

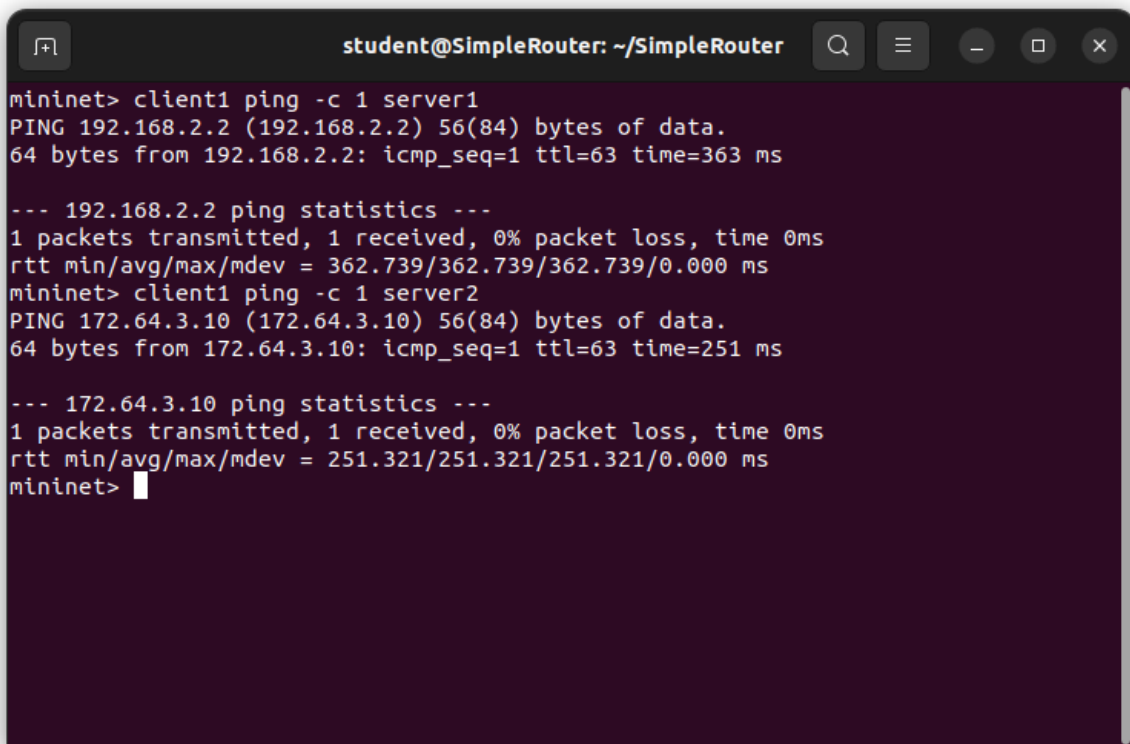
Project 4

Simple Router (layer 3)

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Commands

- ping



```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 ping -c 1 server1
PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.
64 bytes from 192.168.2.2: icmp_seq=1 ttl=63 time=363 ms

--- 192.168.2.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 362.739/362.739/362.739/0.000 ms
mininet> client1 ping -c 1 server2
PING 172.64.3.10 (172.64.3.10) 56(84) bytes of data.
64 bytes from 172.64.3.10: icmp_seq=1 ttl=63 time=251 ms

--- 172.64.3.10 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 251.321/251.321/251.321/0.000 ms
mininet> 
```

- traceroute

```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 traceroute server1
traceroute to 192.168.2.2 (192.168.2.2), 30 hops max, 60 byte packets
 1 _gateway (10.0.1.1) 123.410 ms 122.279 ms 121.678 ms
 2 * * *
 3 * * *
 4 * 192.168.2.2 (192.168.2.2) 278.472 ms 278.418 ms
mininet> client1 traceroute server2
traceroute to 172.64.3.10 (172.64.3.10), 30 hops max, 60 byte packets
 1 _gateway (10.0.1.1) 27.118 ms * *
 2 * * *
 3 * * *
 4 * * *
 5 * 172.64.3.10 (172.64.3.10) 580.947 ms 559.495 ms
mininet>
```

- wget

```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 wget server1
--2025-06-19 21:12:00-- http://192.168.2.2/
Connecting to 192.168.2.2:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 161 [text/html]
Saving to: 'index.html'

index.html      100%[=====>]      161  ---KB/s   in 0s

2025-06-19 21:12:01 (43.7 MB/s) - 'index.html' saved [161/161]

mininet> client1 wget server2
--2025-06-19 21:12:04-- http://172.64.3.10/
Connecting to 172.64.3.10:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 161 [text/html]
Saving to: 'index.html.1'

index.html.1    100%[=====>]      161  ---KB/s   in 0s

2025-06-19 21:12:05 (42.4 MB/s) - 'index.html.1' saved [161/161]

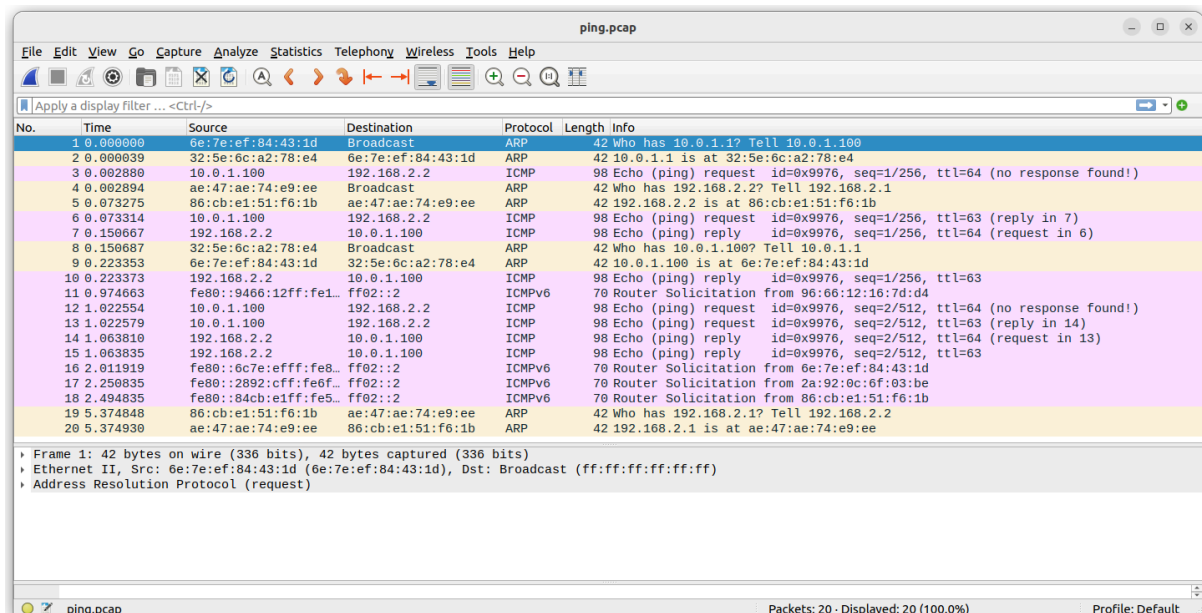
mininet> █
```

ARP

```
student@SimpleRouter: ~/SimpleRouter

mininet> client1 ping -c 2 server1
PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.
64 bytes from 192.168.2.2: icmp_seq=1 ttl=63 time=285 ms
64 bytes from 192.168.2.2: icmp_seq=2 ttl=63 time=125 ms

--- 192.168.2.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1003ms
rtt min/avg/max/mdev = 124.777/204.756/284.735/79.979 ms
mininet>
```



The image shows a Wireshark packet capture of ping traffic. The capture is filtered for 'ping.pcap'. The packet list shows 20 packets, including ARP requests and replies, and ICMP Echo (ping) requests and replies. The packet details pane shows the selected packet (No. 1) as an Ethernet II frame from 6e:7e:ef:84:43:1d to ff:ff:ff:ff:ff:ff (Broadcast), containing an ARP request.

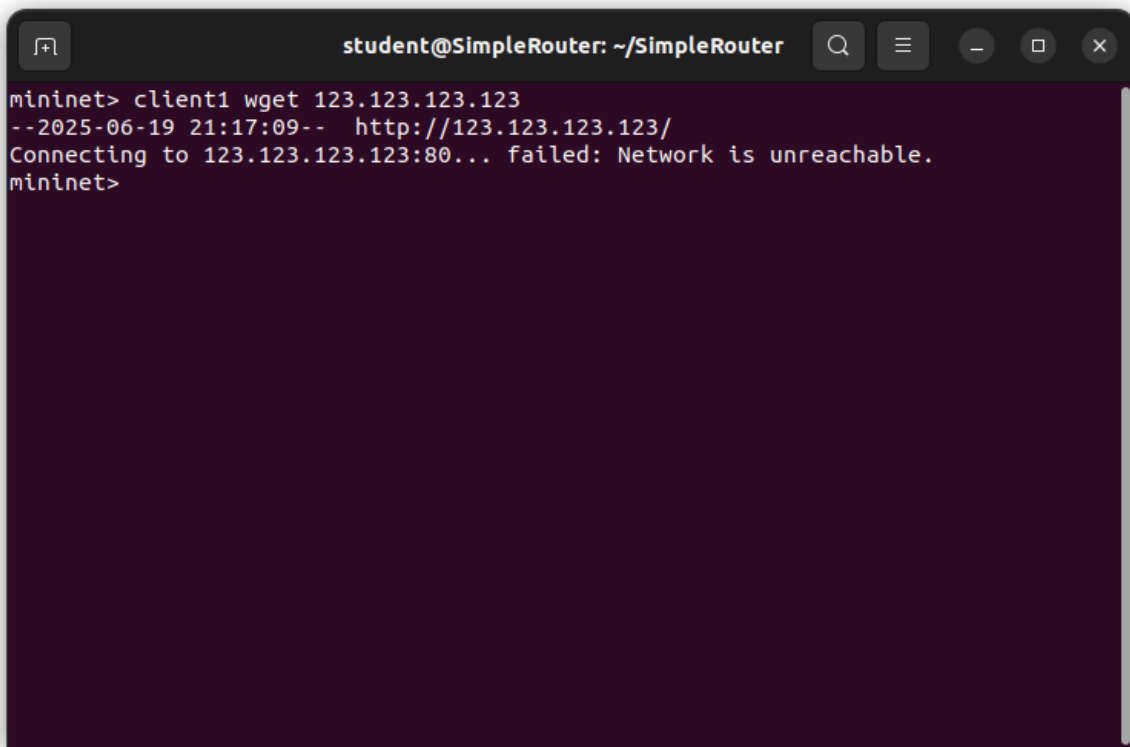
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	6e:7e:ef:84:43:1d	Broadcast	ARP	42	Who has 10.0.1.1? Tell 10.0.1.100
2	0.000039	32:5e:6c:a2:78:e4	6e:7e:ef:84:43:1d	ARP	42	10.0.1.1 is at 32:5e:6c:a2:78:e4
3	0.002880	10.0.1.100	192.168.2.2	ICMP	98	Echo (ping) request id=0x9976, seq=1/256, ttl=64 (no response found!)
4	0.002894	ae:47:ae:74:e9:ee	Broadcast	ARP	42	Who has 192.168.2.2? Tell 192.168.2.1
5	0.073275	86:cb:e1:51:f6:1b	ae:47:ae:74:e9:ee	ARP	42	192.168.2.2 is at 86:cb:e1:51:f6:1b
6	0.073314	10.0.1.100	192.168.2.2	ICMP	98	Echo (ping) request id=0x9976, seq=1/256, ttl=63 (reply in 7)
7	0.150667	192.168.2.2	10.0.1.100	ICMP	98	Echo (ping) reply id=0x9976, seq=1/256, ttl=64 (request in 6)
8	0.150687	32:5e:6c:a2:78:e4	Broadcast	ARP	42	Who has 10.0.1.100? Tell 10.0.1.1
9	0.223353	6e:7e:ef:84:43:1d	32:5e:6c:a2:78:e4	ARP	42	10.0.1.100 is at 6e:7e:ef:84:43:1d
10	0.223373	192.168.2.2	10.0.1.100	ICMP	98	Echo (ping) reply id=0x9976, seq=1/256, ttl=63
11	0.974663	fe80::9466:12ff:fe1...	ff02::2	ICMPv6	70	Router Solicitation from 96:66:12:16:7d:d4
12	1.022554	10.0.1.100	192.168.2.2	ICMP	98	Echo (ping) request id=0x9976, seq=2/512, ttl=64 (no response found!)
13	1.022579	10.0.1.100	192.168.2.2	ICMP	98	Echo (ping) request id=0x9976, seq=2/512, ttl=63 (reply in 14)
14	1.063810	192.168.2.2	10.0.1.100	ICMP	98	Echo (ping) reply id=0x9976, seq=2/512, ttl=64 (request in 13)
15	1.063835	192.168.2.2	10.0.1.100	ICMP	98	Echo (ping) reply id=0x9976, seq=2/512, ttl=63
16	2.011919	fe80::6c7e:efff:fe8...	ff02::2	ICMPv6	70	Router Solicitation from 6e:7e:ef:84:43:1d
17	2.250835	fe80::2892:cff:fe0f...	ff02::2	ICMPv6	70	Router Solicitation from 2a:92:0c:0f:03:be
18	2.494835	fe80::84cb:e1ff:fe5...	ff02::2	ICMPv6	70	Router Solicitation from 86:cb:e1:51:f6:1b
19	5.374848	86:cb:e1:51:f6:1b	ae:47:ae:74:e9:ee	ARP	42	Who has 192.168.2.1? Tell 192.168.2.2
20	5.374930	ae:47:ae:74:e9:ee	86:cb:e1:51:f6:1b	ARP	42	192.168.2.1 is at ae:47:ae:74:e9:ee

From the two pings issued with the command `client1 ping -c 2 server1` you can confirm that the appropriate ARP requests and replies are exchanged, and that

the ARP cache is functioning correctly.

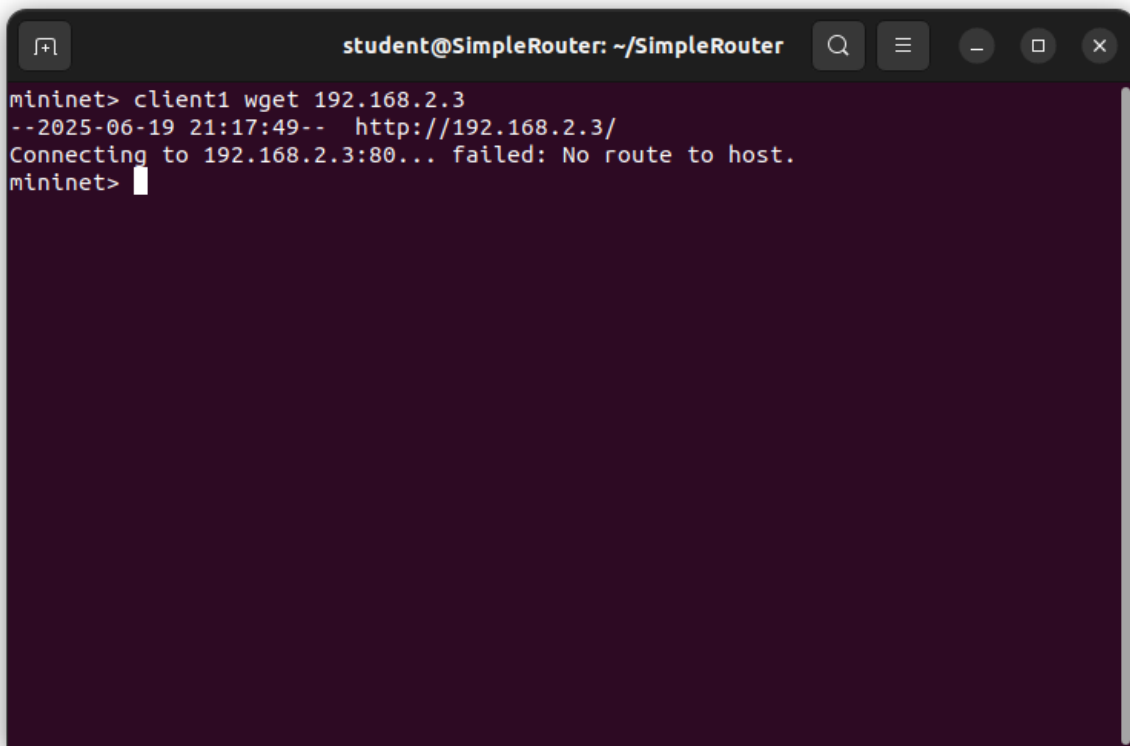
ICMP

- Network unreachable



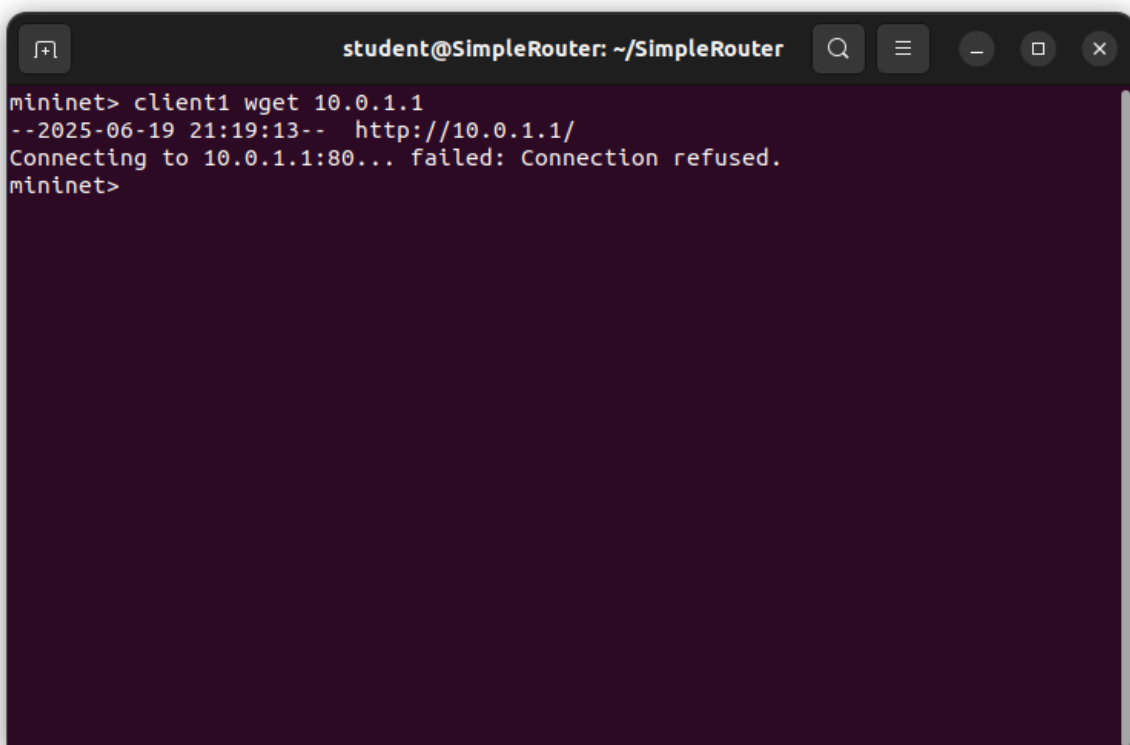
```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 wget 123.123.123.123
--2025-06-19 21:17:09-- http://123.123.123.123/
Connecting to 123.123.123.123:80... failed: Network is unreachable.
mininet>
```

- Host unreachable



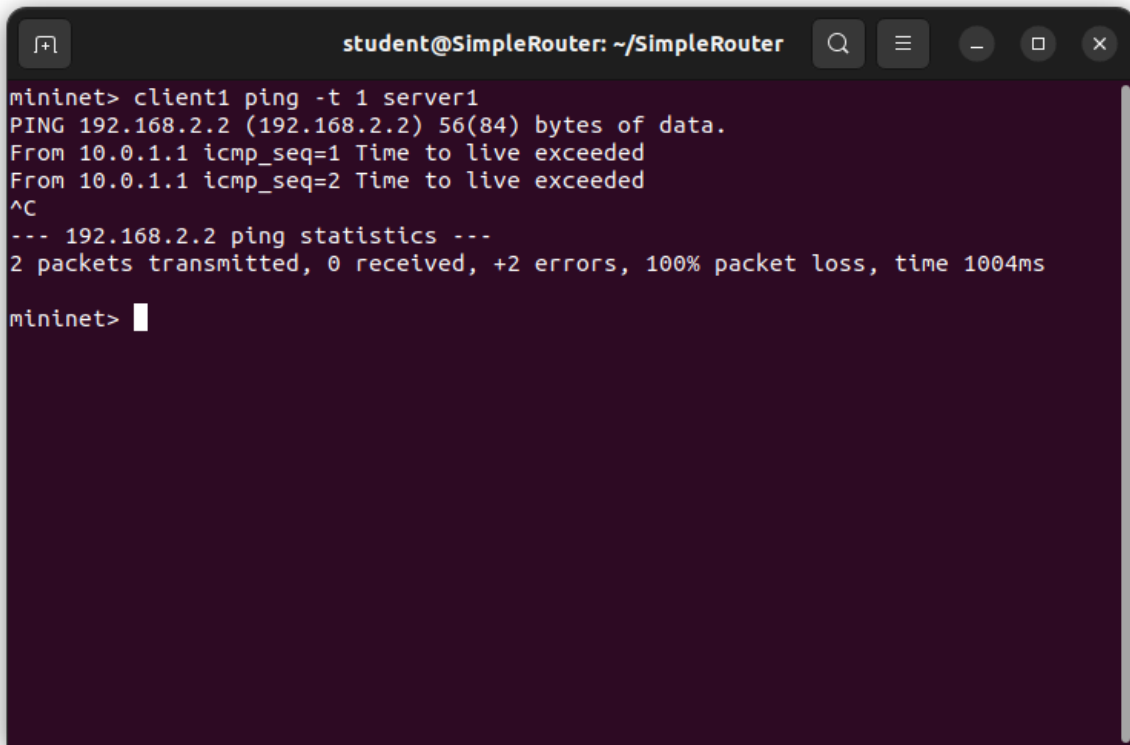
```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 wget 192.168.2.3
--2025-06-19 21:17:49--  http://192.168.2.3/
Connecting to 192.168.2.3:80... failed: No route to host.
mininet>
```

- Port unreachable



```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 wget 10.0.1.1
--2025-06-19 21:19:13--  http://10.0.1.1/
Connecting to 10.0.1.1:80... failed: Connection refused.
mininet>
```

- TTL exceeded



```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 ping -t 1 server1
PING 192.168.2.2 (192.168.2.2) 56(84) bytes of data.
From 10.0.1.1 icmp_seq=1 Time to live exceeded
From 10.0.1.1 icmp_seq=2 Time to live exceeded
^C
--- 192.168.2.2 ping statistics ---
2 packets transmitted, 0 received, +2 errors, 100% packet loss, time 1004ms

mininet> 
```

IP

```
student@SimpleRouter: ~/SimpleRouter

mininet> client1 wget server1
--2025-06-19 21:35:16-- http://192.168.2.2/
Connecting to 192.168.2.2:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 161 [text/html]
Saving to: 'index.html.4'

index.html.4      100%[=====>]      161  ---KB/s   in 0s

2025-06-19 21:35:16 (45.0 MB/s) - 'index.html.4' saved [161/161]

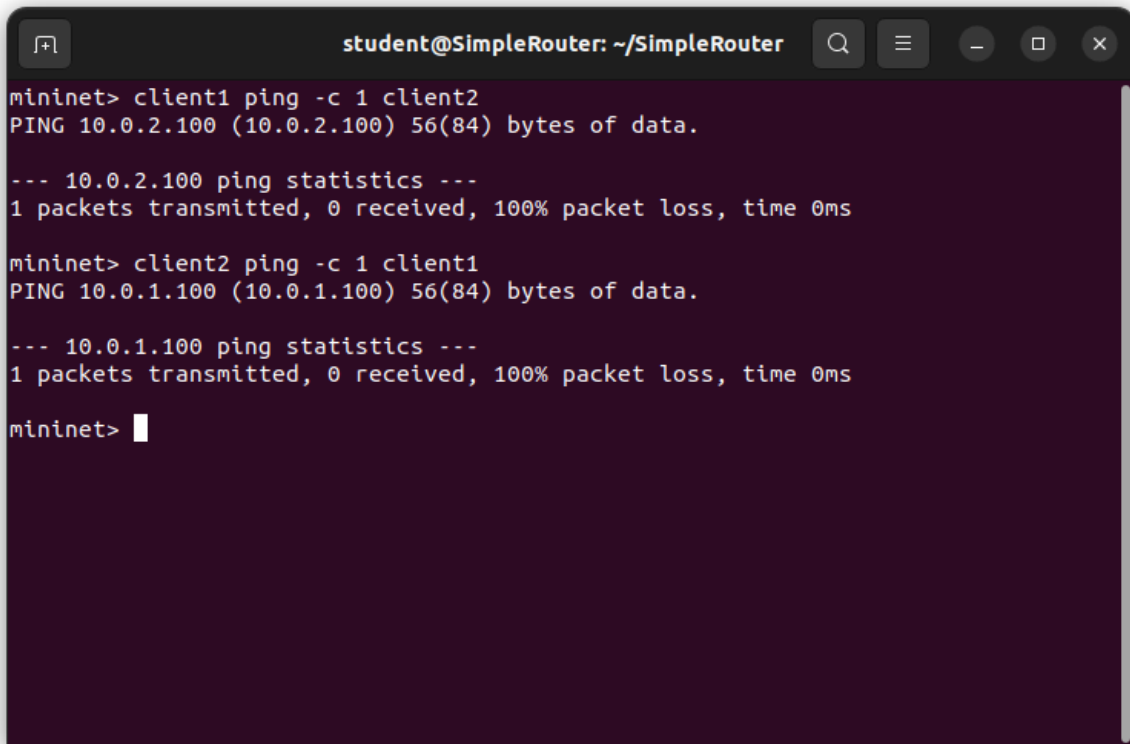
mininet> 
```

wget.pcap					
No.	Time	Source	Destination	Protocol	Length Info
1	0.000000	fe80::6c77:a7ff:fe9...	ff02::2	ICMPv6	70 Router Solicitation from 6e:77:a7:98:2d:01
2	0.290259	fe80::4889:4eff:fe9...	ff02::2	ICMPv6	70 Router Solicitation from 42:89:4e:99:72:02
3	0.291345	fe80::8027:29ff:fea...	ff02::2	ICMPv6	70 Router Solicitation from 82:27:29:a2:a3:95
4	0.531198	fe80::286e:e0ff:fe7...	ff02::2	ICMPv6	70 Router Solicitation from 2a:66:e0:7c:ec:b4
5	7.725765	fe80::4889:4eff:fe9...	ff02::2	ICMPv6	70 Router Solicitation from 42:89:4e:99:72:02
6	8.740129	fe80::286e:e0ff:fe7...	ff02::2	ICMPv6	70 Router Solicitation from 2a:66:e0:7c:ec:b4
7	8.746743	fe80::8027:29ff:fea...	ff02::2	ICMPv6	70 Router Solicitation from 82:27:29:a2:a3:95
8	8.986267	fe80::6c77:a7ff:fe9...	ff02::2	ICMPv6	70 Router Solicitation from 6e:77:a7:98:2d:01
9	11.031171	2a:66:e0:7c:ec:b4	Broadcast	ARP	42 Who has 10.0.1.1? Tell 10.0.1.100
10	11.031197	82:56:a6:6d:b3:df	2a:66:e0:7c:ec:b4	ARP	42 10.0.1.1 is at 82:56:a6:6d:b3:df
11	11.033773	10.0.1.100	192.168.2.2	TCP	74 52676 - 80 [SYN] Seq=0 Win=42340 Len=0 MSS=1460 SACK_PERM=1 TSval=255118806 TSecr=0 WS=512
12	11.033842	92:45:41:38:00:4b	Broadcast	ARP	42 Who has 192.168.2.2? Tell 192.168.2.1
13	11.104541	82:27:29:a2:a3:95	92:45:41:38:00:4b	ARP	42 192.168.2.2 is at 82:27:29:a2:a3:95
14	11.104555	10.0.1.100	192.168.2.2	TCP	74 [TCP Retransmission] 80 - 52676 [SYN, ACK] Seq=0 Win=42340 Len=0 MSS=1460 SACK_PERM=1 TSval=255118806 TSecr=0 WS=512
15	11.178091	192.168.2.2	10.0.1.100	TCP	74 80 - 52676 [SYN, ACK] Seq=0 Ack=1 Win=43440 Len=0 MSS=1460 SACK_PERM=1 TSval=3421000015 TSecr=255118806 WS=512
16	11.178126	82:56:a6:6d:b3:df	Broadcast	ARP	42 Who has 10.0.1.100? Tell 10.0.1.1
17	11.251570	2a:66:e0:7c:ec:b4	82:56:a6:6d:b3:df	ARP	42 10.0.1.100 is at 2a:66:e0:7c:ec:b4
18	11.251591	192.168.2.2	10.0.1.100	TCP	74 [TCP Retransmission] 80 - 52676 [SYN, ACK] Seq=0 Ack=1 Win=42340 Len=0 MSS=1460 SACK_PERM=1 TSval=3421000015 TSecr=255118806 WS=512
19	11.330170	10.0.1.100	192.168.2.2	TCP	66 52676 - 80 [ACK] Seq=1 Ack=1 Win=42496 Len=0 TSval=255119077 TSecr=3421000015
20	11.330490	10.0.1.100	192.168.2.2	TCP	66 [TCP Dup ACK 19#1] 80 - 52676 [ACK] Seq=1 Ack=1 Win=42496 Len=0 TSval=255119077 TSecr=3421000015
21	11.330585	10.0.1.100	192.168.2.2	HTTP	192 GET / HTTP/1.1
22	11.330994	10.0.1.100	192.168.2.2	TCP	192 [TCP Retransmission] 52676 - 80 [PSH, ACK] Seq=1 Ack=1 Win=42496 Len=120 TSval=255119077 TSecr=3421000015
23	11.407114	192.168.2.2	10.0.1.100	TCP	66 80 - 52676 [ACK] Seq=1 Ack=127 Win=43520 Len=0 TSval=3421000241 TSecr=255119077
24	11.407143	192.168.2.2	10.0.1.100	TCP	83 [TCP Dup ACK 23#1] 80 - 52676 [ACK] Seq=1 Ack=127 Win=43520 Len=0 TSval=3421000241 TSecr=255119077
25	11.407160	192.168.2.2	10.0.1.100	TCP	83 [TCP Out of Order ACK] 80 - 52676 [PSH, ACK] Seq=1 Ack=127 Win=43520 Len=17 TSval=3421000241 TSecr=255119077 [TCP segment of a reassembled PDU]
26	11.407276	192.168.2.2	10.0.1.100	TCP	83 [TCP Retransmission] 80 - 52676 [PSH, ACK] Seq=1 Ack=127 Win=43520 Len=17 TSval=3421000241 TSecr=255119077
27	11.409663	192.168.2.2	10.0.1.100	HTTP	396 HTTP/1.0 200 OK (text/html)
28	11.409693	192.168.2.2	10.0.1.100	TCP	396 [TCP Out of Order ACK] 80 - 52676 [FIN, PSH, ACK] Seq=10 Ack=127 Win=43520 Len=389 TSval=3421000242 TSecr=255119077 [Reassembly e...]
29	11.476974	10.0.1.100	192.168.2.2	TCP	66 52676 - 80 [ACK] Seq=127 Ack=10 Win=42496 Len=0 TSval=255119233 TSecr=3421000241
30	11.478996	10.0.1.100	192.168.2.2	TCP	66 [TCP Dup ACK 29#1] 52676 - 80 [ACK] Seq=127 Ack=10 Win=42496 Len=0 TSval=255119233 TSecr=3421000241
31	11.480746	10.0.1.100	192.168.2.2	TCP	66 52676 - 80 [FIN, ACK] Seq=127 Ack=349 Win=42496 Len=0 TSval=255119234 TSecr=3421000242
32	11.480760	192.168.2.2	10.0.1.100	TCP	66 [TCP Out of Order ACK] 80 - 52676 [FIN, ACK] Seq=127 Ack=349 Win=42496 Len=0 TSval=255119234 TSecr=3421000242
33	11.552195	192.168.2.2	10.0.1.100	TCP	66 80 - 52676 [ACK] Seq=349 Ack=120 Win=43520 Len=0 TSval=3421000384 TSecr=255119234
34	11.552125	192.168.2.2	10.0.1.100	TCP	66 [TCP Dup ACK 33#1] 80 - 52676 [ACK] Seq=349 Ack=120 Win=43520 Len=0 TSval=3421000384 TSecr=255119234
35	17.064450	82:27:29:a2:a3:95	92:45:41:38:00:4b	ARP	42 Who has 192.168.2.1? Tell 192.168.2.2
36	17.064511	92:45:41:38:00:4b	82:27:29:a2:a3:95	ARP	42 192.168.2.1 is at 92:45:41:38:00:4b

By running the command `client1 wget server1` you can confirm that IP connectivity is working correctly.

Firewall

- Inbound & Outbound

A terminal window titled "student@SimpleRouter: ~/SimpleRouter" with standard window controls. The terminal shows two ping commands and their results. The first command is "mininet> client1 ping -c 1 client2", which results in "PING 10.0.2.100 (10.0.2.100) 56(84) bytes of data." followed by "--- 10.0.2.100 ping statistics ---" and "1 packets transmitted, 0 received, 100% packet loss, time 0ms". The second command is "mininet> client2 ping -c 1 client1", which results in "PING 10.0.1.100 (10.0.1.100) 56(84) bytes of data." followed by "--- 10.0.1.100 ping statistics ---" and "1 packets transmitted, 0 received, 100% packet loss, time 0ms". The prompt "mininet>" is followed by a cursor.

```
student@SimpleRouter: ~/SimpleRouter
mininet> client1 ping -c 1 client2
PING 10.0.2.100 (10.0.2.100) 56(84) bytes of data.

--- 10.0.2.100 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms

mininet> client2 ping -c 1 client1
PING 10.0.1.100 (10.0.1.100) 56(84) bytes of data.

--- 10.0.1.100 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms

mininet> 
```



```
student@SimpleRouter: ~/SimpleRouter/router
student@SimpleRouter:~/SimpleRouter/router$ ./sr
Using VNS sr stub code revised 2009-10-14 (rev 0.20)
Loading routing table from server, clear local routing table.
Loading routing table
-----
Destination      Gateway          Mask             Iface
10.0.1.100        10.0.1.100       255.255.255.0    eth3
10.0.2.100        10.0.2.100       255.255.255.0    eth4
192.168.2.2       192.168.2.2      255.255.255.0    eth1
172.64.3.10       172.64.3.10      255.255.255.0    eth2
-----
Client student connecting to Server localhost:8888
Requesting topology 0
successfully authenticated as student
Loading routing table from server, clear local routing table.
Loading routing table
-----
Destination      Gateway          Mask             Iface
10.0.1.100        10.0.1.100       255.255.255.0    eth3
10.0.2.100        10.0.2.100       255.255.255.0    eth4
192.168.2.2       192.168.2.2      255.255.255.0    eth1
172.64.3.10       172.64.3.10      255.255.255.0    eth2
-----
Router interfaces:
eth4  MAC Addr: aa:e1:ef:4e:b1:e1
      IP Addr: 10.0.2.1
eth3  MAC Addr: 02:ef:4b:3d:60:54
      IP Addr: 10.0.1.1
eth2  MAC Addr: 8e:4e:89:81:61:23
      IP Addr: 172.64.3.1
eth1  MAC Addr: de:3b:28:15:27:46
      IP Addr: 192.168.2.1
<-- Ready to process packets -->
[IP blocked] : 10.0.2.100
[IP blocked] : 10.0.2.100
```