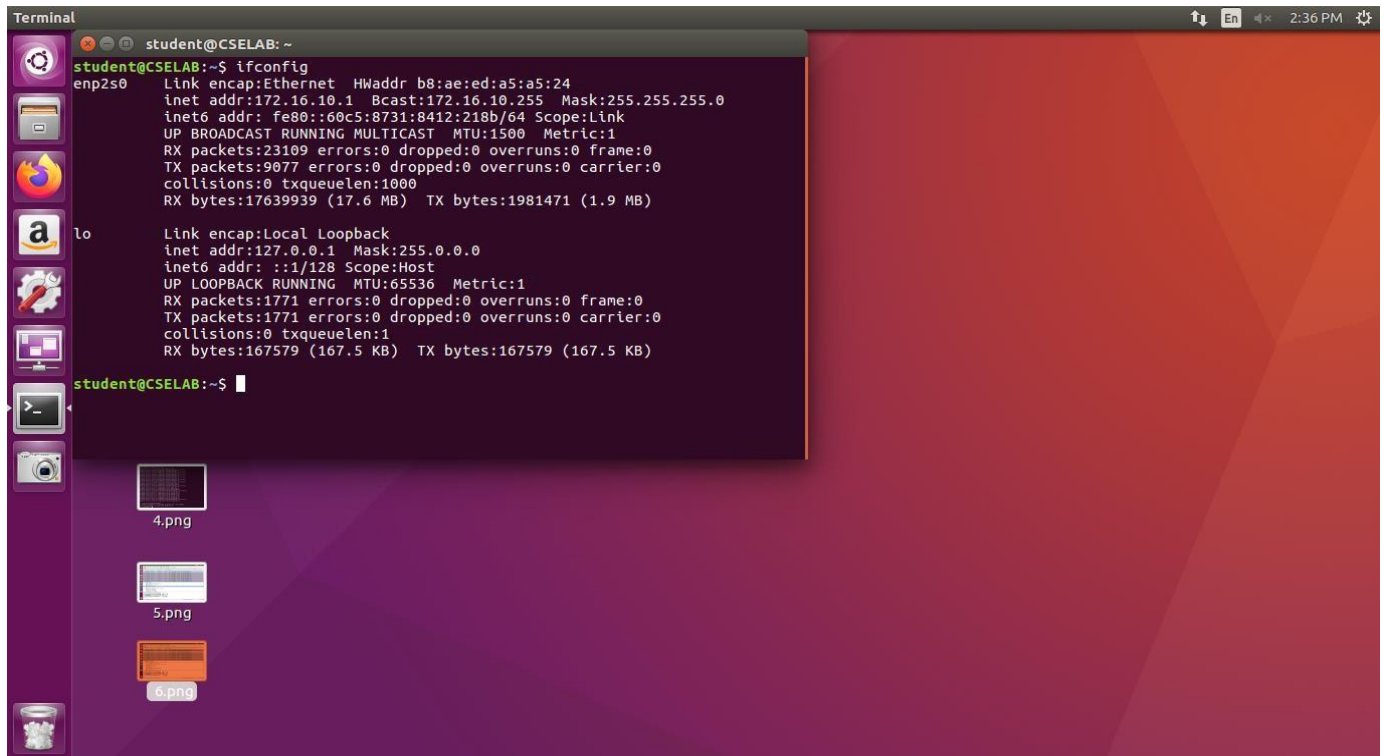


Computer networks laboratory week 8

Name: Pranav R. Hegde SRN: PES1UG19CS343 Section: F1

STEP 1: Assigning IP Addresses to each computer At H_a :

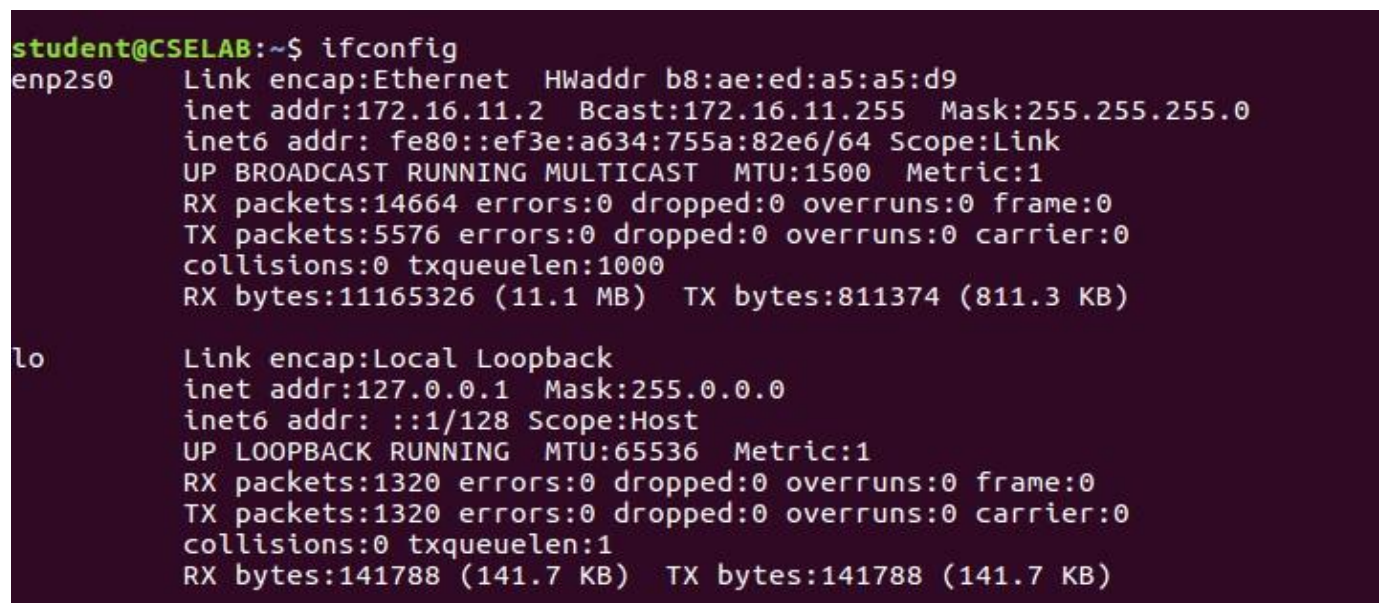


```
Terminal
student@CSELAB: ~
student@CSELAB:~$ ifconfig
enp2s0    Link encap:Ethernet  HWaddr b8:ae:ed:a5:a5:24
          inet addr:172.16.10.1  Bcast:172.16.10.255  Mask:255.255.255.0
          inet6 addr: fe80::60c5:8731:8412:218b/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:23109 errors:0 dropped:0 overruns:0 frame:0
          TX packets:9077 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:17639939 (17.6 MB)  TX bytes:1981471 (1.9 MB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:1771 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1771 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:167579 (167.5 KB)  TX bytes:167579 (167.5 KB)

student@CSELAB:~$
```

At H_b :



```
student@CSELAB:~$ ifconfig
enp2s0    Link encap:Ethernet  HWaddr b8:ae:ed:a5:a5:d9
          inet addr:172.16.11.2  Bcast:172.16.11.255  Mask:255.255.255.0
          inet6 addr: fe80::ef3e:a634:755a:82e6/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:14664 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5576 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:11165326 (11.1 MB)  TX bytes:811374 (811.3 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:1320 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1320 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:141788 (141.7 KB)  TX bytes:141788 (141.7 KB)
```

At R₁:

```
student@CSELAB:~$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether b8:ae:ed:a5:a5:ff brd ff:ff:ff:ff:ff:ff
    inet 172.16.10.2/24 brd 172.16.10.255 scope global enp2s0
        valid_lft forever preferred_lft forever
    inet6 fe80::35bb:8c3:281:5c15/64 scope link
        valid_lft forever preferred_lft forever
```

At R₂:

```
student@CSELAB:~$ ifconfig
enp2s0    Link encap:Ethernet  HWaddr b8:ae:ed:a5:a6:6a
          inet addr:172.16.10.3  Bcast:172.16.10.255  Mask:255.255.255.0
          inet6 addr: fe80::e884:d003:928b:2815/64  Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:20806 errors:0 dropped:0 overruns:0 frame:0
          TX packets:7772 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:18323273 (18.3 MB)  TX bytes:1015130 (1.0 MB)

enx00594d6ea7c2 Link encap:Ethernet  HWaddr 00:59:4d:6e:a7:c2
          inet addr:172.16.11.1  Bcast:172.16.11.255  Mask:255.255.255.0
          inet6 addr: fe80::f0c8:1a5c:7cc1:9aa/64  Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:9 errors:0 dropped:0 overruns:0 frame:0
          TX packets:42 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:2388 (2.3 KB)  TX bytes:6024 (6.0 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128  Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:4824 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4824 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:369371 (369.3 KB)  TX bytes:369371 (369.3 KB)
```


Disabling accepting the ICMP redirect packets

At H_a:

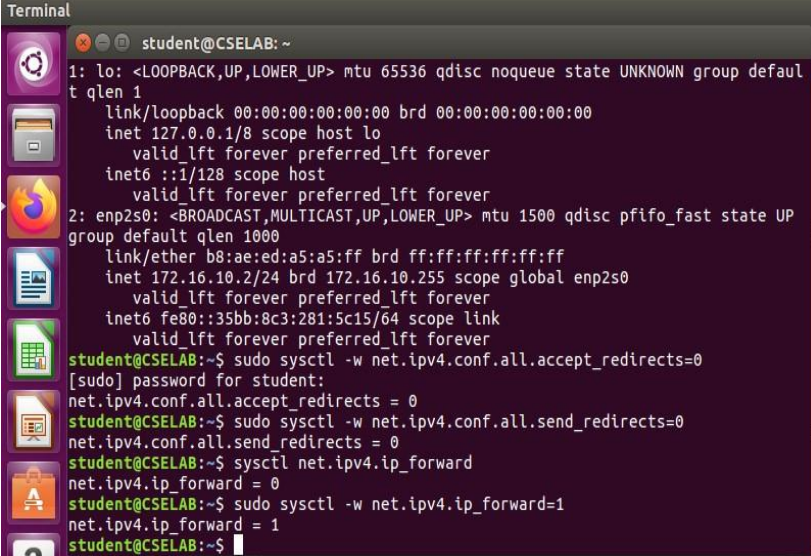
```
student@CSELAB: ~  
student@CSELAB:~$ ip addr show  
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1  
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00  
    inet 127.0.0.1/8 scope host lo  
        valid_lft forever preferred_lft forever  
    inet6 ::1/128 scope host  
        valid_lft forever preferred_lft forever  
2: enp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000  
    link/ether b8:ae:ed:a5:a5:24 brd ff:ff:ff:ff:ff:ff  
    inet 172.16.10.1/24 brd 172.16.10.255 scope global enp2s0  
        valid_lft forever preferred_lft forever  
    inet6 fe80::7ce9:724d:5d7:5ccd/64 scope link  
        valid_lft forever preferred_lft forever  
3: br-4c89ae5b019e: <BROADCAST,MULTICAST> mtu 1500 qdisc noqueue state DOWN group default  
    link/ether 02:42:9d:c8:14:a4 brd ff:ff:ff:ff:ff:ff  
4: docker0: <BROADCAST,MULTICAST> mtu 1500 qdisc noqueue state DOWN group default  
    link/ether 02:42:59:92:0d:5d brd ff:ff:ff:ff:ff:ff  
student@CSELAB:~$ sudo sysctl -w net.ipv4.conf.all.accept_redirects=0  
[sudo] password for student:  
net.ipv4.conf.all.accept_redirects = 0  
student@CSELAB:~$
```

At H_b:

```
student@CSELAB:~$ ifconfig  
enp2s0    Link encap:Ethernet  HWaddr b8:ae:ed:a5:a5:d9  
          inet addr:172.16.11.2  Bcast:172.16.11.255  Mask:255.255.255.0  
          inet6 addr: fe80::ef3e:a634:755a:82e6/64 Scope:Link  
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1  
          RX packets:14664 errors:0 dropped:0 overruns:0 frame:0  
          TX packets:5576 errors:0 dropped:0 overruns:0 carrier:0  
          collisions:0 txqueuelen:1000  
          RX bytes:11165326 (11.1 MB)  TX bytes:811374 (811.3 KB)  
  
lo        Link encap:Local Loopback  
          inet addr:127.0.0.1  Mask:255.0.0.0  
          inet6 addr: ::1/128 Scope:Host  
          UP LOOPBACK RUNNING  MTU:65536  Metric:1  
          RX packets:1320 errors:0 dropped:0 overruns:0 frame:0  
          TX packets:1320 errors:0 dropped:0 overruns:0 carrier:0  
          collisions:0 txqueuelen:1  
          RX bytes:141788 (141.7 KB)  TX bytes:141788 (141.7 KB)  
  
student@CSELAB:~$ sudo sysctl -w net.ipv4.conf.all.accept_redirects=0  
[sudo] password for student:  
net.ipv4.conf.all.accept_redirects = 0  
student@CSELAB:~$
```

STEP 2: Converting two systems into routers R₁ and R₂

At R₁:



Terminal output for R1 configuration:

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether b8:ae:ed:a5:a5:ff brd ff:ff:ff:ff:ff:ff
    inet 172.16.10.2/24 brd 172.16.10.255 scope global enp2s0
        valid_lft forever preferred_lft forever
    inet6 fe80::35bb:8c3:281:5c15/64 scope link
        valid_lft forever preferred_lft forever

student@CSELAB:~$ sudo systemctl -w net.ipv4.conf.all.accept_redirects=0
[sudo] password for student:
net.ipv4.conf.all.accept_redirects = 0
student@CSELAB:~$ sudo systemctl -w net.ipv4.conf.all.send_redirects=0
net.ipv4.conf.all.send_redirects = 0
student@CSELAB:~$ systemctl net.ipv4.ip_forward
net.ipv4.ip_forward = 0
student@CSELAB:~$ sudo systemctl -w net.ipv4.ip_forward=1
net.ipv4.ip_forward = 1
student@CSELAB:~$
```

At R1:

```
$ sudo systemctl -w net.ipv4.ip_forward=1
```

At R2:

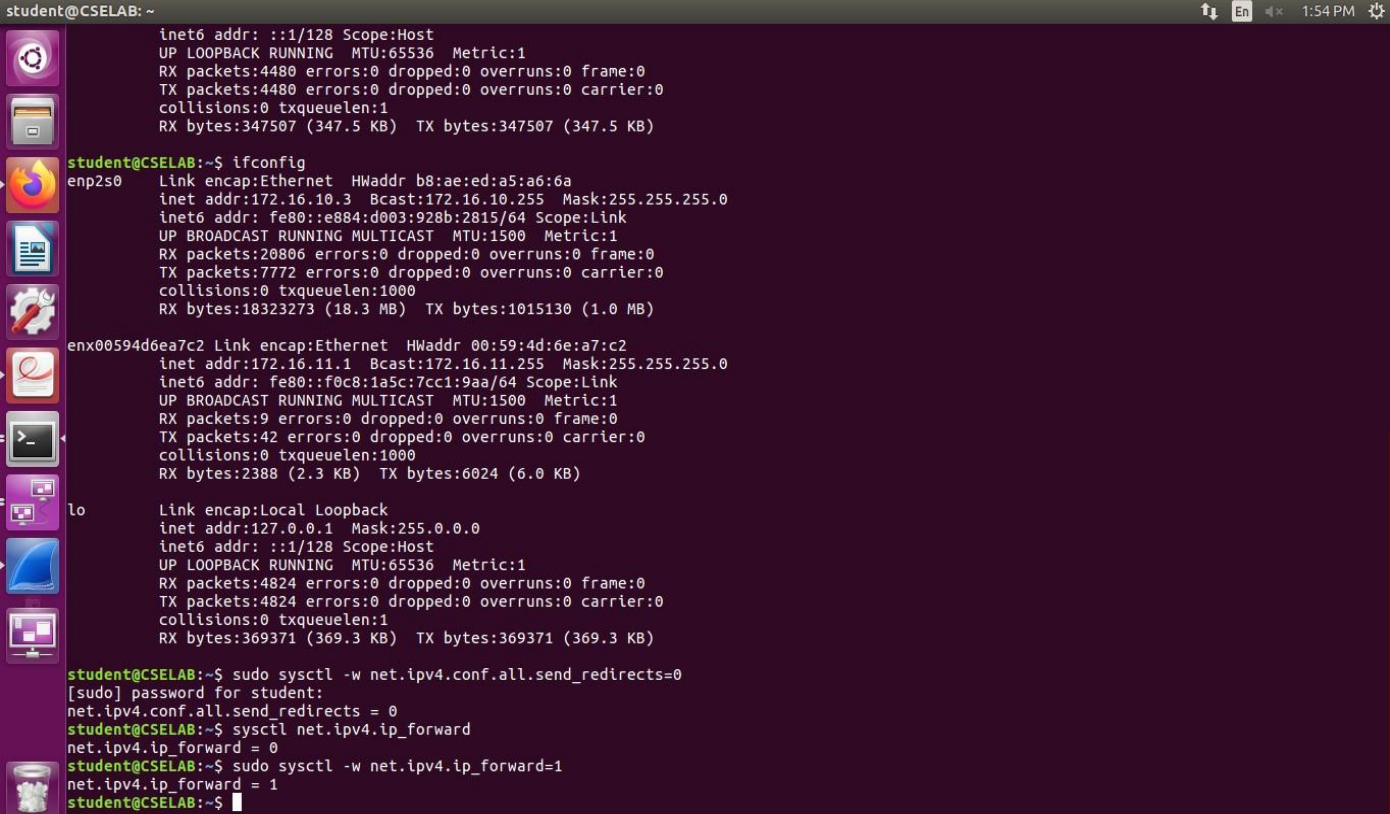
```
$ sudo systemctl -w net.ipv4.ip_forward=1
```

student@student-H81H3-I:~\$ sudo systemctl -w net.ipv4.ip_forward=1
net.ipv4.ip_forward = 1

Step 3: Verify the Local Network connection using ping command.

Initially test the connection of systems within the same network

At R₂:



Terminal output for R2 configuration:

```
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:4480 errors:0 dropped:0 overruns:0 frame:0
TX packets:4480 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:347507 (347.5 KB) TX bytes:347507 (347.5 KB)

student@CSELAB:~$ ifconfig
enp2s0  Link encap:Ethernet HWaddr b8:ae:ed:a5:a6:6a
        inet addr:172.16.10.3 Bcast:172.16.10.255 Mask:255.255.255.0
        inet6 addr: fe80::e884:d003:928b:2815/64 Scope:Link
        UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
        RX packets:20806 errors:0 dropped:0 overruns:0 frame:0
        TX packets:7772 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:18323273 (18.3 MB) TX bytes:1015130 (1.0 MB)

enx00594d6ea7c2 Link encap:Ethernet HWaddr 00:59:4d:6e:a7:c2
        inet addr:172.16.11.1 Bcast:172.16.11.255 Mask:255.255.255.0
        inet6 addr: fe80::f0c8:1a5c:7cc1:9aa/64 Scope:Link
        UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
        RX packets:9 errors:0 dropped:0 overruns:0 frame:0
        TX packets:42 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:2388 (2.3 KB) TX bytes:6024 (6.0 KB)

lo      Link encap:Local Loopback
        inet addr:127.0.0.1 Mask:255.0.0.0
        inet6 addr: ::1/128 Scope:Host
        UP LOOPBACK RUNNING MTU:65536 Metric:1
        RX packets:4824 errors:0 dropped:0 overruns:0 frame:0
        TX packets:4824 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1
        RX bytes:369371 (369.3 KB) TX bytes:369371 (369.3 KB)

student@CSELAB:~$ sudo systemctl -w net.ipv4.conf.all.send_redirects=0
[sudo] password for student:
net.ipv4.conf.all.send_redirects = 0
student@CSELAB:~$ systemctl net.ipv4.ip_forward
net.ipv4.ip_forward = 0
student@CSELAB:~$ sudo systemctl -w net.ipv4.ip_forward=1
net.ipv4.ip_forward = 1
student@CSELAB:~$
```


STEP 3: Verifying the local network using ping command

At H_a:

```
student@CSELAB:~$ ping 172.16.10.1
PING 172.16.10.1 (172.16.10.1) 56(84) bytes of data.
64 bytes from 172.16.10.1: icmp_seq=1 ttl=64 time=0.077 ms
64 bytes from 172.16.10.1: icmp_seq=2 ttl=64 time=0.066 ms
64 bytes from 172.16.10.1: icmp_seq=3 ttl=64 time=0.073 ms
64 bytes from 172.16.10.1: icmp_seq=4 ttl=64 time=0.072 ms
64 bytes from 172.16.10.1: icmp_seq=5 ttl=64 time=0.065 ms
^C
--- 172.16.10.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 3998ms
rtt min/avg/max/mdev = 0.065/0.070/0.077/0.010 ms
student@CSELAB:~$
```

At H_b:

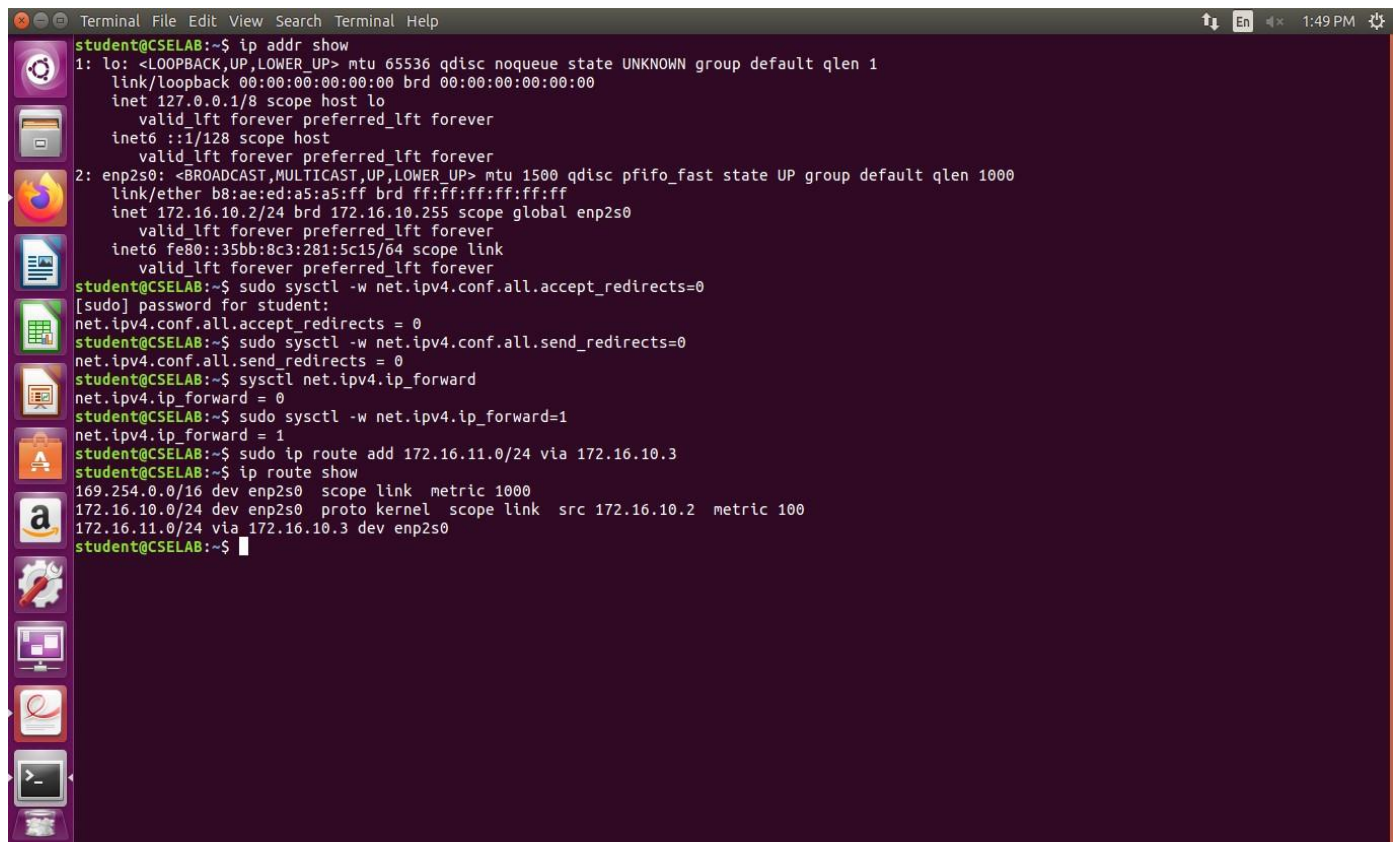
```
student@CSELAB:~$ ping 172.16.11.1
PING 172.16.11.1 (172.16.11.1) 56(84) bytes of data.
64 bytes from 172.16.11.1: icmp_seq=1 ttl=64 time=0.439 ms
64 bytes from 172.16.11.1: icmp_seq=2 ttl=64 time=0.331 ms
64 bytes from 172.16.11.1: icmp_seq=3 ttl=64 time=0.351 ms
64 bytes from 172.16.11.1: icmp_seq=4 ttl=64 time=0.330 ms
64 bytes from 172.16.11.1: icmp_seq=5 ttl=64 time=0.347 ms
64 bytes from 172.16.11.1: icmp_seq=6 ttl=64 time=0.357 ms
^C
--- 172.16.11.1 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 4997ms
rtt min/avg/max/mdev = 0.330/0.359/0.439/0.038 ms
student@CSELAB:~$
```

STEP 4: Inserting routing table entries to direct ipv4 packets

At H_a:

```
student@CSELAB:~$ sudo ip route add 172.16.11.0/24 via 172.16.10.2
student@CSELAB:~$ ip route show
169.254.0.0/16 dev enp2s0 scope link metric 1000
172.16.10.0/24 dev enp2s0 proto kernel scope link src 172.16.10.1 metric 100
172.16.11.0/24 via 172.16.10.2 dev enp2s0
student@CSELAB:~$
```

At R₁:

A terminal window titled 'Terminal' with a menu bar (File, Edit, View, Search, Terminal, Help) and a status bar (En, 1:49 PM). The terminal shows the following commands and output:

```
student@CSELAB:~$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
   inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
   inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: enp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
   link/ether b8:ae:ed:a5:a5:ff brd ff:ff:ff:ff:ff:ff
   inet 172.16.10.2/24 brd 172.16.10.255 scope global enp2s0
       valid_lft forever preferred_lft forever
   inet6 fe80::35bb:8c3:281:5c15/64 scope link
       valid_lft forever preferred_lft forever
student@CSELAB:~$ sudo sysctl -w net.ipv4.conf.all.accept_redirects=0
[sudo] password for student:
net.ipv4.conf.all.accept_redirects = 0
student@CSELAB:~$ sudo sysctl -w net.ipv4.conf.all.send_redirects=0
net.ipv4.conf.all.send_redirects = 0
student@CSELAB:~$ sysctl net.ipv4.ip_forward
net.ipv4.ip_forward = 0
student@CSELAB:~$ sudo sysctl -w net.ipv4.ip_forward=1
net.ipv4.ip_forward = 1
student@CSELAB:~$ sudo ip route add 172.16.11.0/24 via 172.16.10.3
student@CSELAB:~$ ip route show
169.254.0.0/16 dev enp2s0 scope link metric 1000
172.16.10.0/24 dev enp2s0 proto kernel scope link src 172.16.10.2 metric 100
172.16.11.0/24 via 172.16.10.3 dev enp2s0
student@CSELAB:~$
```

At H_b:

```
student@CSELAB:~$ sudo ip route add 172.16.10.0/24 via 172.16.11.1
student@CSELAB:~$ ip route show
169.254.0.0/16 dev enp2s0 scope link metric 1000
172.16.10.0/24 via 172.16.11.1 dev enp2s0
172.16.11.0/24 dev enp2s0 proto kernel scope link src 172.16.11.2 metric 100
student@CSELAB:~$
```


STEP 5: Capturing packets on Wireshark

Pinging H_b from H_a:

```
student@CSELAB:~$ ping 172.16.11.2
PING 172.16.11.2 (172.16.11.2) 56(84) bytes of data.
From 172.16.10.2: icmp_seq=1 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=1 ttl=63 time=1.32 ms
From 172.16.10.2: icmp_seq=2 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=2 ttl=63 time=0.761 ms
From 172.16.10.2: icmp_seq=3 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=3 ttl=63 time=0.670 ms
From 172.16.10.2: icmp_seq=4 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=4 ttl=63 time=0.774 ms
From 172.16.10.2: icmp_seq=5 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=5 ttl=63 time=0.831 ms
From 172.16.10.2: icmp_seq=6 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=6 ttl=63 time=0.763 ms
64 bytes from 172.16.11.2: icmp_seq=7 ttl=63 time=0.768 ms
From 172.16.10.2: icmp_seq=8 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=8 ttl=63 time=0.678 ms
64 bytes from 172.16.11.2: icmp_seq=9 ttl=63 time=0.615 ms
64 bytes from 172.16.11.2: icmp_seq=10 ttl=63 time=0.688 ms
From 172.16.10.2: icmp_seq=11 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=11 ttl=63 time=0.724 ms
64 bytes from 172.16.11.2: icmp_seq=12 ttl=63 time=0.672 ms
64 bytes from 172.16.11.2: icmp_seq=13 ttl=63 time=0.671 ms
64 bytes from 172.16.11.2: icmp_seq=14 ttl=63 time=0.723 ms
64 bytes from 172.16.11.2: icmp_seq=15 ttl=63 time=0.593 ms
64 bytes from 172.16.11.2: icmp_seq=16 ttl=63 time=0.656 ms
From 172.16.10.2: icmp_seq=17 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=17 ttl=63 time=0.493 ms
^C
--- 172.16.11.2 ping statistics ---
17 packets transmitted, 17 received, 0% packet loss, time 15999ms
rtt min/avg/max/mdev = 0.493/0.729/1.326/0.171 ms
student@CSELAB:~$
```

Capturing packets at H_a:

The image shows the Wireshark network protocol analyzer interface. The top menu bar includes File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Wireless, Tools, and Help. The toolbar contains various icons for file operations, packet selection, and analysis. The main display area is divided into three panes:

- Packet List:** A table showing captured packets. The first column is 'No.', followed by 'Time', 'Source', 'Destination', 'Protocol', 'Length', and 'Info'. The list shows 23 packets, all of which are ICMP Echo (ping) requests or Redirects from 172.16.10.1 to 172.16.11.2.
- Packet Details:** A pane showing the hierarchical structure of the selected packet (No. 3). It includes the Ethernet II header, Internet Protocol Version 4 header, and Internet Control Message Protocol (ICMP) header. The ICMP header shows it's an Echo (ping) request with ID 0x0f01, sequence 1, and TTL 64.
- Packet Bytes:** A pane showing the raw hexadecimal and ASCII data of the selected packet. It starts with the Ethernet II frame header and the ICMP Echo request data.

At the bottom of the interface, a status bar indicates 'Packets: 52 · Displayed: 43 (82.7%)' and 'Profile: Default'.

Capturing packets at R₁:

Capturing from enp2s0 (icmp)

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=1/256, ttl=64 (no response found!)
2	0.000000048	172.16.10.1	172.16.11.2	ICMP	126	Redirect (Redirect for host)
3	0.000000096	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=1/256, ttl=63 (no response found!)
4	1.001366221	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=2/512, ttl=64 (no response found!)
5	1.001403463	172.16.10.1	172.16.11.2	ICMP	126	Redirect (Redirect for host)
6	1.001409343	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=2/512, ttl=63 (no response found!)
7	2.000298212	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=3/768, ttl=64 (no response found!)
8	2.000317565	172.16.10.1	172.16.11.2	ICMP	126	Redirect (Redirect for host)
9	2.000319916	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=3/768, ttl=63 (no response found!)
10	2.999301551	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=4/1024, ttl=64 (no response found!)
11	2.999322096	172.16.10.1	172.16.11.2	ICMP	126	Redirect (Redirect for host)
12	3.99922096	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=4/1024, ttl=63 (no response found!)
13	3.999280995	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=5/1280, ttl=64 (no response found!)
14	3.999298298	172.16.10.1	172.16.11.2	ICMP	126	Redirect (Redirect for host)
15	3.999309739	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=5/1280, ttl=63 (no response found!)
16	4.999295969	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=6/1536, ttl=64 (no response found!)
17	4.999314305	172.16.10.1	172.16.11.2	ICMP	126	Redirect (Redirect for host)
18	4.999316615	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=6/1536, ttl=63 (no response found!)
19	5.999237467	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=7/1792, ttl=64 (no response found!)

Identification: 0x7b24 (31524)
Flags: 0x4000, Don't fragment
Time to live: 64
Protocol: ICMP (1)
Header checksum: 0x5261 [validation disabled]
[Header checksum status: Unverified]
Source: 172.16.10.1
Destination: 172.16.11.2

Internet Control Message Protocol
Type: 8 (Echo (ping) request)
Code: 0
Checksum: 0x4d99 [correct]
[Checksum Status: Good]
Identifier (BE): 3841 (0x0f01)
Identifier (LE): 271 (0x010f)
Sequence number (BE): 1 (0x0001)
Sequence number (LE): 256 (0x0100)
[No response seen]
Timestamp from icmp data: Mar 30, 2021 13:53:32.000000000 IST
[Timestamp from icmp data (relative): 0.510320749 seconds]
Data (48 bytes)

0000 b8 ae ed a5 a5 ff b8 ae ed a5 a5 24 08 00 45 00j.....E
0010 00 54 7b 24 40 00 40 01 52 61 ac 10 0a 01 ac 10 ..T(\$@? Ra.....
0020 00 02 08 00 4d 99 0f 01 00 01 04 e0 62 60 00 00M.....b.....

enp2s0: <live capture in progress> Packets: 43 · Displayed: 43 (100.0%) Profile: Default

Capturing packets at R₂:

Capturing from enp2s0 (icmp)

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
18	7.999447536	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=9/2304, ttl=63 (request in 17)
19	8.999287788	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=10/2560, ttl=63 (reply in 20)
20	8.999574237	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=10/2560, ttl=63 (request in 19)
21	9.999229587	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=11/2816, ttl=63 (reply in 22)
22	9.999597040	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=11/2816, ttl=63 (request in 21)
23	10.999299834	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=12/3072, ttl=63 (reply in 24)
24	10.999603244	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=12/3072, ttl=63 (request in 23)
25	11.999254829	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=13/3328, ttl=63 (reply in 26)
26	11.999595210	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=13/3328, ttl=63 (request in 25)
27	12.999384366	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=14/3584, ttl=63 (reply in 28)
28	12.999696409	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=14/3584, ttl=63 (request in 27)
29	13.999247657	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=15/3840, ttl=63 (reply in 30)
30	13.999559514	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=15/3840, ttl=63 (request in 29)
31	14.999321701	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=16/4096, ttl=63 (reply in 32)
32	14.999648545	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=16/4096, ttl=63 (request in 31)
33	15.999309661	172.16.10.1	172.16.11.2	ICMP	98	Echo (ping) request id=0x0f01, seq=17/4352, ttl=63 (reply in 34)
34	15.999564868	172.16.11.2	172.16.10.1	ICMP	98	Echo (ping) reply id=0x0f01, seq=17/4352, ttl=63 (request in 33)

Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
Ethernet II, Src: Elitegro_a5:a5:ff (b8:ae:ed:a5:a5:ff), Dst: Elitegro_a5:a6:6a (b8:ae:ed:a5:a6:6a)
Internet Protocol Version 4, Src: 172.16.10.1, Dst: 172.16.11.2
Internet Control Message Protocol

0000 b8 ae ed a5 a6 6a b8 ae ed a5 a5 ff 00 00 45 00j.....E
0010 00 54 7b 24 40 00 3f 01 53 61 ac 10 0a 01 ac 10 ..T(\$@? Sa.....
0020 00 02 08 00 4d 99 0f 01 00 01 04 e0 62 60 00 00M.....b.....
0030 00 00 73 51 02 00 00 00 00 00 10 11 12 13 14 15sQ.....
0040 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25!#\$%&'()*+,-./012345
0050 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 67
0060 36 37

enp2s0: <live capture in progress> Packets: 34 · Displayed: 34 (100.0%) Profile: Default

Capturing packets at H_b:

The image shows a Wireshark packet capture window. The top menu bar includes File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Wireless, Tools, and Help. The toolbar contains various icons for packet capture and analysis. The packet list pane on the left shows a list of 15 ICMP Echo (ping) requests and replies. The packet details pane on the right shows the details of the selected packet (No. 1, Time 0.000000000, Source 172.16.10.1, Destination 172.16.11.2, Protocol ICMP, Length 64). The packet bytes pane at the bottom shows the raw data of the selected packet in hexadecimal and ASCII.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=1/256, ttl=62 ...
2	0.000041170	172.16.11.2	172.16.10.1	ICMP	64	Echo (ping) reply id=0xf01, seq=1/256, ttl=64 ...
3	1.001141152	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=2/512, ttl=62 ...
4	1.001174163	172.16.11.2	172.16.10.1	ICMP	64	Echo (ping) reply id=0xf01, seq=2/512, ttl=64 ...
5	2.000031742	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=3/768, ttl=62 ...
6	2.000064798	172.16.11.2	172.16.10.1	ICMP	64	Echo (ping) reply id=0xf01, seq=3/768, ttl=64 ...
7	2.999077001	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=4/1024, ttl=62 ...
8	2.999105246	172.16.11.2	172.16.10.1	ICMP	64	Echo (ping) reply id=0xf01, seq=4/1024, ttl=64 ...
9	3.999147549	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=5/1280, ttl=62 ...
10	3.999169088	172.16.11.2	172.16.10.1	ICMP	64	Echo (ping) reply id=0xf01, seq=5/1280, ttl=64 ...
11	4.999073808	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=6/1536, ttl=62 ...
12	4.999102282	172.16.11.2	172.16.10.1	ICMP	64	Echo (ping) reply id=0xf01, seq=6/1536, ttl=64 ...
15	5.998996052	172.16.10.1	172.16.11.2	ICMP	64	Echo (ping) request id=0xf01, seq=7/1792, ttl=62 ...

Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
Ethernet II, Src: 08:59:4d:6e:a7:c2 (08:59:4d:6e:a7:c2), Dst: Elitegro_a5:a5:d9 (b8:ae:ed:a5:a5:d9)
Internet Protocol Version 4, Src: 172.16.10.1, Dst: 172.16.11.2
Internet Control Message Protocol
Type: 8 (Echo (ping) request)
Code: 0
Checksum: 0x4d99 [correct]
[Checksum Status: Good]
Identifier (BE): 3841 (0x0f01)
Identifier (LE): 271 (0x010f)
Sequence number (BE): 1 (0x0001)
Sequence number (LE): 256 (0x0100)
[Response frame: 2]
Timestamp from icmp data: Mar 30, 2021 13:53:32.000000000 IST
[Timestamp from icmp data (relative): 0.500028125 seconds]

0000 b8 ae ed a5 a5 d9 00 59 4d 6e a7 c2 08 00 45 00Y Mn...E...
0010 00 54 7b 24 40 00 3e 01 54 61 ac 10 0a 01 ac 10 ..T{S>..Ta....
0020 00 02 08 00 4d 99 0f 01 00 01 04 09 62 00 00 00 ..T.W....d....
0030 00 00 73 51 02 00 00 00 00 00 10 11 12 13 14 15 ..sQ.....
0040 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25!#\$%&'()*+,-./012345
0050 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35
0060 36 37 67

Internet Control Message Protocol (icmp), 64 bytes
Packets: 38 · Displayed: 34 (89.5%)
Profile: Default

$$H_a:$$

```
^C
--- 172.16.11.2 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5000ms
rtt min/avg/max/mdev = 0.621/0.673/0.709/0.037 ms
student@CSELAB:~$ ping 172.16.11.2
PING 172.16.11.2 (172.16.11.2) 56(84) bytes of data.
From 172.16.10.2: icmp_seq=1 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=1 ttl=63 time=0.742 ms
From 172.16.10.2: icmp_seq=2 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=2 ttl=63 time=0.616 ms
From 172.16.10.2: icmp_seq=3 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=3 ttl=63 time=0.602 ms
From 172.16.10.2: icmp_seq=4 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=4 ttl=63 time=0.724 ms
From 172.16.10.2: icmp_seq=5 Redirect Host(New nexthop: 172.16.10.3)
64 bytes from 172.16.11.2: icmp_seq=5 ttl=63 time=0.644 ms
^C
--- 172.16.11.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 3997ms
rtt min/avg/max/mdev = 0.602/0.665/0.742/0.063 ms
student@CSELAB:~$ ip neigh show
172.16.10.3 dev enp2s0 lladdr 00:59:4d:6e:9f:de STALE
172.16.10.2 dev enp2s0 lladdr b8:ae:ed:a5:a5:ff STALE
student@CSELAB:~$
```

At R_1 :

[illegible]

At R₂:

```
student@CSELAB: ~  
enp2s0 Link encap:Ethernet HWaddr b8:ae:ed:a5:a6:6a  
inet addr:172.16.10.3 Bcast:172.16.10.255 Mask:255.255.255.0  
inet6 addr: fe80::e884:d003:928b:2815/64 Scope:Link  
UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1  
RX packets:20806 errors:0 dropped:0 overruns:0 frame:0  
TX packets:7772 errors:0 dropped:0 overruns:0 carrier:0  
collisions:0 txqueuelen:1000  
RX bytes:18323273 (18.3 MB) TX bytes:1015130 (1.0 MB)  
  
enx00594d6ea7c2 Link encap:Ethernet HWaddr 00:59:4d:6e:a7:c2  
inet addr:172.16.11.1 Bcast:172.16.11.255 Mask:255.255.255.0  
inet6 addr: fe80::f0c8:1a5c:7cc1:9aa/64 Scope:Link  
UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1  
RX packets:9 errors:0 dropped:0 overruns:0 frame:0  
TX packets:42 errors:0 dropped:0 overruns:0 carrier:0  
collisions:0 txqueuelen:1000  
RX bytes:2388 (2.3 KB) TX bytes:6024 (6.0 KB)  
  
lo Link encap:Local Loopback  
inet addr:127.0.0.1 Mask:255.0.0.0  
inet6 addr: ::1/128 Scope:Host  
UP LOOPBACK RUNNING MTU:65536 Metric:1  
RX packets:4824 errors:0 dropped:0 overruns:0 frame:0  
TX packets:4824 errors:0 dropped:0 overruns:0 carrier:0  
collisions:0 txqueuelen:1  
RX bytes:369371 (369.3 KB) TX bytes:369371 (369.3 KB)  
  
student@CSELAB:~$ sudo sysctl -w net.ipv4.conf.all.send_redirects=0  
[sudo] password for student:  
net.ipv4.conf.all.send_redirects = 0  
student@CSELAB:~$ sysctl net.ipv4.ip_forward  
net.ipv4.ip_forward = 0  
student@CSELAB:~$ sudo sysctl -w net.ipv4.ip_forward=1  
net.ipv4.ip_forward = 1  
student@CSELAB:~$ ip neigh show  
172.16.10.2 dev enp2s0 lladdr b8:ae:ed:a5:a5:ff STALE  
172.16.11.2 dev enx00594d6ea7c2 lladdr b8:ae:ed:a5:a5:d9 STALE  
172.16.10.1 dev enp2s0 lladdr b8:ae:ed:a5:a5:24 STALE  
student@CSELAB:~$ ip neigh show  
172.16.10.2 dev enp2s0 lladdr b8:ae:ed:a5:a5:ff STALE  
172.16.11.2 dev enx00594d6ea7c2 lladdr b8:ae:ed:a5:a5:d9 REACHABLE  
172.16.10.1 dev enp2s0 lladdr b8:ae:ed:a5:a5:24 REACHABLE  
student@CSELAB:~$
```

Sending data from H_b to H_a using nc command

At H_b:

```
student@CSELAB: ~  
RX bytes:141788 (141.7 KB) TX bytes:141788 (141.7 KB)  
  
student@CSELAB:~$ sudo sysctl -w net.ipv4.conf.all.accept_redirects=0  
[sudo] password for student:  
net.ipv4.conf.all.accept_redirects = 0  
student@CSELAB:~$ ping 172.16.11.1  
PING 172.16.11.1 (172.16.11.1) 56(84) bytes of data.  
64 bytes from 172.16.11.1: icmp_seq=1 ttl=64 time=0.439 ms  
64 bytes from 172.16.11.1: icmp_seq=2 ttl=64 time=0.331 ms  
64 bytes from 172.16.11.1: icmp_seq=3 ttl=64 time=0.351 ms  
64 bytes from 172.16.11.1: icmp_seq=4 ttl=64 time=0.330 ms  
64 bytes from 172.16.11.1: icmp_seq=5 ttl=64 time=0.347 ms  
64 bytes from 172.16.11.1: icmp_seq=6 ttl=64 time=0.357 ms  
^C  
--- 172.16.11.1 ping statistics ---  
6 packets transmitted, 6 received, 0% packet loss, time 4997ms  
rtt min/avg/max/mdev = 0.330/0.359/0.439/0.038 ms  
student@CSELAB:~$ sudo ip route add 172.16.10.0/24 via 172.16.11.1  
student@CSELAB:~$ ip route show  
169.254.0.0/16 dev enp2s0 scope link metric 1000  
172.16.10.0/24 via 172.16.11.1 dev enp2s0  
172.16.11.0/24 dev enp2s0 proto kernel scope link src 172.16.11.2 metric 100  
student@CSELAB:~$ ip neigh show  
172.16.11.1 dev enp2s0 lladdr 00:59:4d:6e:a7:c2 REACHABLE  
student@CSELAB:~$ ip route show  
169.254.0.0/16 dev enp2s0 scope link metric 1000  
172.16.10.0/24 via 172.16.11.1 dev enp2s0  
172.16.11.0/24 dev enp2s0 proto kernel scope link src 172.16.11.2 metric 100  
student@CSELAB:~$ nc -l 1002  
nc: Permission denied  
student@CSELAB:~$ sudo nc -l 1002  
[sudo] password for student:  
abcdef  
student@CSELAB:~$ sudo nc -l 1002  
PES1UG19CS467  
PES1UG19CS468  
PES1UG19CS494  
PES1UG19CS469  
^C  
student@CSELAB:~$ sudo nc -l 1002  
PES1UG19CS467  
student@CSELAB:~$ ^C  
student@CSELAB:~$
```

At H_a:

```
student@CSELAB: ~  
64 bytes from 172.16.11.2: icmp_seq=24 ttl=63 time=0.595 ms  
64 bytes from 172.16.11.2: icmp_seq=25 ttl=63 time=0.714 ms  
64 bytes from 172.16.11.2: icmp_seq=26 ttl=63 time=0.719 ms  
64 bytes from 172.16.11.2: icmp_seq=27 ttl=63 time=0.686 ms  
64 bytes from 172.16.11.2: icmp_seq=28 ttl=63 time=0.688 ms  
64 bytes from 172.16.11.2: icmp_seq=29 ttl=63 time=0.732 ms  
64 bytes from 172.16.11.2: icmp_seq=30 ttl=63 time=0.741 ms  
64 bytes from 172.16.11.2: icmp_seq=31 ttl=63 time=0.718 ms  
64 bytes from 172.16.11.2: icmp_seq=32 ttl=63 time=0.716 ms  
64 bytes from 172.16.11.2: icmp_seq=33 ttl=63 time=0.701 ms  
64 bytes from 172.16.11.2: icmp_seq=34 ttl=63 time=0.730 ms  
64 bytes from 172.16.11.2: icmp_seq=35 ttl=63 time=0.756 ms  
64 bytes from 172.16.11.2: icmp_seq=36 ttl=63 time=0.597 ms  
64 bytes from 172.16.11.2: icmp_seq=37 ttl=63 time=0.596 ms  
64 bytes from 172.16.11.2: icmp_seq=38 ttl=63 time=0.609 ms  
64 bytes from 172.16.11.2: icmp_seq=39 ttl=63 time=0.780 ms  
64 bytes from 172.16.11.2: icmp_seq=40 ttl=63 time=0.675 ms  
64 bytes from 172.16.11.2: icmp_seq=41 ttl=63 time=0.615 ms  
64 bytes from 172.16.11.2: icmp_seq=42 ttl=63 time=0.694 ms  
64 bytes from 172.16.11.2: icmp_seq=43 ttl=63 time=0.612 ms  
64 bytes from 172.16.11.2: icmp_seq=44 ttl=63 time=0.701 ms  
64 bytes from 172.16.11.2: icmp_seq=45 ttl=63 time=0.651 ms  
64 bytes from 172.16.11.2: icmp_seq=46 ttl=63 time=0.735 ms  
64 bytes from 172.16.11.2: icmp_seq=47 ttl=63 time=0.700 ms  
^C  
--- 172.16.11.2 ping statistics ---  
47 packets transmitted, 47 received, 0% packet loss, time 45999ms  
rtt min/avg/max/mdev = 0.595/0.708/0.783/0.053 ms  
student@CSELAB:~$ cat xyz.txt|nc 172.16.11.2 1002  
cat: xyz.txt: No such file or directory  
abcdef  
student@CSELAB:~$ cat xyz.txt|nc 172.16.11.2 1005  
cat: xyz.txt: No such file or directory  
student@CSELAB:~$ gedit xyz.txt  
student@CSELAB:~$ cat xyz.txt|nc 172.16.11.2 1002  
student@CSELAB:~$ gedit xyz.txt  
student@CSELAB:~$ cat xyz.txt|nc 172.16.11.2 1002  
student@CSELAB:~$ cat xyzw.txt|nc 172.16.11.2 1002  
cat: xyzw.txt: No such file or directory  
student@CSELAB:~$ cat xyz.txt|nc 172.16.11.2 1002  
PES1UG19CS467  
student@CSELAB:~$ gedit xyz.txt  
student@CSELAB:~$
```