

## Homework 5

### Instructions

Set up a DHCP server on R4 (eth2) such that it leases IP addresses from the 10.10.11.X/28 subnet to the Ubuntu VM. Calculate the network, broadcast, and useable range of IP addresses for your address range. Select the first useable IP address as the static address for the R4 interface (remember that we cannot use the network and broadcast). The remaining addresses will go into the pool that the DHCP server will lease and manage.

Before starting this lab, please read RFC 2131.

**Note:** Please make any necessary changes to the /etc/network/interfaces file of Ubuntu before you proceed. The file should already have an existing entry for DHCP which includes:

```
iface eth0 inet dhcp
```

## Part 1: Configuring DHCP

The first step is to configure the `dhcpd.conf` (DHCP daemon configuration) file in router R4. This file is present in the `/etc/dhcp` directory. You can make edits to this file using any text editor.

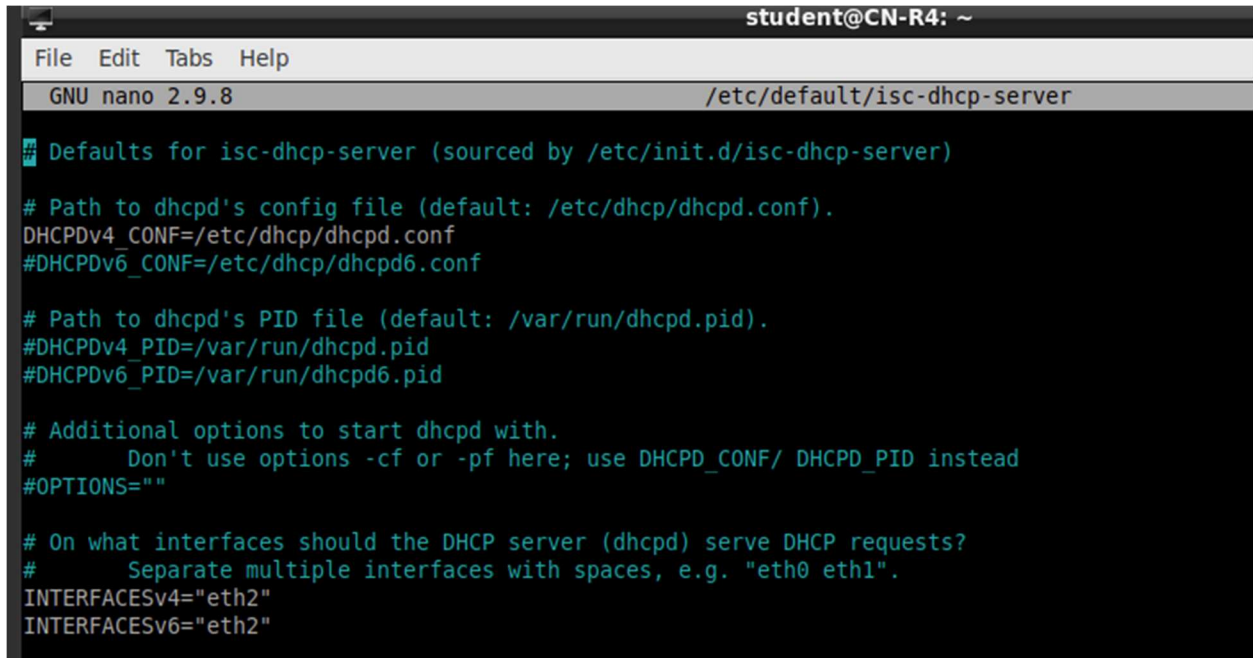
Consult the example configuration options in the `dhcpd.conf` file to configure your DHCP server on R4. Make sure to set `default-lease-time` to 300.

Note that you do not need to provide configurations for the option `domain-name` or `domain name - servers`.

```
subnet 10.10.11.16 netmask 255.255.255.240 {  
    range 10.10.11.18 10.10.11.30;  
    #option domain-name-servers nsl.internal.example.org;  
    #option domain-name "internal.example.org;"  
    option subnet-mask 255.255.255.240;  
    option routers 10.10.11.17;  
    option broadcast-address 10.10.11.31;  
    default-lease-time 300;  
    max-lease-time 7200;  
}
```

## Part 2: Server Interface

Check the `/etc/default/isc-dhcp-server` file on R4. This file has to be changed so the DHCP server knows which interface it should listen on for serving IP addresses.



```
student@CN-R4: ~  
File Edit Tabs Help  
GNU nano 2.9.8 /etc/default/isc-dhcp-server  
Defaults for isc-dhcp-server (sourced by /etc/init.d/isc-dhcp-server)  
  
# Path to dhcpd's config file (default: /etc/dhcp/dhcpd.conf).  
DHCPDv4_CONF=/etc/dhcp/dhcpd.conf  
#DHCPDv6_CONF=/etc/dhcp/dhcpd6.conf  
  
# Path to dhcpd's PID file (default: /var/run/dhcpd.pid).  
#DHCPDv4_PID=/var/run/dhcpd.pid  
#DHCPDv6_PID=/var/run/dhcpd6.pid  
  
# Additional options to start dhcpd with.  
# Don't use options -cf or -pf here; use DHCPD_CONF/ DHCPD_PID instead  
#OPTIONS=""  
  
# On what interfaces should the DHCP server (dhcpd) serve DHCP requests?  
# Separate multiple interfaces with spaces, e.g. "eth0 eth1".  
INTERFACESv4="eth2"  
INTERFACESv6="eth2"
```

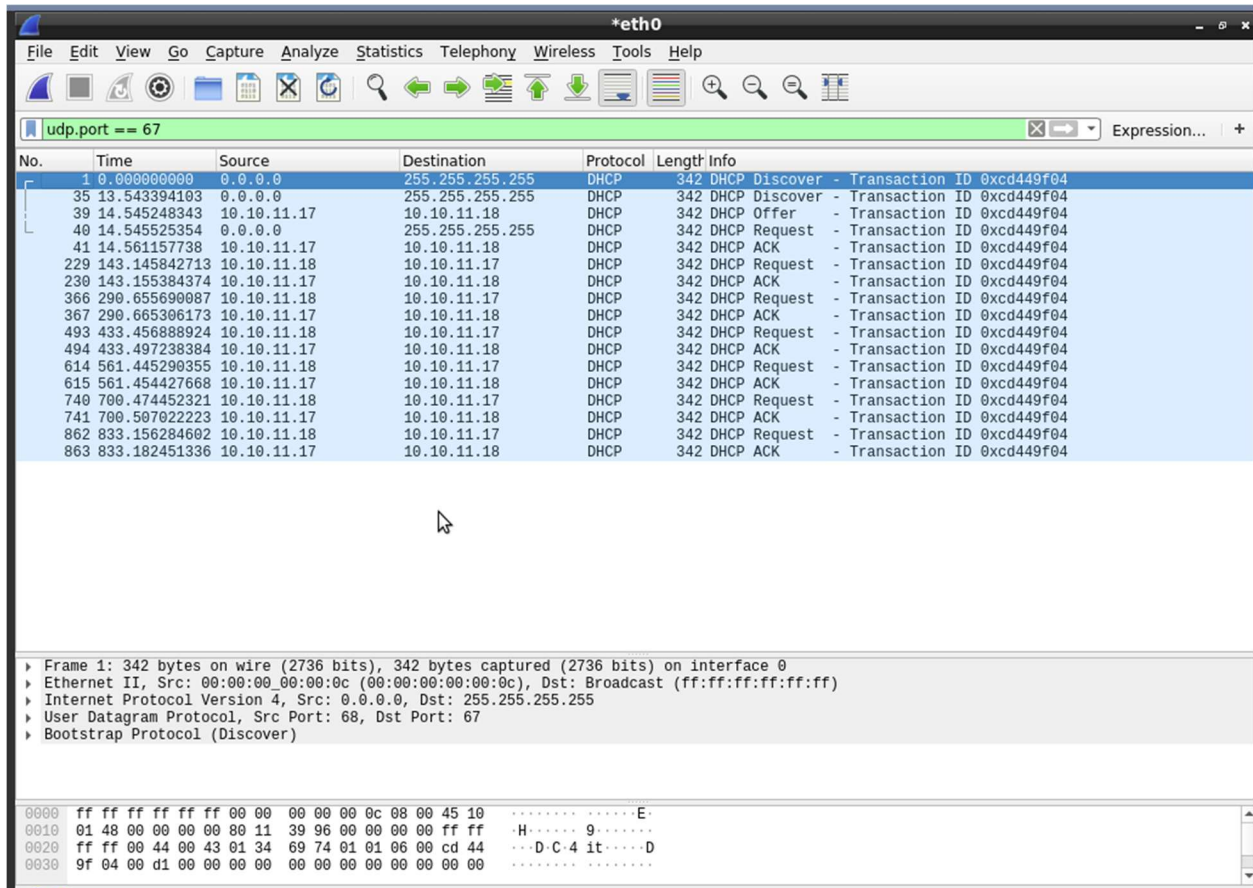
### Part 3: Verifying DHCP and Wireshark

We will verify that Ubuntu has obtained an IP address.

1. Shutdown R4 and Ubuntu.
2. Power on Ubuntu and run Wireshark via the terminal: `sudo wireshark`
3. Monitor incoming traffic on the appropriate interface.
4. Now power on R4 and view Wireshark traffic on Ubuntu.
5. Use the following filter to show DHCP messages: `udp.port == 67`
6. Take a screenshot showing all captured DHCP messages.

Note: Verify that the DHCP server is running properly on R4 by using the following command:

`sudo systemctl status isc-dhcp-server.service`



```
student@CN-R4:~$ sudo nano /etc/default/isc-dhcp-server
student@CN-R4:~$ sudo systemctl status isc-dhcp-server.service
● isc-dhcp-server.service - ISC DHCP IPv4 server
   Loaded: loaded (/lib/systemd/system/isc-dhcp-server.service; enabled; vendor preset: enabled)
   Active: active (running) since Mon 2021-03-08 11:14:39 PST; 13min ago
     Docs: man:dhcpcd(8)
    Main PID: 890 (dhcpcd)
      Tasks: 1 (limit: 4670)
     Memory: 11.3M
    CGroup: /system.slice/isc-dhcp-server.service
            └─890 dhcpcd -user dhcpcd -group dhcpcd -f -4 -pf /run/dhcp-server/dhcpcd.pid -cf /etc/dhcp/dhcpcd.conf

Mar 08 11:16:52 CN-R4 dhcpcd[890]: DHCPREQUEST for 10.10.11.18 from 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:16:52 CN-R4 dhcpcd[890]: DHCPACK on 10.10.11.18 to 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:19:20 CN-R4 dhcpcd[890]: DHCPREQUEST for 10.10.11.18 from 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:19:20 CN-R4 dhcpcd[890]: DHCPACK on 10.10.11.18 to 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:21:43 CN-R4 dhcpcd[890]: DHCPREQUEST for 10.10.11.18 from 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:21:43 CN-R4 dhcpcd[890]: DHCPACK on 10.10.11.18 to 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:23:50 CN-R4 dhcpcd[890]: DHCPREQUEST for 10.10.11.18 from 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:23:50 CN-R4 dhcpcd[890]: DHCPACK on 10.10.11.18 to 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:26:10 CN-R4 dhcpcd[890]: DHCPREQUEST for 10.10.11.18 from 00:00:00:00:00:0c (Ubuntu) via eth2
Mar 08 11:26:10 CN-R4 dhcpcd[890]: DHCPACK on 10.10.11.18 to 00:00:00:00:00:0c (Ubuntu) via eth2
student@CN-R4:~$
```

```
student@Ubuntu:~$ sudo nano /var/lib/dhcp/dhclient.eth0.leases
student@Ubuntu:~$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.10.11.18 netmask 255.255.255.240 broadcast 10.10.10.7
    inet6 fe80::200:ff:fe00:c prefixlen 64 scopeid 0x20<link>
    ether 00:00:00:00:00:0c txqueuelen 1000 (Ethernet)
    RX packets 531 bytes 51074 (51.0 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 682 bytes 55742 (55.7 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

```
student@Ubuntu: ~
File Edit Tabs Help
GNU nano 2.9.8 /var/lib/dhcp/dhclient.eth0.leases

lease {
    interface "eth0";
    fixed-address 10.10.11.18;
    option subnet-mask 255.255.255.240;
    option routers 10.10.11.17;
    option dhcp-lease-time 300;
    option dhcp-message-type 5;
    option dhcp-server-identifier 10.10.11.17;
    option broadcast-address 10.10.11.31;
    renew 1 2021/03/08 19:16:52;
    rebind 1 2021/03/08 19:19:05;
    expire 1 2021/03/08 19:19:43;
}
lease {
    interface "eth0";
    fixed-address 10.10.11.18;
    option subnet-mask 255.255.255.240;
    option routers 10.10.11.17;
    option dhcp-lease-time 300;
    option dhcp-message-type 5;
    option dhcp-server-identifier 10.10.11.17;
    option broadcast-address 10.10.11.31;
    renew 1 2021/03/08 19:19:19;
    rebind 1 2021/03/08 19:21:14;
    expire 1 2021/03/08 19:21:52;
}
lease {
    interface "eth0";
    fixed-address 10.10.11.18;
    option subnet-mask 255.255.255.240;
    option routers 10.10.11.17;
    option dhcp-lease-time 300;
    option dhcp-message-type 5;
    option dhcp-server-identifier 10.10.11.17;
    option broadcast-address 10.10.11.31;
}
Read 52 lines
```

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[20 points] The leases file on R4 found in /var/lib/dhcp/dhcpd.leases

DHCPD.leases on R4

```
student@CN-R4: ~
File Edit Tabs Help
GNU nano 2.9.8 /var/lib/dhcp/dhcpd.leases

# The format of this file is documented in the dhcpd.leases(5) manual page.
# This lease file was written by isc-dhcp-4.3.5

# authoring-byte-order entry is generated, DO NOT DELETE
authoring-byte-order little-endian;

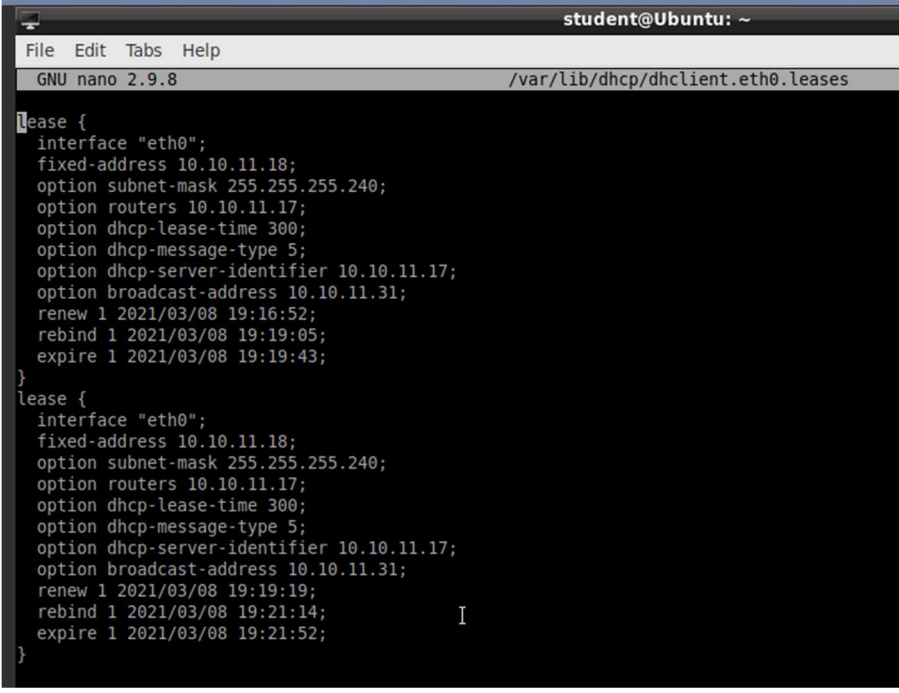
lease 10.10.11.18 {
  starts 1 2021/03/08 19:08:02;
  ends 1 2021/03/08 19:13:02;
  tstp 1 2021/03/08 19:13:02;
  cltt 1 2021/03/08 19:08:02;
  binding state free;
  hardware ethernet 00:00:00:00:00:0c;
}
server-duid "\000\001\000\001'\331\034\260\000\000\000\000\000\013";

lease 10.10.11.18 {
  starts 1 2021/03/08 19:14:44;
  ends 1 2021/03/08 19:19:44;
  cltt 1 2021/03/08 19:14:44;
  binding state active;
  next binding state free;
  rewind binding state free;
  hardware ethernet 00:00:00:00:00:0c;
  client-hostname "Ubuntu";
}
lease 10.10.11.18 {
  starts 1 2021/03/08 19:16:52;
  ends 1 2021/03/08 19:21:52;
  cltt 1 2021/03/08 19:16:52;
  binding state active;
  next binding state free;
  rewind binding state free;
  hardware ethernet 00:00:00:00:00:0c;
  client-hostname "Ubuntu";
}
```



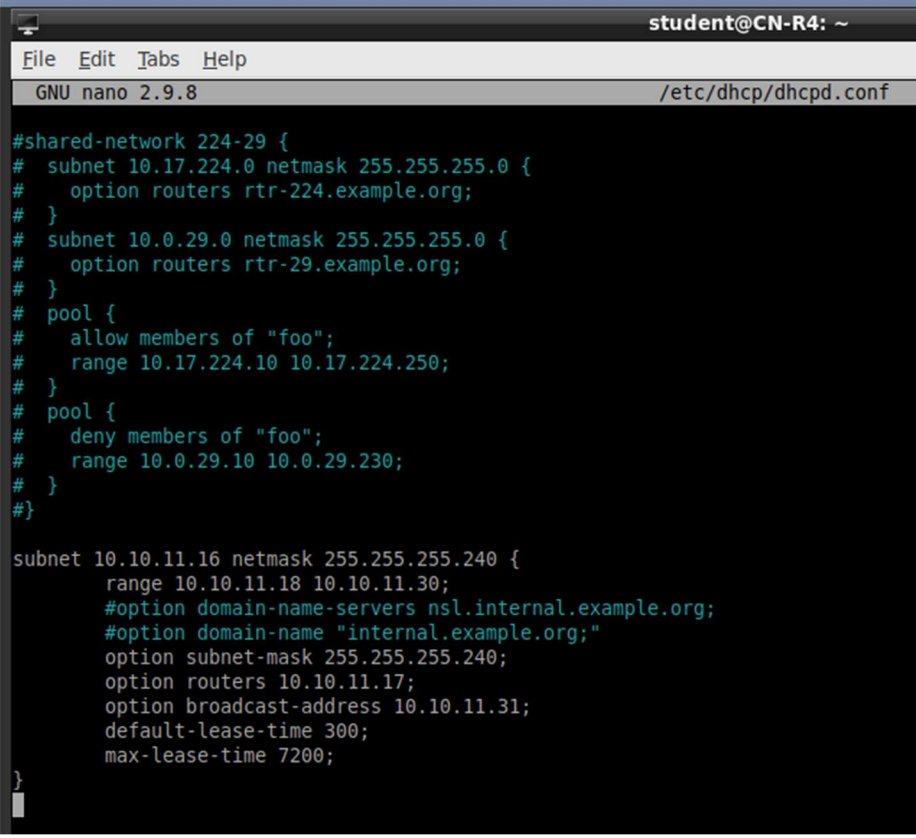
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DHCP client lease on Ubuntu.



```
student@Ubuntu: ~  
File Edit Tabs Help  
GNU nano 2.9.8 /var/lib/dhcp/dhclient.eth0.leases  
  
lease {  
  interface "eth0";  
  fixed-address 10.10.11.18;  
  option subnet-mask 255.255.255.240;  
  option routers 10.10.11.17;  
  option dhcp-lease-time 300;  
  option dhcp-message-type 5;  
  option dhcp-server-identifier 10.10.11.17;  
  option broadcast-address 10.10.11.31;  
  renew 1 2021/03/08 19:16:52;  
  rebind 1 2021/03/08 19:19:05;  
  expire 1 2021/03/08 19:19:43;  
}  
lease {  
  interface "eth0";  
  fixed-address 10.10.11.18;  
  option subnet-mask 255.255.255.240;  
  option routers 10.10.11.17;  
  option dhcp-lease-time 300;  
  option dhcp-message-type 5;  
  option dhcp-server-identifier 10.10.11.17;  
  option broadcast-address 10.10.11.31;  
  renew 1 2021/03/08 19:19:19;  
  rebind 1 2021/03/08 19:21:14;  
  expire 1 2021/03/08 19:21:52;  
}
```

[20 points] Your configuration for the DHCP server.



```
student@CN-R4: ~  
File Edit Tabs Help  
GNU nano 2.9.8 /etc/dhcp/dhcpd.conf  
  
#shared-network 224-29 {  
#  subnet 10.17.224.0 netmask 255.255.255.0 {  
#    option routers rtr-224.example.org;  
#  }  
#  subnet 10.0.29.0 netmask 255.255.255.0 {  
#    option routers rtr-29.example.org;  
#  }  
#  pool {  
#    allow members of "foo";  
#    range 10.17.224.10 10.17.224.250;  
#  }  
#  pool {  
#    deny members of "foo";  
#    range 10.0.29.10 10.0.29.230;  
#  }  
#}  
  
subnet 10.10.11.16 netmask 255.255.255.240 {  
  range 10.10.11.18 10.10.11.30;  
  #option domain-name-servers ns1.internal.example.org;  
  #option domain-name "internal.example.org;"  
  option subnet-mask 255.255.255.240;  
  option routers 10.10.11.17;  
  option broadcast-address 10.10.11.31;  
  default-lease-time 300;  
  max-lease-time 7200;  
}
```

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[20 points] Screenshot of ifconfig on Ubuntu.

Before R4 is powered on

```
student@Ubuntu: ~  
File Edit Tabs Help  
student@Ubuntu:~$ ifconfig  
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
    inet6 fe80::200:ff:fe00:c prefixlen 64 scopeid 0x20<link>  
    ether 00:00:00:00:00:0c txqueuelen 1000 (Ethernet)  
    RX packets 13 bytes 864 (864.0 B)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 17 bytes 3065 (3.0 KB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

After R4 is powered on

```
student@Ubuntu:~$ sudo nano /var/lib/ncp/ncclient/eth0.leases  
student@Ubuntu:~$ ifconfig  
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
    inet 10.10.11.18 netmask 255.255.255.240 broadcast 10.10.10.7  
    inet6 fe80::200:ff:fe00:c prefixlen 64 scopeid 0x20<link>  
    ether 00:00:00:00:00:0c txqueuelen 1000 (Ethernet)  
    RX packets 620 bytes 58910 (58.9 KB)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 787 bytes 63880 (63.8 KB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536  
    inet 127.0.0.1 netmask 255.0.0.0  
    inet6 ::1 prefixlen 128 scopeid 0x10<host>  
    loop txqueuelen 1000 (Local Loopback)  
    RX packets 219 bytes 19642 (19.6 KB)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 219 bytes 19642 (19.6 KB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
student@Ubuntu:~$
```

[20 points] Screenshot showing Ubuntu pinging R4

Pinging R4 on all 3 interfaces.

```
student@Ubuntu: ~  
File Edit Tabs Help  
student@Ubuntu:~$ ping 10.10.11.10  
PING 10.10.11.10 (10.10.11.10) 56(84) bytes of data:  
64 bytes from 10.10.11.10: icmp_seq=1 ttl=64 time=0.306 ms  
64 bytes from 10.10.11.10: icmp_seq=2 ttl=64 time=0.267 ms  
64 bytes from 10.10.11.10: icmp_seq=3 ttl=64 time=0.304 ms  
^C  
--- 10.10.11.10 ping statistics ---  
3 packets transmitted, 3 received, 0% packet loss, time 52ms  
rtt min/avg/max/mdev = 0.267/0.292/0.306/0.022 ms  
student@Ubuntu:~$ ping 10.10.11.6  
PING 10.10.11.6 (10.10.11.6) 56(84) bytes of data:  
64 bytes from 10.10.11.6: icmp_seq=1 ttl=64 time=0.247 ms  
64 bytes from 10.10.11.6: icmp_seq=2 ttl=64 time=0.225 ms  
^C  
--- 10.10.11.6 ping statistics ---  
2 packets transmitted, 2 received, 0% packet loss, time 31ms  
rtt min/avg/max/mdev = 0.225/0.236/0.247/0.011 ms  
student@Ubuntu:~$ ping 10.10.11.17  
PING 10.10.11.17 (10.10.11.17) 56(84) bytes of data:  
64 bytes from 10.10.11.17: icmp_seq=1 ttl=64 time=0.237 ms  
64 bytes from 10.10.11.17: icmp_seq=2 ttl=64 time=0.268 ms  
^C  
--- 10.10.11.17 ping statistics ---  
2 packets transmitted, 2 received, 0% packet loss, time 28ms  
rtt min/avg/max/mdev = 0.237/0.252/0.268/0.022 ms  
student@Ubuntu:~$
```



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Ubuntu's arp table

```
student@Ubuntu:~$ man arp
student@Ubuntu:~$ arp -a
? (10.10.11.17) at 00:00:00:00:00:0b [ether] on eth0
student@Ubuntu:~$
```

[20 points] Screenshot showing Wireshark DHCP messages (4 Types).

| No. | Time          | Source      | Destination     | Protocol | Length | Info                                      |
|-----|---------------|-------------|-----------------|----------|--------|---|
| 1   | 0.000000000   | 0.0.0.0     | 255.255.255.255 | DHCP     | 342    | DHCP Discover - Transaction ID 0xcd449f04 |
| 35  | 13.543394103  | 0.0.0.0     | 255.255.255.255 | DHCP     | 342    | DHCP Discover - Transaction ID 0xcd449f04 |
| 39  | 14.545248343  | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP Offer - Transaction ID 0xcd449f04    |
| 40  | 14.545525354  | 0.0.0.0     | 255.255.255.255 | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 41  | 14.561157738  | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |
| 229 | 143.145842713 | 10.10.11.18 | 10.10.11.17     | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 230 | 143.155384374 | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |
| 366 | 290.655690087 | 10.10.11.18 | 10.10.11.17     | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 367 | 290.665306173 | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |
| 493 | 433.456888924 | 10.10.11.18 | 10.10.11.17     | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 494 | 433.497238384 | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |
| 614 | 561.445290355 | 10.10.11.18 | 10.10.11.17     | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 615 | 561.454427668 | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |
| 740 | 700.474452321 | 10.10.11.18 | 10.10.11.17     | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 741 | 700.507022223 | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |
| 862 | 833.156284602 | 10.10.11.18 | 10.10.11.17     | DHCP     | 342    | DHCP Request - Transaction ID 0xcd449f04  |
| 863 | 833.182451336 | 10.10.11.17 | 10.10.11.18     | DHCP     | 342    | DHCP ACK - Transaction ID 0xcd449f04      |

**DHCP Discover**-The Ubuntu client broadcasts this packet through its interface to discover what DHCP servers are in this network. This is sent towards destination 255.255.255.255 as the broadcast address and has the source as 0.0.0.0 because the Ubuntu client has no IP address.

**DHCP Offer**-After R4 receives the DHCP Discover message, it will reply to the Ubuntu client with a DHCP Offer message. The message contains an offer to use an IPv4 address with certain specifications, including what IP address can be leased and for how long, granted by the R4 DHCP server. These specifications come from the settings written into /etc/dhcp directory.

**DHCP Request Message** – Client replies to the DHCP Offer message by broadcasting the DHCP Offer specifications to the interface. Once R4 receives the message, R4 will know that the Ubuntu client wants to accept this offer. The message is broadcasted so that any other DHCP servers that sent a different offer will rescind their offer if the request message does not match their lease.

**DHCP ACK** – The R4 DHCP server sends an acknowledgement to the Ubuntu client to let the client confirm that the DHCP lease is now available to use until the client's lease expires.