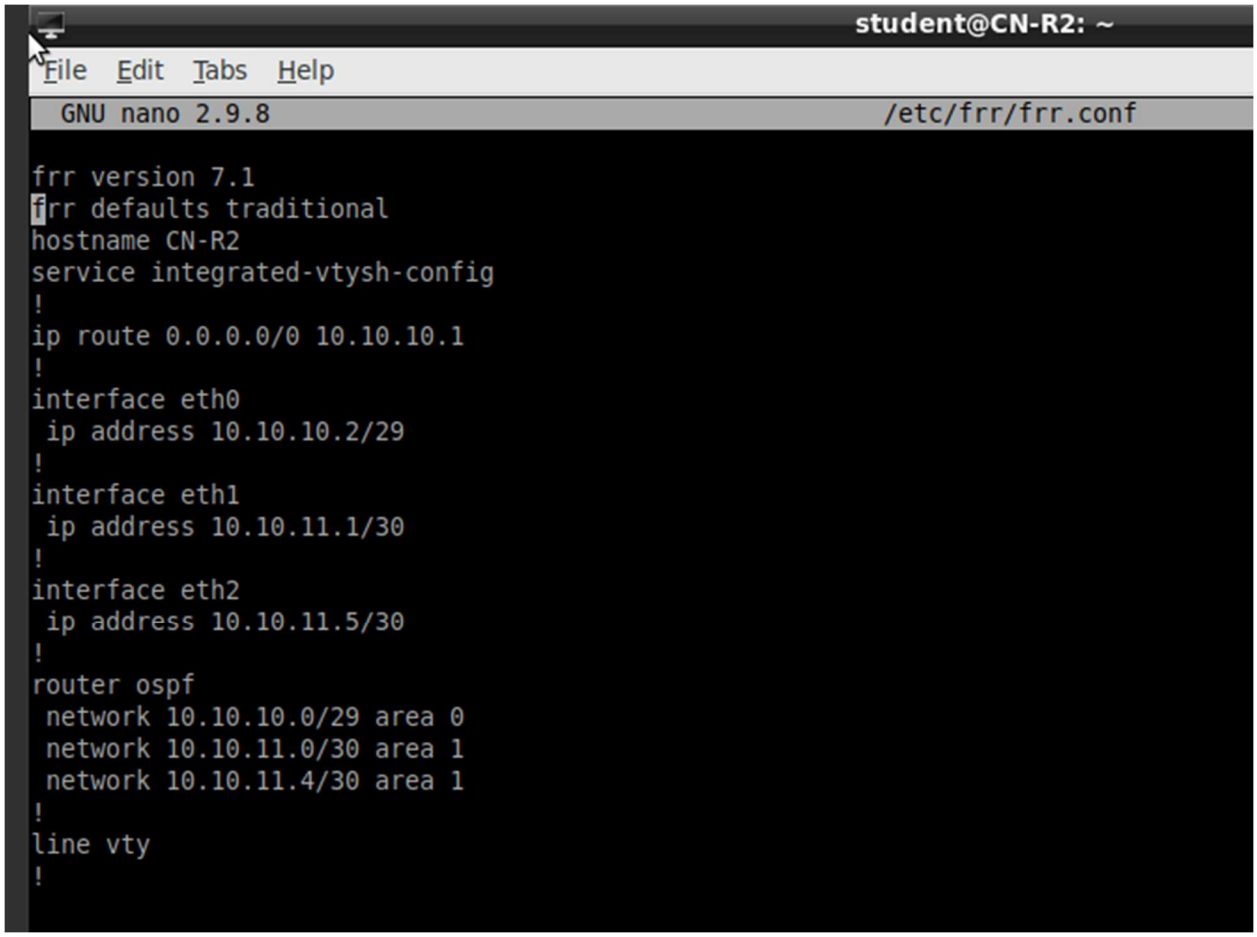

R3

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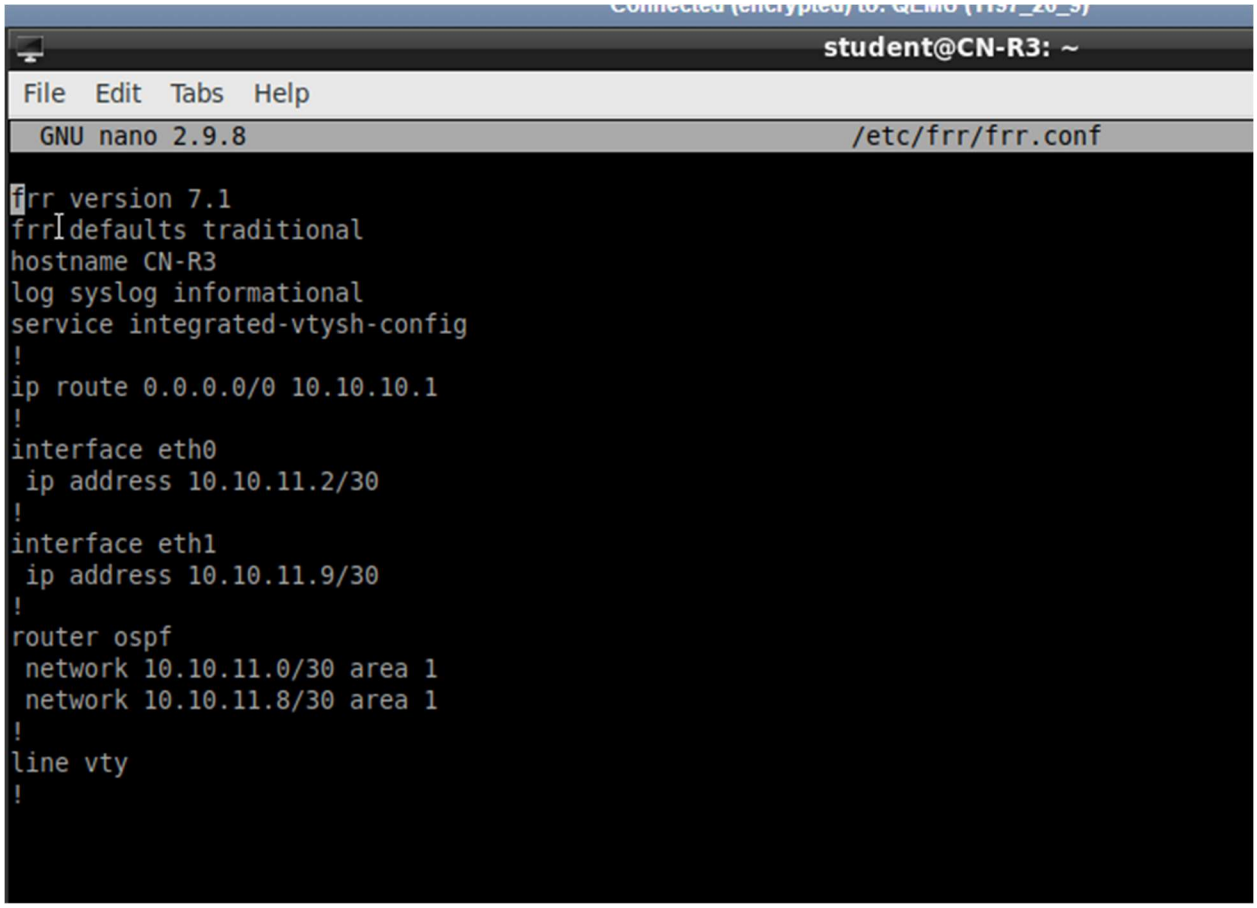

R4

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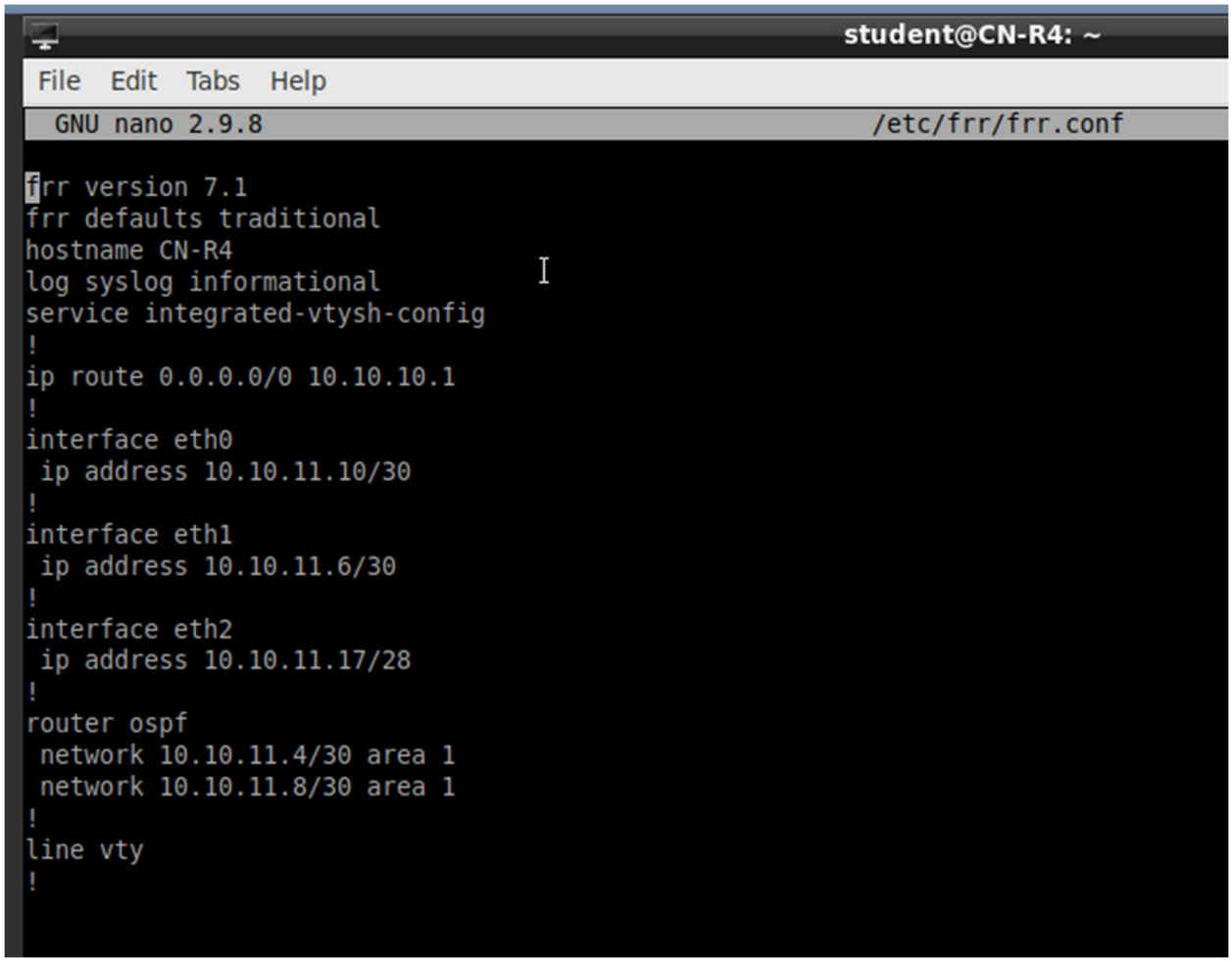

[10 points] ICMP results from R3 to R1

R1’s Wireshark

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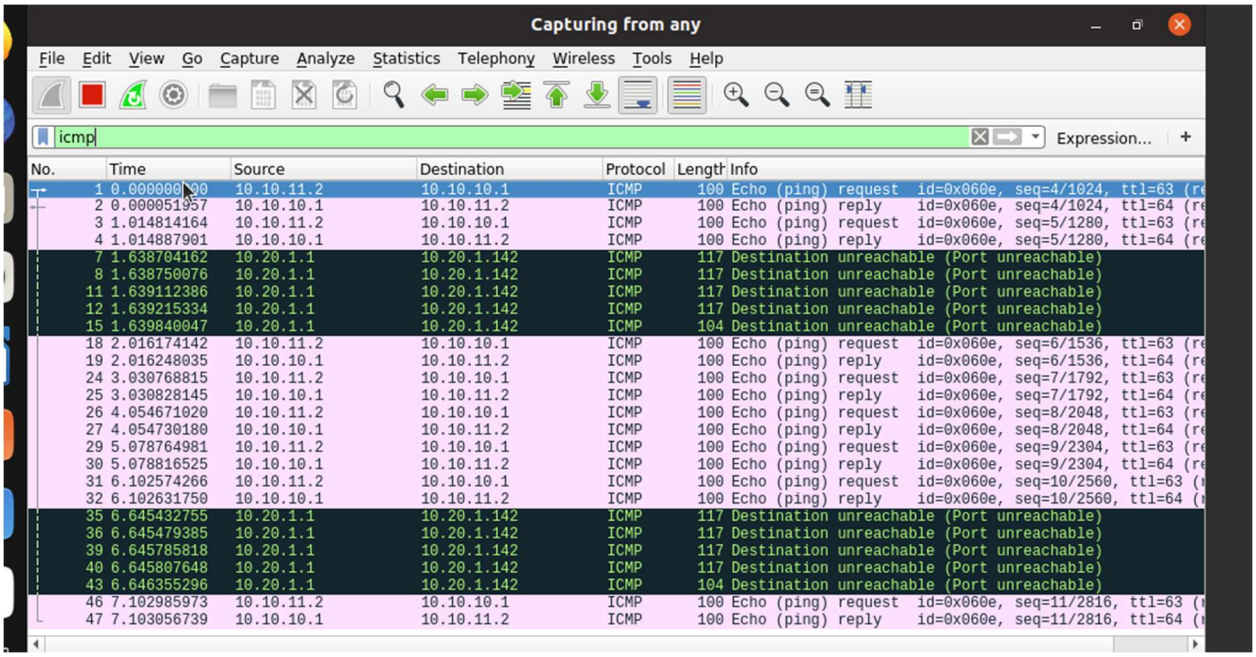
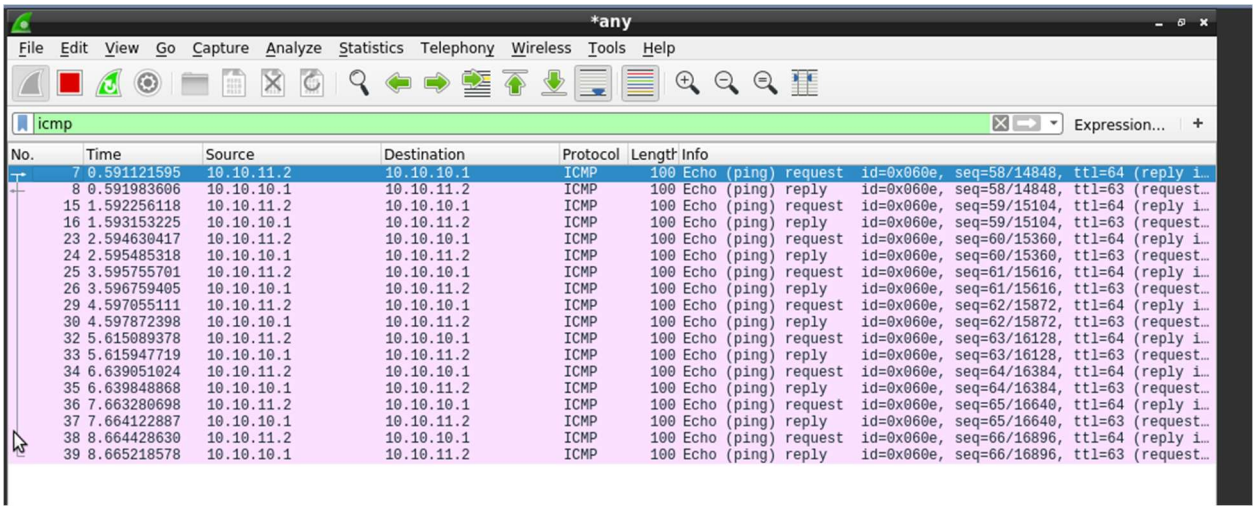


R3's Wireshark



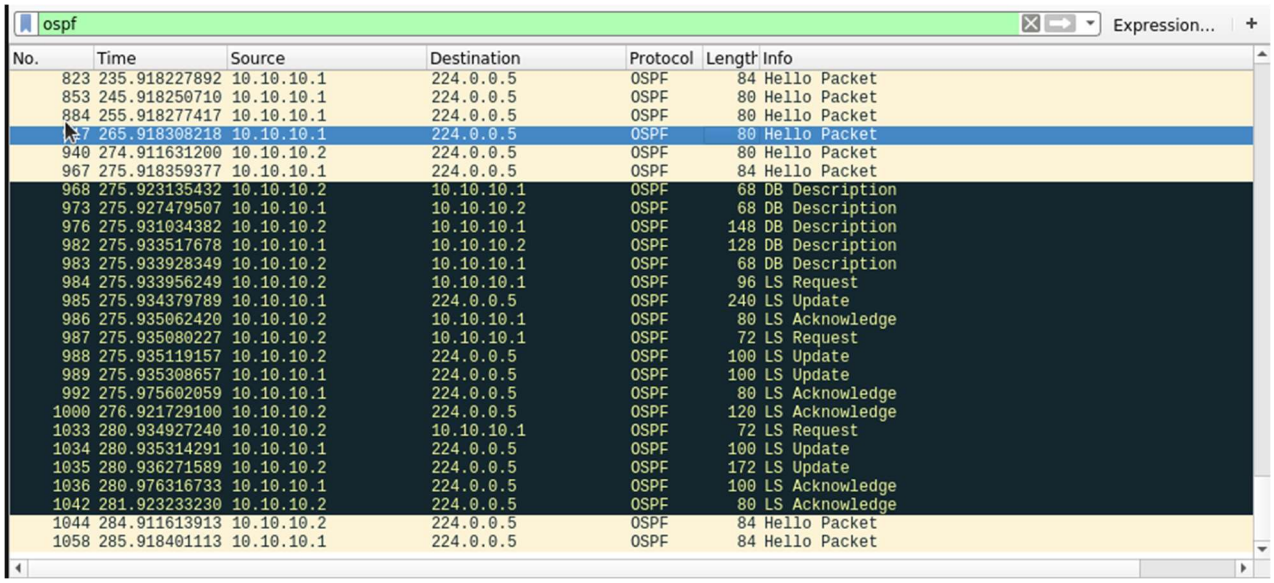
Because R2 is the area-border router, it has to be turned on so that R3 and R1 can send ICMP messages between each other.

Brandon Vo

```
64 bytes from 10.10.10.1: icmp_seq=1 ttl=63 time=1.01 ms
64 bytes from 10.10.10.1: icmp_seq=2 ttl=63 time=1.07 ms
64 bytes from 10.10.10.1: icmp_seq=3 ttl=63 time=0.991 ms
64 bytes from 10.10.10.1: icmp_seq=4 ttl=63 time=1.19 ms
64 bytes from 10.10.10.1: icmp_seq=5 ttl=63 time=1.17 ms
64 bytes from 10.10.10.1: icmp_seq=6 ttl=63 time=0.925 ms
64 bytes from 10.10.10.1: icmp_seq=7 ttl=63 time=0.914 ms
64 bytes from 10.10.10.1: icmp_seq=8 ttl=63 time=0.878 ms
64 bytes from 10.10.10.1: icmp_seq=9 ttl=63 time=0.878 ms
64 bytes from 10.10.10.1: icmp_seq=10 ttl=63 time=1.00 ms
^C
--- 10.10.10.1 ping statistics ---
17 packets transmitted, 10 received, 41.1765% packet loss, time 191ms
rtt min/avg/max/mdev = 0.878/1.002/1.187/0.105 ms
student@CN-R3:~$ ping 10.10.10.1
PING 10.10.10.1 (10.10.10.1) 56(84) bytes of data.
ping: sendmsg: Network is unreachable
ping: sendmsg: Network is unreachable
From 10.10.11.2 icmp_seq=24 Destination Host Unreachable
ping: sendmsg: Network is unreachable
ping: sendmsg: Network is unreachable
ping: sendmsg: Network is unreachable
ping: sendmsg: Network is unreachable
```

Turning off R2 will create a Network is unreachable message.

[10 points] Wireshark screenshots on R1



[10 points] Screenshots depicting successful ping requests to the SFTP server (128.238.77.36) from R1, R2, R3, and R4

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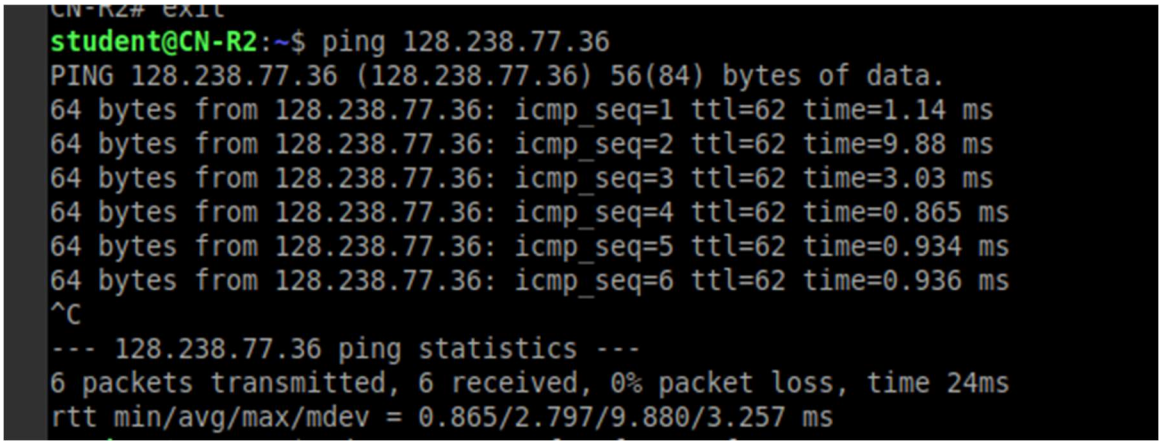
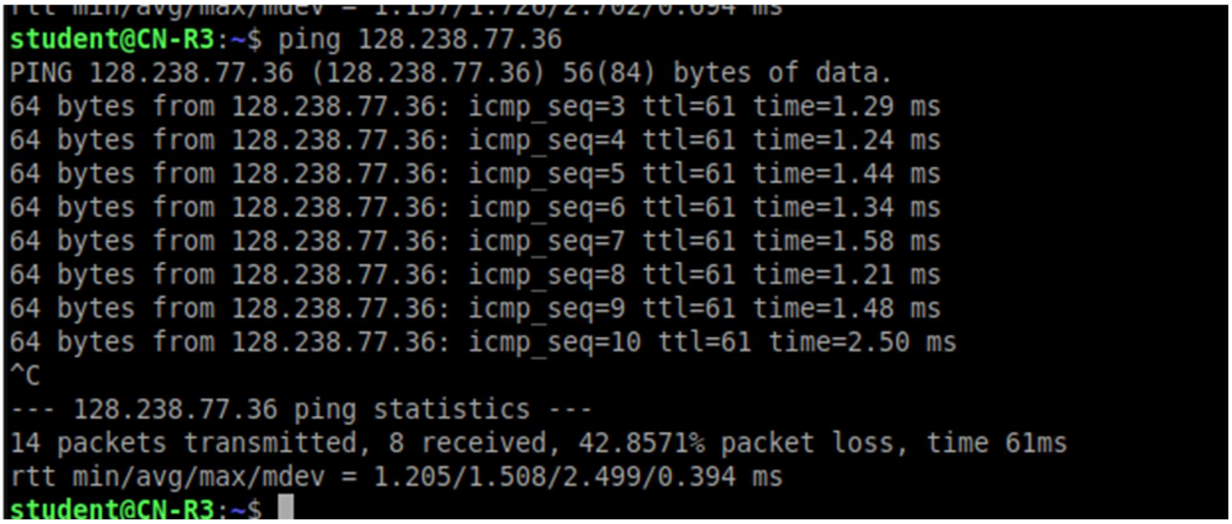
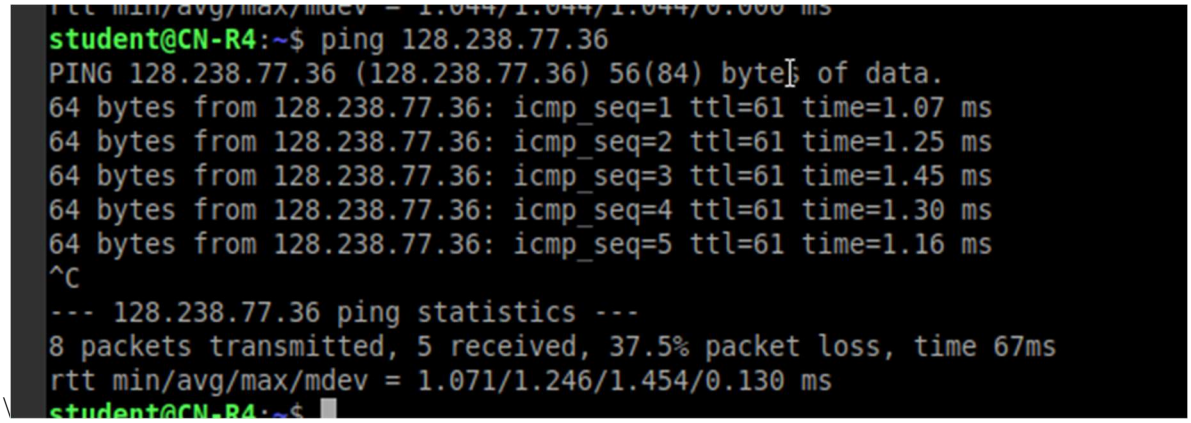
R2



R3



R4



[50 points] Answers to questions 5a-5c Please remember to submit your lab results as a single PDF document. While you may work in groups, you MUST submit your own work.