

## Homework 2

### Part 0: Warmup

- a. What is the slash notation representation of 255.255.255.0?

/24

- b. What is the dot-decimal representation of /30?

255.255.255.252

- c. What is the smallest subnet size that would accommodate 5 hosts?

255.255.255.248/29

3 bits is needed for the subnet size.  $2^2 + 2^1 + 2^0 = 7$

The smallest subnet size is 7.

- d. Fill in the blank cells in the table below

3 hosts  $\rightarrow$  255.255.255.x/y

Need 3 IP addresses + the 2 reserved addresses (broadcast and network addresses), meaning 5 IP addresses are needed. Because IP addresses are distributed in powers of two, 8 IP addresses must be taken.

$X = 8 \rightarrow$  255.255.255.248

$Y = 2^3 \rightarrow 32 - 3 = 29$

VM (interface)	IP Address (CIDR Notation)
R1 (eth0)	10.10.10.1/29
R2 (eth1)	10.10.10.2/29
Kali (eth0)	10.10.10.3/29

Network address is 10.10.10.0/29

Broadcast address must be 10.10.10.7/29 (The largest address size provided)

## Part 1: Configuring Network Interfaces

Open a terminal window (Applications > System Tools > MATE Terminal) and issue the following commands on both R1 (eth1) and R2 (eth0): (Read Basics and Zebra of FRR User Manual)

```
sudo su
```

```
vytysh
```

```
configure terminal
```

```
interface <interface name> // interface name can be eth0, eth1, or eth2
```

```
ip address x.x.x.w/29 // i.e. IP address and subnet mask (i.e. 192.0.2.130/30)
```

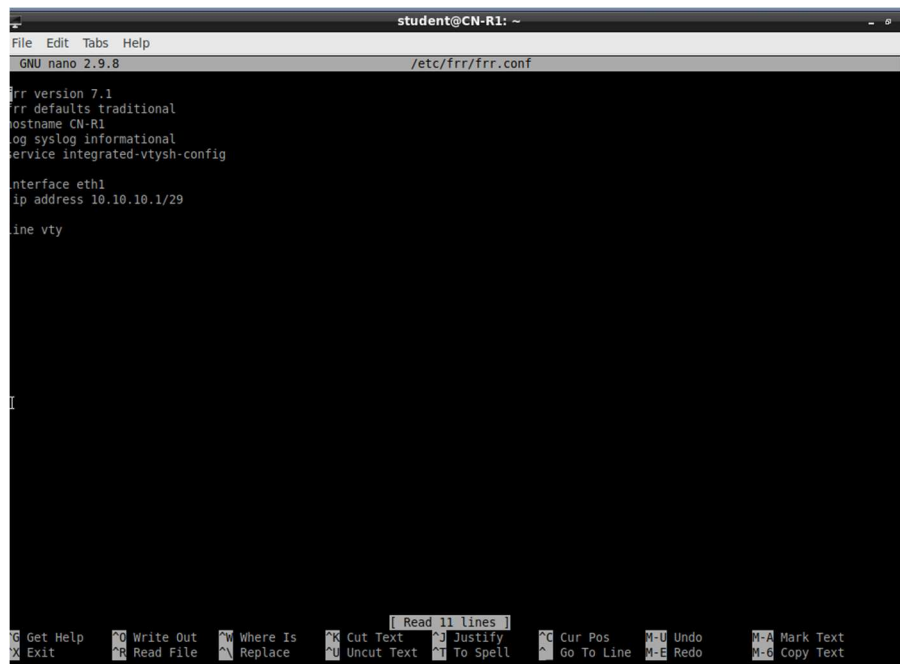
```
end
```

```
write
```

```
exit
```

You may use Linux's `ifconfig` command in order to verify that you have saved your network configuration (see `man ifconfig`)

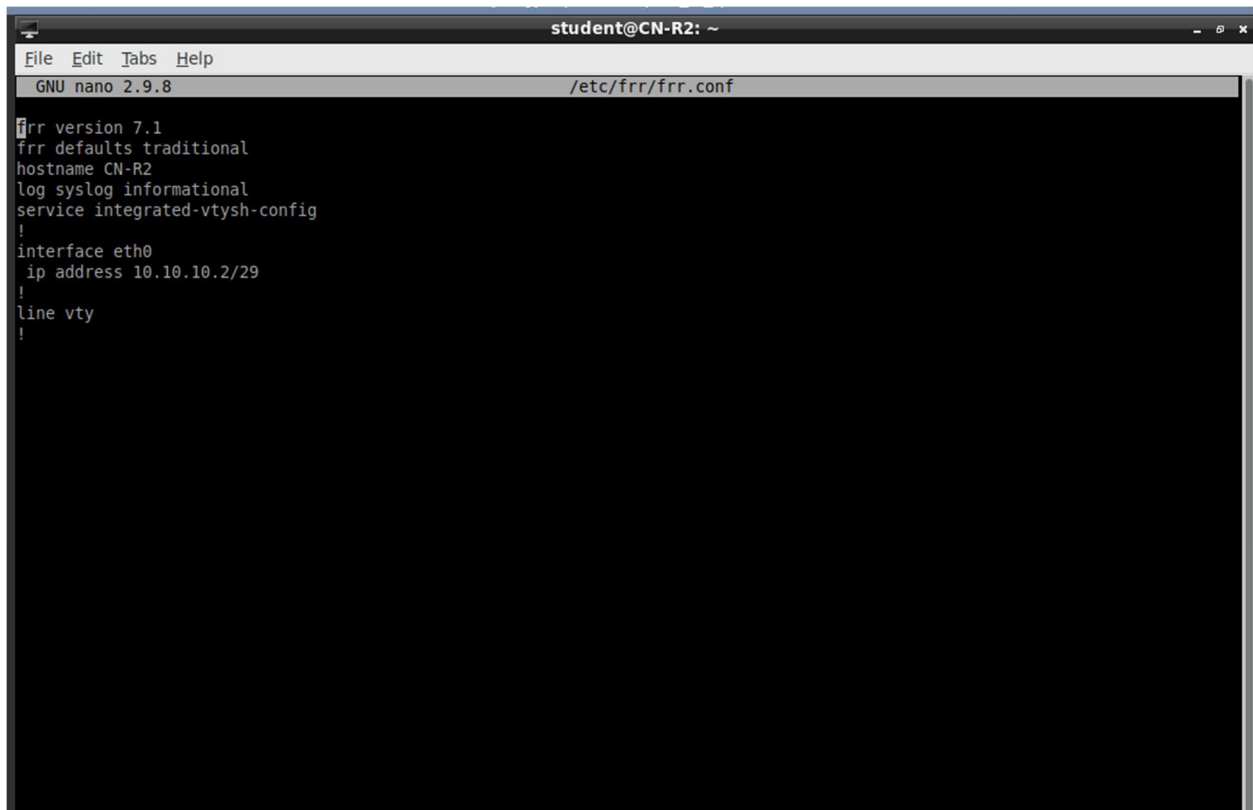
R1 configuration:



```
student@CN-R1: ~  
File Edit Tabs Help  
GNU nano 2.9.8 /etc/frr/frr.conf  
frr version 7.1  
frr defaults traditional  
hostname CN-R1  
log syslog informational  
service integrated-vtysh-config  
  
interface eth1  
ip address 10.10.10.1/29  
  
line vty  
  
[ Read 11 lines ]  
Get Help Write Out Where Is Cut Text Justify Cur Pos M-U Undo M-A Mark Text  
Exit Read File Replace Uncut Text To Spell Go To Line M-E Redo M-G Copy Text
```

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## R2 configuration:



The screenshot shows a terminal window titled "student@CN-R2: ~". Inside the terminal, the GNU nano 2.9.8 text editor is open, editing the file "/etc/frr/frr.conf". The configuration text is as follows:

```
frr version 7.1
frr defaults traditional
hostname CN-R2
log syslog informational
service integrated-vtysh-config
!
interface eth0
 ip address 10.10.10.2/29
!
line vty
!
```

## Part 2: Configuring Kali

Kali must be configured using the Linux commands:

**sudo su**

**nano /etc/network/interfaces (or nano/vi/vim)**

**Your configuration file should have the following entries:**

**auto eth0**

**iface eth0 inet static**

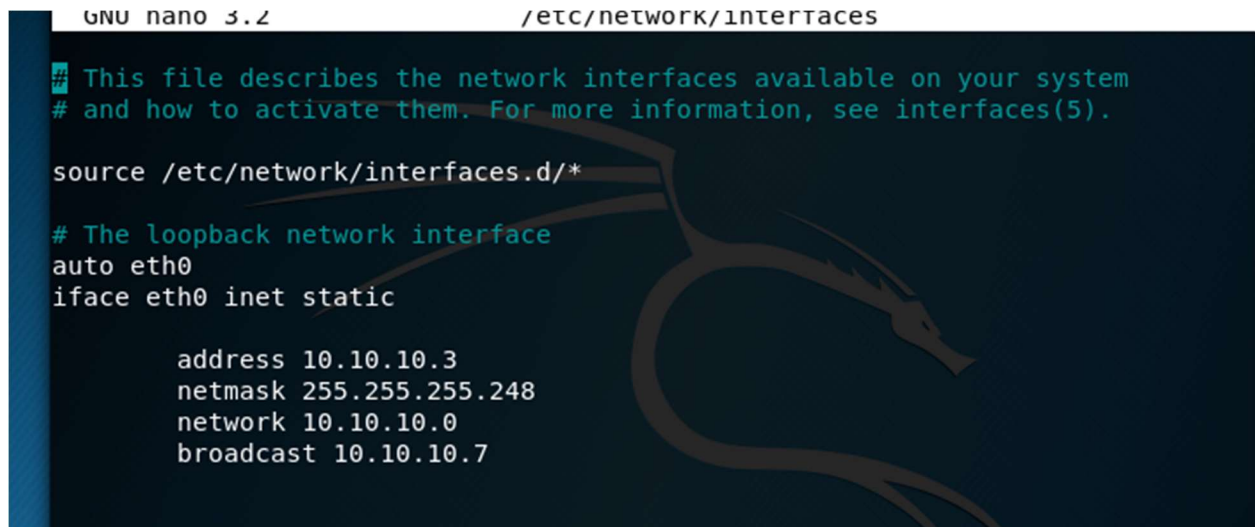
**address x.x.x.w**

**netmask A.A.A.B // convert your netmask to octet notation**

**network x.x.x.y**

**broadcast x.x.x.z**

**Once you have finished, reboot Kali**



```
GNU nano 3.2 /etc/network/interfaces

# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

source /etc/network/interfaces.d/*

# The loopback network interface
auto eth0
iface eth0 inet static

    address 10.10.10.3
    netmask 255.255.255.248
    network 10.10.10.0
    broadcast 10.10.10.7
```

Will be using

auto eth0

iface eth0 inet static

address 10.10.10.3

netmask 255.255.255.248 // convert your netmask to octet notation

network 10.10.10.0

- Network Address must be the first address in the network, matching the subnet<sup>1</sup>

broadcast 10.10.10.7

- The broadcast address must be the last address in the network<sup>2</sup>.

---

1

[http://ladu.htk.tlu.ee/erika/taavi/doc2/network\\_and\\_broadcast\\_address.html#:~:text=Broadcast%20address%20is%20the%20last,remote%20announcements%20in%20network%20segment](http://ladu.htk.tlu.ee/erika/taavi/doc2/network_and_broadcast_address.html#:~:text=Broadcast%20address%20is%20the%20last,remote%20announcements%20in%20network%20segment).

2

[http://ladu.htk.tlu.ee/erika/taavi/doc2/network\\_and\\_broadcast\\_address.html#:~:text=Broadcast%20address%20is%20the%20last,remote%20announcements%20in%20network%20segment](http://ladu.htk.tlu.ee/erika/taavi/doc2/network_and_broadcast_address.html#:~:text=Broadcast%20address%20is%20the%20last,remote%20announcements%20in%20network%20segment).

### Part 3

- a) Why did we choose the /29 subnet mask for Area 0? (10 points)

/29 has a set of 8 IP addresses and uses 1/32 of the class C networks. This is the minimum amount that can be used for 3 hosts because, in addition to the 3 hosts, another 2 IP addresses need to be reserved for the broadcast address and the network address. A total of 5 IP addresses are necessary for the network.

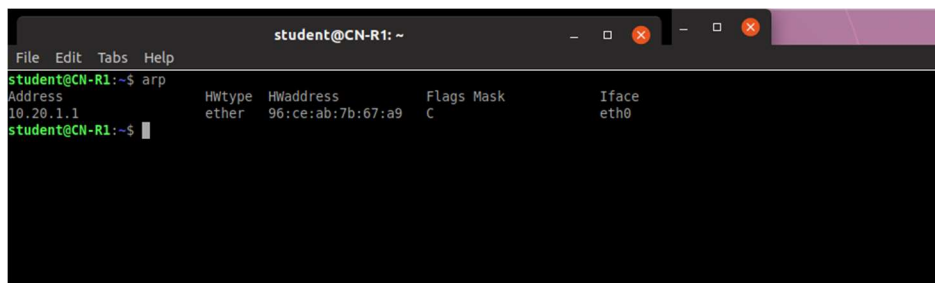
/30 can't be used because it has a netmask of 255.255.255.252. This isn't enough for the 5 IP addresses needed.

- b) The Linux arp (see man arp) command will print the current entries in the machine's address resolution protocol table. Now that you have configured Area 0, what entries are currently in R1, R2, and Kali? (10 points)

An ARP entry starts off empty and adds entries as requested from the machine. This is because the ARP tables are maintained dynamically. As a result, all machines (with the exception of R1) will start off empty when booted on.

R1:

R1 contains the IP address of 10.20.1.1 because it was preconfigured with that address for interface eth0.



```
student@CN-R1: ~  
File Edit Tabs Help  
student@CN-R1:~$ arp  
Address HWtype HWaddress Flags Mask Iface  
10.20.1.1 ether 96:ce:ab:7b:67:a9 C eth0  
student@CN-R1:~$
```

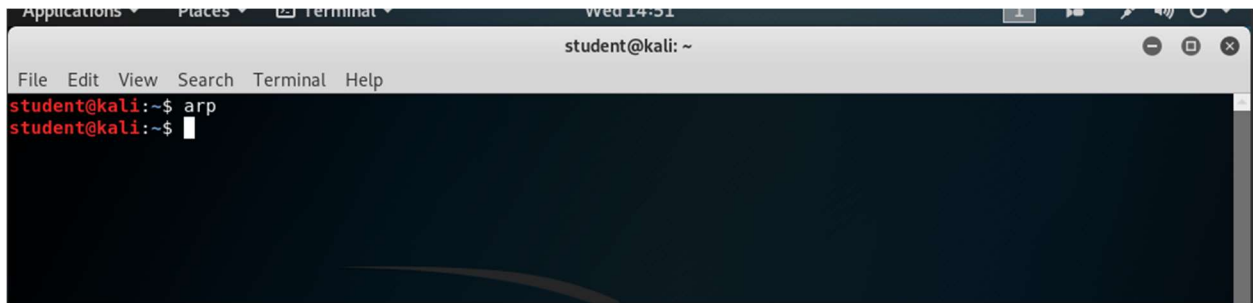
R2:



```
student@CN-R2: ~  
File Edit Tabs Help  
student@CN-R2:~$ arp  
student@CN-R2:~$
```

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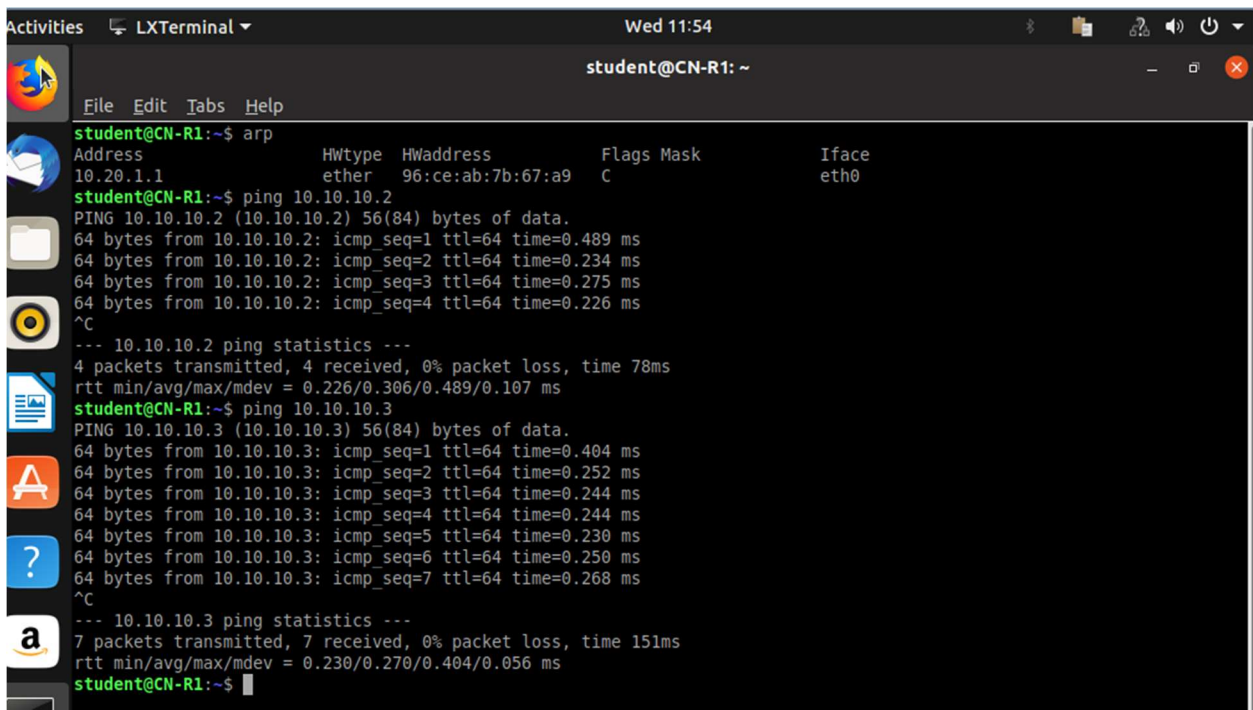
R3:



```
student@kali: ~  
File Edit View Search Terminal Help  
student@kali:~$ arp  
student@kali:~$
```

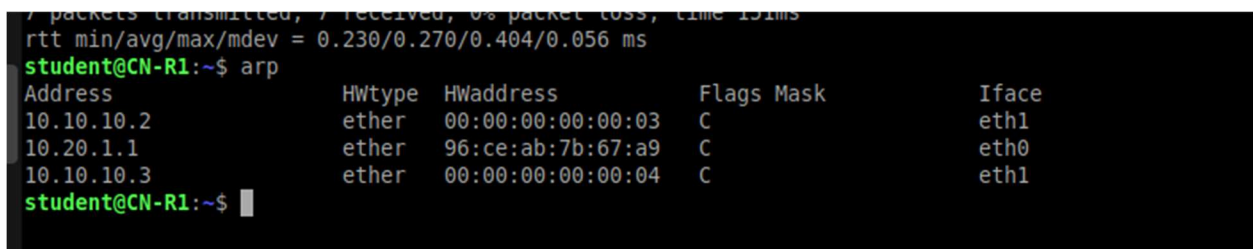
- c) Now ping both R2 and Kali from R1. Note the changes on each machine's arp table. At this point, R2 should be aware of Kali, but why doesn't R2 have a table entry for Kali? (10 points)

Pinging Kali and R2 from R1.



```
student@CN-R1:~$ arp  
Address          Hwtype Hwaddress      Flags Mask      Iface  
10.20.1.1         ether  96:ce:ab:7b:67:a9 C              eth0  
student@CN-R1:~$ ping 10.10.10.2  
PING 10.10.10.2 (10.10.10.2) 56(84) bytes of data.  
64 bytes from 10.10.10.2: icmp_seq=1 ttl=64 time=0.489 ms  
64 bytes from 10.10.10.2: icmp_seq=2 ttl=64 time=0.234 ms  
64 bytes from 10.10.10.2: icmp_seq=3 ttl=64 time=0.275 ms  
64 bytes from 10.10.10.2: icmp_seq=4 ttl=64 time=0.226 ms  
^C  
--- 10.10.10.2 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 78ms  
rtt min/avg/max/mdev = 0.226/0.306/0.489/0.107 ms  
student@CN-R1:~$ ping 10.10.10.3  
PING 10.10.10.3 (10.10.10.3) 56(84) bytes of data.  
64 bytes from 10.10.10.3: icmp_seq=1 ttl=64 time=0.404 ms  
64 bytes from 10.10.10.3: icmp_seq=2 ttl=64 time=0.252 ms  
64 bytes from 10.10.10.3: icmp_seq=3 ttl=64 time=0.244 ms  
64 bytes from 10.10.10.3: icmp_seq=4 ttl=64 time=0.244 ms  
64 bytes from 10.10.10.3: icmp_seq=5 ttl=64 time=0.230 ms  
64 bytes from 10.10.10.3: icmp_seq=6 ttl=64 time=0.250 ms  
64 bytes from 10.10.10.3: icmp_seq=7 ttl=64 time=0.268 ms  
^C  
--- 10.10.10.3 ping statistics ---  
7 packets transmitted, 7 received, 0% packet loss, time 151ms  
rtt min/avg/max/mdev = 0.230/0.270/0.404/0.056 ms  
student@CN-R1:~$
```

R1's new arp table



```
student@CN-R1:~$ arp  
Address          Hwtype Hwaddress      Flags Mask      Iface  
10.10.10.2         ether  00:00:00:00:00:03 C              eth1  
10.20.1.1         ether  96:ce:ab:7b:67:a9 C              eth0  
10.10.10.3         ether  00:00:00:00:00:04 C              eth1  
student@CN-R1:~$
```

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R2's arp table

```
student@CN-R2: ~  
File Edit Tabs Help  
student@CN-R2:~$ arp  
student@CN-R2:~$ arp  
Address          HWtype  HWaddress      Flags Mask    Iface  
10.10.10.1       ether   00:00:00:00:00:02 C             eth0  
student@CN-R2:~$ arp  
Address          HWtype  HWaddress      Flags Mask    Iface  
10.10.10.1       ether   00:00:00:00:00:02 C             eth0  
student@CN-R2:~$
```

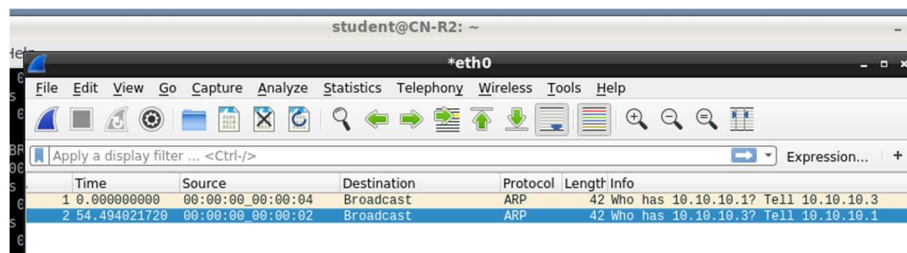
Kali's arp table

```
Applications ▾ Places ▾ Terminal ▾ Wed 14:56 1  
student@kali: ~  
File Edit View Search Terminal Help  
student@kali:~$ arp  
student@kali:~$ arp  
Address          HWtype  HWaddress      Flags Mask    Iface  
10.10.10.1       ether   00:00:00:00:00:02 C             eth0  
student@kali:~$ arp  
Address          HWtype  HWaddress      Flags Mask    Iface  
10.10.10.1       ether   00:00:00:00:00:02 C             eth0  
student@kali:~$
```

- why doesn't R2 have a table entry for Kali?

The ARP request is a broadcast message sent to all machines within a network. The ARP Reply is sent directly to the machine that sent the ARP Request message. According to Wireshark, the R2 machine will read R1's arp request for Kali, but it will never detect Kali's ARP response. This is because while the ARP request is broadcasted, the ARP response is unicast and sent directly to the client that sent out the ARP request.

R2 will read R1's ARP request, but Kali will send the ARP response directly to R1. R2 will not receive Kali's ARP response to R1.



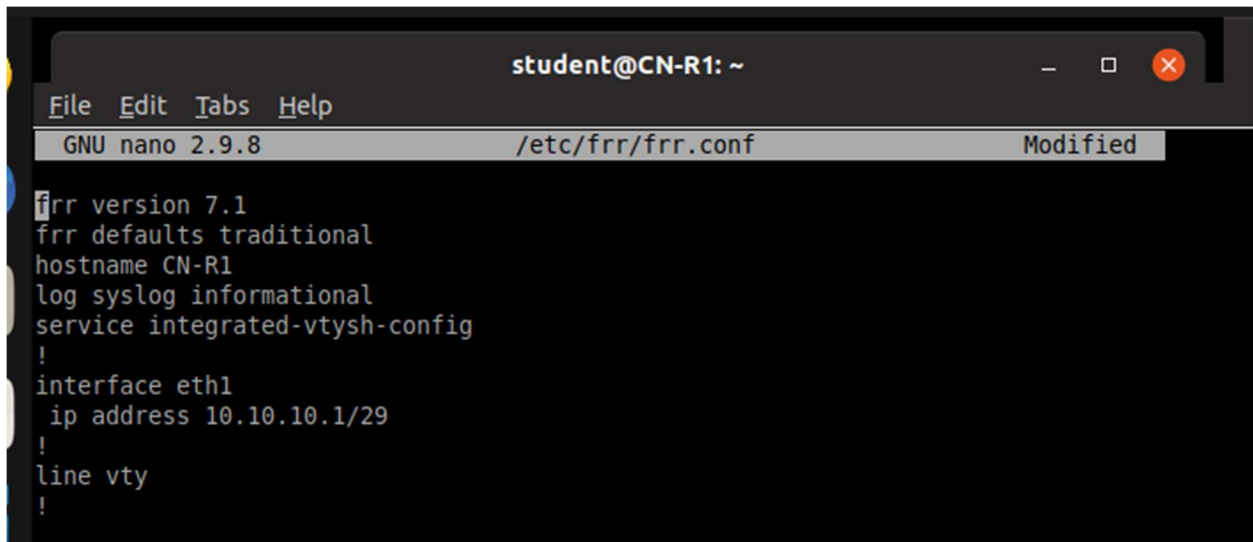
Time	Source	Destination	Protocol	Length	Info
1.0.000000000	00:00:00:00:00:04	Broadcast	ARP	42	Who has 10.10.10.1? Tell 10.10.10.3
2.54.494021720	00:00:00:00:00:02	Broadcast	ARP	42	Who has 10.10.10.3? Tell 10.10.10.1



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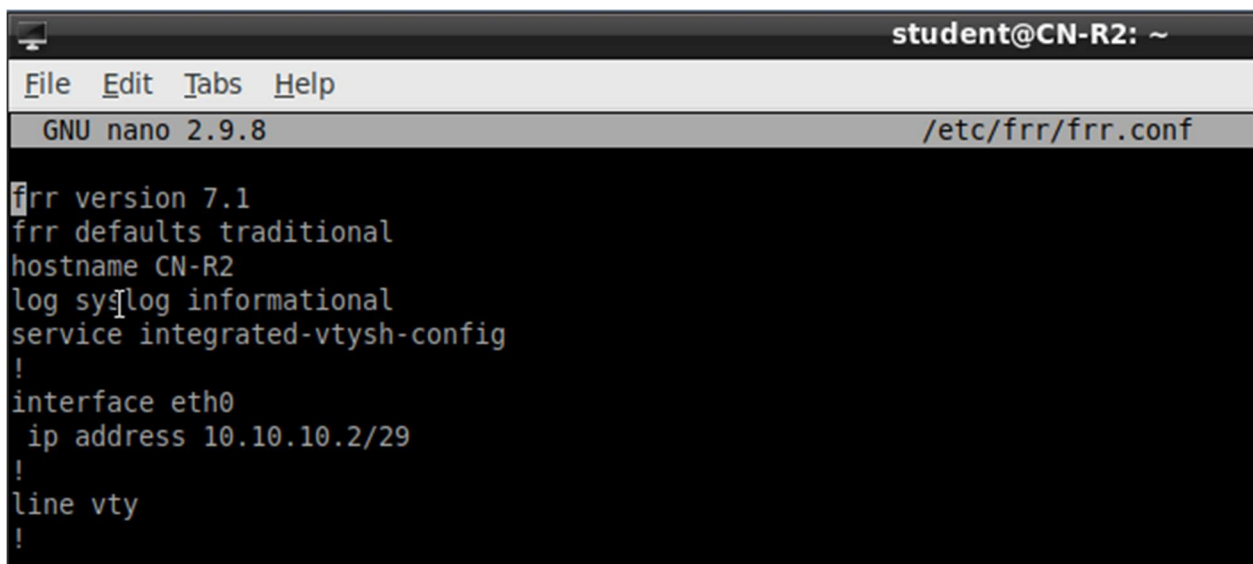
[30 pts] Screenshot of the .conf file under /etc/frr/frr.conf from R1 and R2.

R1's conf file

A screenshot of a terminal window on a device named CN-R1. The window title is 'student@CN-R1: ~'. The terminal shows the nano 2.9.8 editor editing the file /etc/frr/frr.conf. The file content is as follows:

```
frr version 7.1
frr defaults traditional
hostname CN-R1
log syslog informational
service integrated-vtysh-config
!
interface eth1
  ip address 10.10.10.1/29
!
line vty
!
```

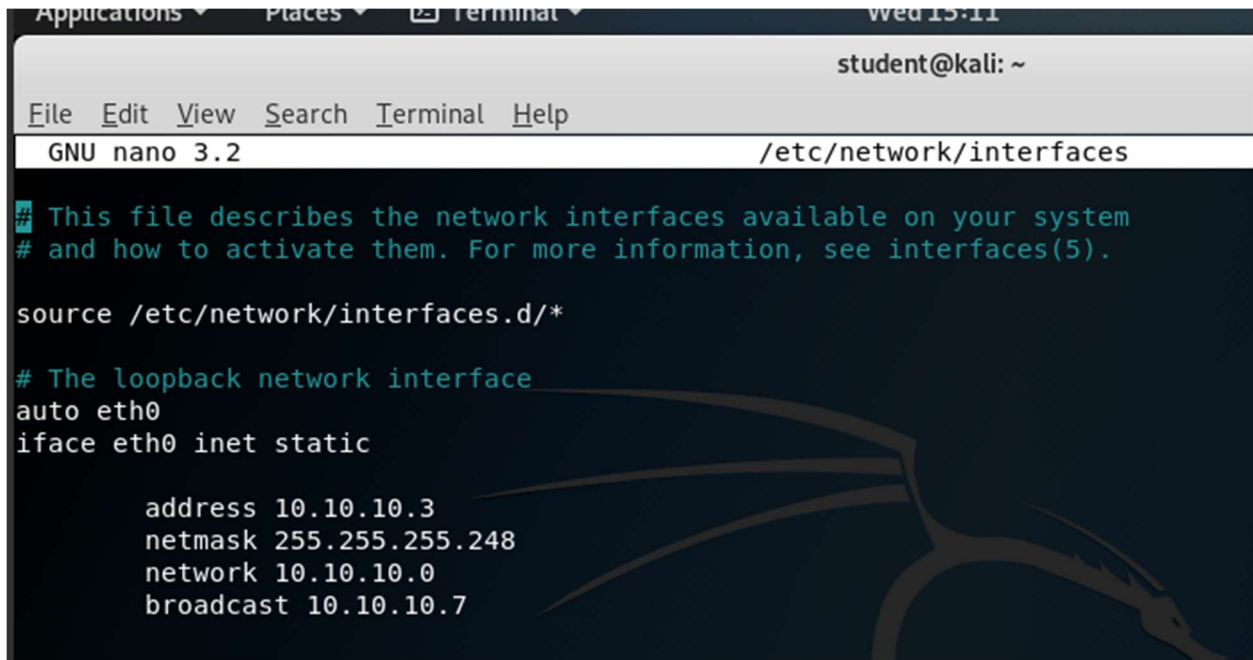
R2's conf file

A screenshot of a terminal window on a device named CN-R2. The window title is 'student@CN-R2: ~'. The terminal shows the nano 2.9.8 editor editing the file /etc/frr/frr.conf. The file content is as follows:

```
frr version 7.1
frr defaults traditional
hostname CN-R2
log syslog informational
service integrated-vtysh-config
!
interface eth0
  ip address 10.10.10.2/29
!
line vty
!
```

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[10 pts] Screenshot of the /etc/network/interfaces file in Kali.

A screenshot of a Kali Linux terminal window. The window title bar shows 'Applications', 'Places', 'Terminal', and the date 'Wed 13-11'. The terminal prompt is 'student@kali: ~'. The nano editor is open to the file '/etc/network/interfaces'. The editor's status bar at the top shows 'GNU nano 3.2'. The file content is as follows:

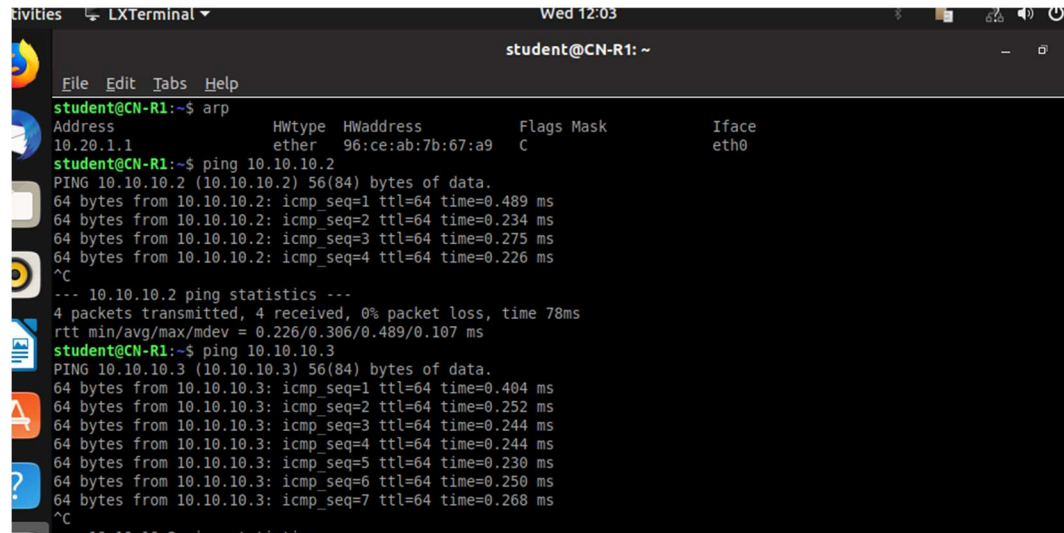
```
This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

source /etc/network/interfaces.d/*

# The loopback network interface
auto eth0
iface eth0 inet static
    address 10.10.10.3
    netmask 255.255.255.248
    network 10.10.10.0
    broadcast 10.10.10.7
```

[20 pts] Screenshot showing that pinging works between R1, R2, and Kali.

R1's pinging



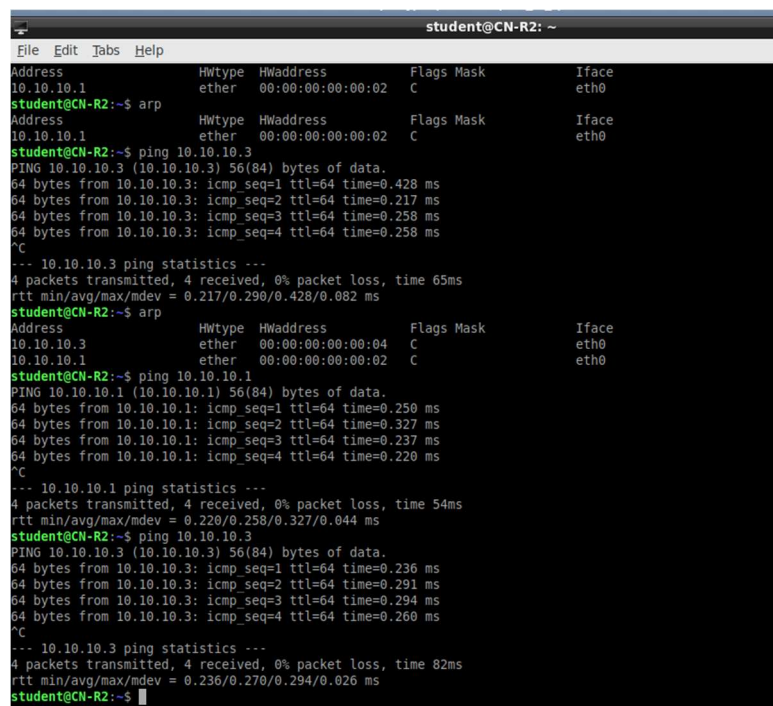
The screenshot shows a terminal window titled "student@CN-R1: ~". The user has entered the following commands and received the following output:

```
student@CN-R1:~$ arp
Address                  Hwtype  Hwaddress      Flags Mask          Iface
10.20.1.1                ether   96:ce:ab:7b:67:a9 C                   eth0

student@CN-R1:~$ ping 10.10.10.2
PING 10.10.10.2 (10.10.10.2) 56(84) bytes of data.
64 bytes from 10.10.10.2: icmp_seq=1 ttl=64 time=0.489 ms
64 bytes from 10.10.10.2: icmp_seq=2 ttl=64 time=0.234 ms
64 bytes from 10.10.10.2: icmp_seq=3 ttl=64 time=0.275 ms
64 bytes from 10.10.10.2: icmp_seq=4 ttl=64 time=0.226 ms
^C
--- 10.10.10.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 78ms
rtt min/avg/max/mdev = 0.226/0.306/0.489/0.107 ms

student@CN-R1:~$ ping 10.10.10.3
PING 10.10.10.3 (10.10.10.3) 56(84) bytes of data.
64 bytes from 10.10.10.3: icmp_seq=1 ttl=64 time=0.404 ms
64 bytes from 10.10.10.3: icmp_seq=2 ttl=64 time=0.252 ms
64 bytes from 10.10.10.3: icmp_seq=3 ttl=64 time=0.244 ms
64 bytes from 10.10.10.3: icmp_seq=4 ttl=64 time=0.244 ms
64 bytes from 10.10.10.3: icmp_seq=5 ttl=64 time=0.230 ms
64 bytes from 10.10.10.3: icmp_seq=6 ttl=64 time=0.250 ms
64 bytes from 10.10.10.3: icmp_seq=7 ttl=64 time=0.268 ms
^C
--- 10.10.10.3 ping statistics ---
```

R2's pinging



The screenshot shows a terminal window titled "student@CN-R2: ~". The user has entered the following commands and received the following output:

```
student@CN-R2:~$ arp
Address                  Hwtype  Hwaddress      Flags Mask          Iface
10.10.10.1                ether   00:00:00:00:00:02 C                   eth0

student@CN-R2:~$ ping 10.10.10.3
PING 10.10.10.3 (10.10.10.3) 56(84) bytes of data.
64 bytes from 10.10.10.3: icmp_seq=1 ttl=64 time=0.428 ms
64 bytes from 10.10.10.3: icmp_seq=2 ttl=64 time=0.217 ms
64 bytes from 10.10.10.3: icmp_seq=3 ttl=64 time=0.258 ms
64 bytes from 10.10.10.3: icmp_seq=4 ttl=64 time=0.258 ms
^C
--- 10.10.10.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 65ms
rtt min/avg/max/mdev = 0.217/0.290/0.428/0.082 ms

student@CN-R2:~$ arp
Address                  Hwtype  Hwaddress      Flags Mask          Iface
10.10.10.3                ether   00:00:00:00:00:04 C                   eth0
10.10.10.1                ether   00:00:00:00:00:02 C                   eth0

student@CN-R2:~$ ping 10.10.10.1
PING 10.10.10.1 (10.10.10.1) 56(84) bytes of data.
64 bytes from 10.10.10.1: icmp_seq=1 ttl=64 time=0.250 ms
64 bytes from 10.10.10.1: icmp_seq=2 ttl=64 time=0.327 ms
64 bytes from 10.10.10.1: icmp_seq=3 ttl=64 time=0.237 ms
64 bytes from 10.10.10.1: icmp_seq=4 ttl=64 time=0.220 ms
^C
--- 10.10.10.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 54ms
rtt min/avg/max/mdev = 0.220/0.258/0.327/0.044 ms

student@CN-R2:~$ ping 10.10.10.3
PING 10.10.10.3 (10.10.10.3) 56(84) bytes of data.
64 bytes from 10.10.10.3: icmp_seq=1 ttl=64 time=0.236 ms
64 bytes from 10.10.10.3: icmp_seq=2 ttl=64 time=0.291 ms
64 bytes from 10.10.10.3: icmp_seq=3 ttl=64 time=0.294 ms
64 bytes from 10.10.10.3: icmp_seq=4 ttl=64 time=0.260 ms
^C
--- 10.10.10.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 82ms
rtt min/avg/max/mdev = 0.236/0.270/0.294/0.026 ms

student@CN-R2:~$
```

## Kali's pinging

```
student@kali: ~  
File Edit View Search Terminal Help  
student@kali:~$ ping 10.10.10.1  
PING 10.10.10.1 (10.10.10.1) 56(84) bytes of data.  
64 bytes from 10.10.10.1: icmp_seq=1 ttl=64 time=0.441 ms  
64 bytes from 10.10.10.1: icmp_seq=2 ttl=64 time=0.505 ms  
64 bytes from 10.10.10.1: icmp_seq=3 ttl=64 time=0.462 ms  
64 bytes from 10.10.10.1: icmp_seq=4 ttl=64 time=0.432 ms  
^C  
--- 10.10.10.1 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 58ms  
rtt min/avg/max/mdev = 0.432/0.460/0.505/0.028 ms  
student@kali:~$ ping 10.10.10.2  
PING 10.10.10.2 (10.10.10.2) 56(84) bytes of data.  
64 bytes from 10.10.10.2: icmp_seq=1 ttl=64 time=0.742 ms  
64 bytes from 10.10.10.2: icmp_seq=2 ttl=64 time=0.487 ms  
64 bytes from 10.10.10.2: icmp_seq=3 ttl=64 time=0.511 ms  
64 bytes from 10.10.10.2: icmp_seq=4 ttl=64 time=0.455 ms  
^C  
--- 10.10.10.2 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 80ms  
rtt min/avg/max/mdev = 0.455/0.548/0.742/0.116 ms  
student@kali:~$
```

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[10 pts] Screenshot of the ARP tables on R1, R2, and Kali.

These arp tables were after all 3 machines pinged each other.

### R1's arp table

```
10.10.10.3 ether 00:00:00:00:00:04 C eth1
student@CN-R1:~$ arp
Address HWtype HWaddress Flags Mask Iface
10.10.10.2 ether 00:00:00:00:00:03 C eth1
10.20.1.1 ether 96:ce:ab:7b:67:a9 C eth0
10.10.10.3 ether 00:00:00:00:00:04 C eth1
student@CN-R1:~$
```

### R2's arp table

```
4 packets transmitted, 4 received, 0% packet loss, time 82ms
rtt min/avg/max/mdev = 0.236/0.270/0.294/0.026 ms
student@CN-R2:~$ arp
Address HWtype HWaddress Flags Mask Iface
10.10.10.3 ether 00:00:00:00:00:04 C eth0
10.10.10.1 ether 00:00:00:00:00:02 C eth0
student@CN-R2:~$
```

### Kali's arp table

```
3 packets transmitted, 3 received, 0% packet loss, time 31ms
rtt min/avg/max/mdev = 0.188/0.213/0.230/0.021 ms
student@kali:~$ arp
Address HWtype HWaddress Flags Mask Iface
10.10.10.1 ether 00:00:00:00:00:02 C eth0
10.10.10.2 ether 00:00:00:00:00:03 C eth0
student@kali:~$
```

[30 pts] Answers to questions 3a-3c