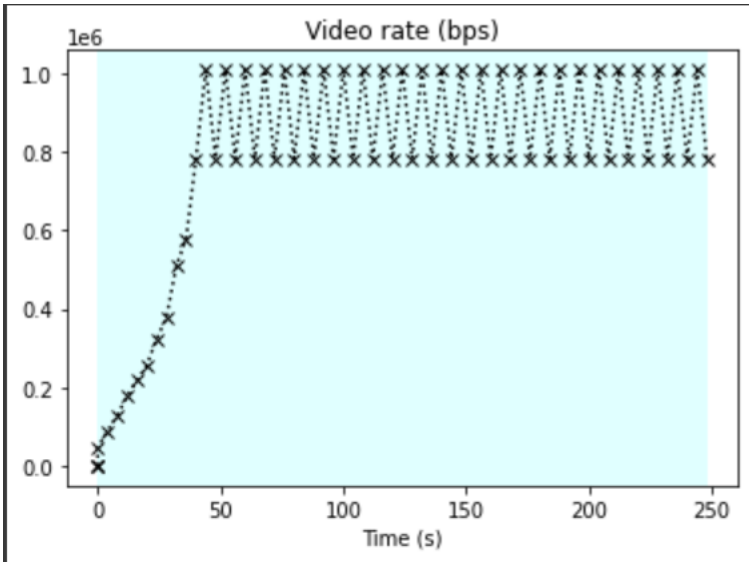
CSE434 Lab 3 Report
Group 82

Group Members:

Jeet Thakkar

Wei Hng Yeo

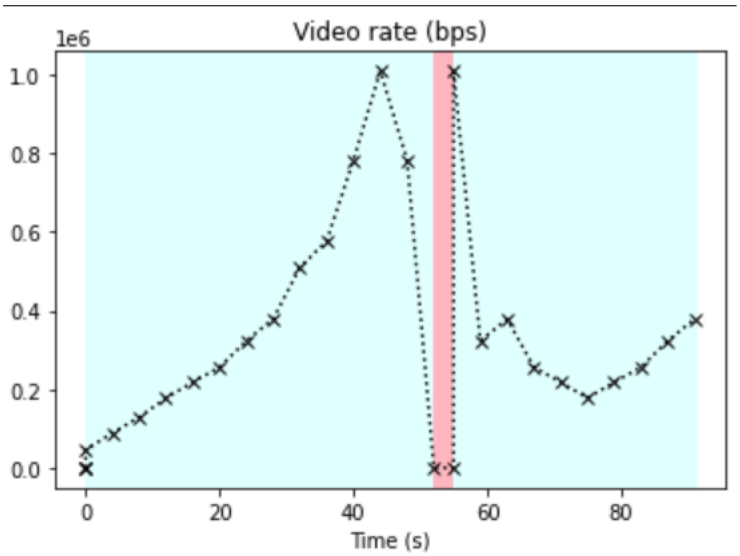
Exercise 1.1: Experiment: Constant Bit Rate



Video rate as a function of time

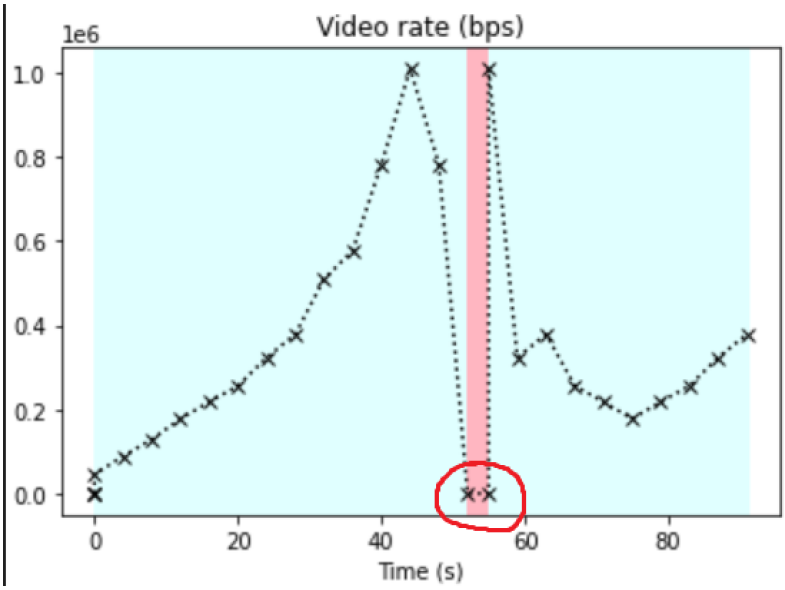
As shown on the diagram on the above, the playback does not have any rebuffering and the playback was not frozen.

Exercise 1.2: Experiment: Constant Bit Rate with Interruption



Video rate as a function of time

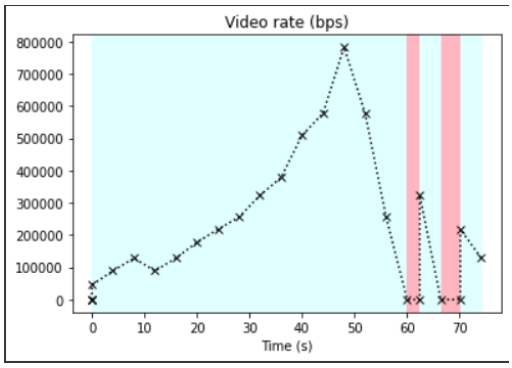
Yes, I am able to cause rebuffering. As annotated on the diagram shown below in red, there is a massive drop for video rate (region in pink) showing that rebuffering occurring and the playback is frozen during that time.



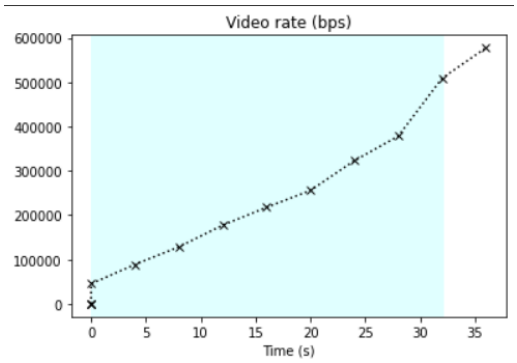
Annotated Video rate vs Time

Exercise 1.3: Experiment: Mobile User

Location 1: Long Island Rail Road



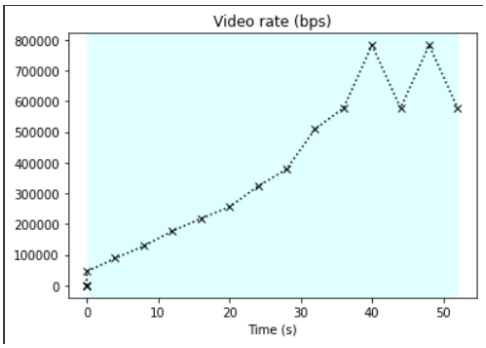
Scaling Factor 0.1



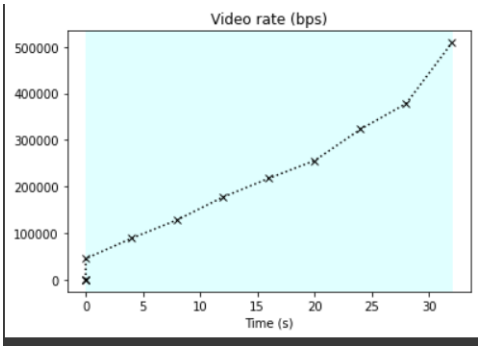
Scaling Factor 0.6

For long island rail road, the throughput rises constantly until the 50 second mark before seeing a massive dip in throughput and some rises, but the throughput never recovers back anywhere near the original peak throughput. For the scaling factor of 0.6, the throughput rises constantly and at a certain point in time, there will likely also be some dips and rise in throughput. The scaling factor of 0.1 is insufficient to stream video as there is too much instability in the throughput. The scaling factor of 0.6 is sufficient to stream video.

Location 2: Ferry



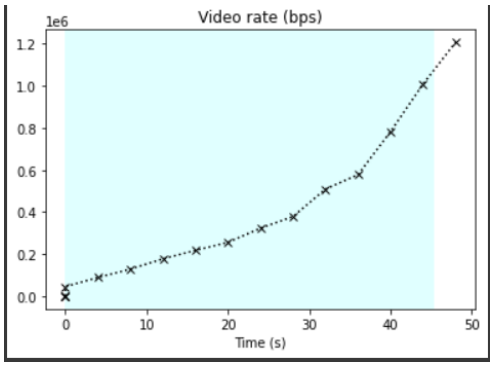
Scaling Factor 0.1



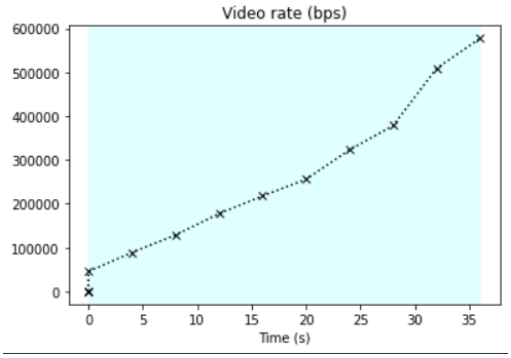
Scaling Factor 0.6

For the ferry, the throughput rises constantly up to the time at 40 second where there starts to be dips and rises in network throughput. For the scaling factor of 0.6, the throughput also rises constantly and there will also likely be dips and rises after a certain point in time. In both cases, the throughput enough to stream the video.

Location 3: Car



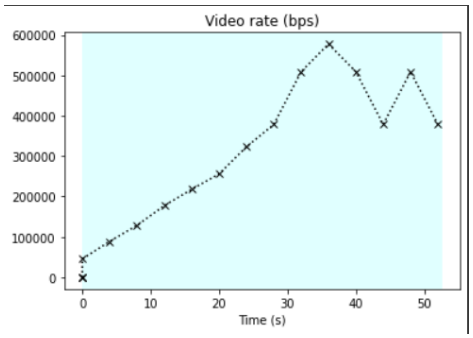
Scaling Factor 0.1



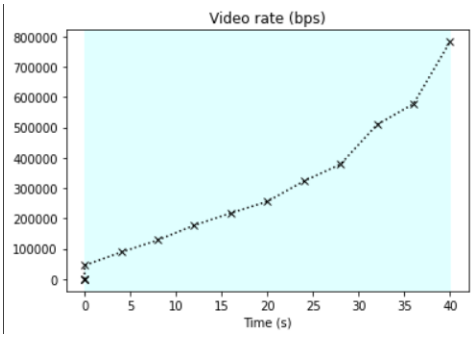
Scaling Factor 0.6

For the car, the throughput is increasing constantly for both scaling factor of 0.6 and 0.1 but the scaling factor of 0.6 increases in throughput slightly faster than 0.1. At a certain time for both scaling factor, there will likely be some dip and rises. In both cases, the throughput enough to stream the video.

Location 4: Bus



Scaling Factor 0.1



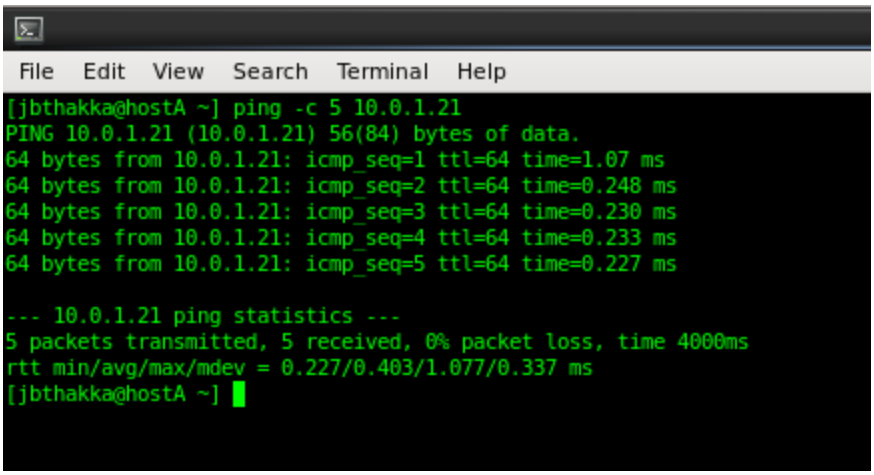
Scaling Factor 0.6

For the bus, the throughput is rises constantly for scaling factor of 0.1 and then there are some dips and rises after the 35 second mark. On the other hand, the throughput of scaling factor of 0.6 rises relatively constantly and then it will also have some dip and rises after a certain time. In both cases, the throughput enough to stream the video.

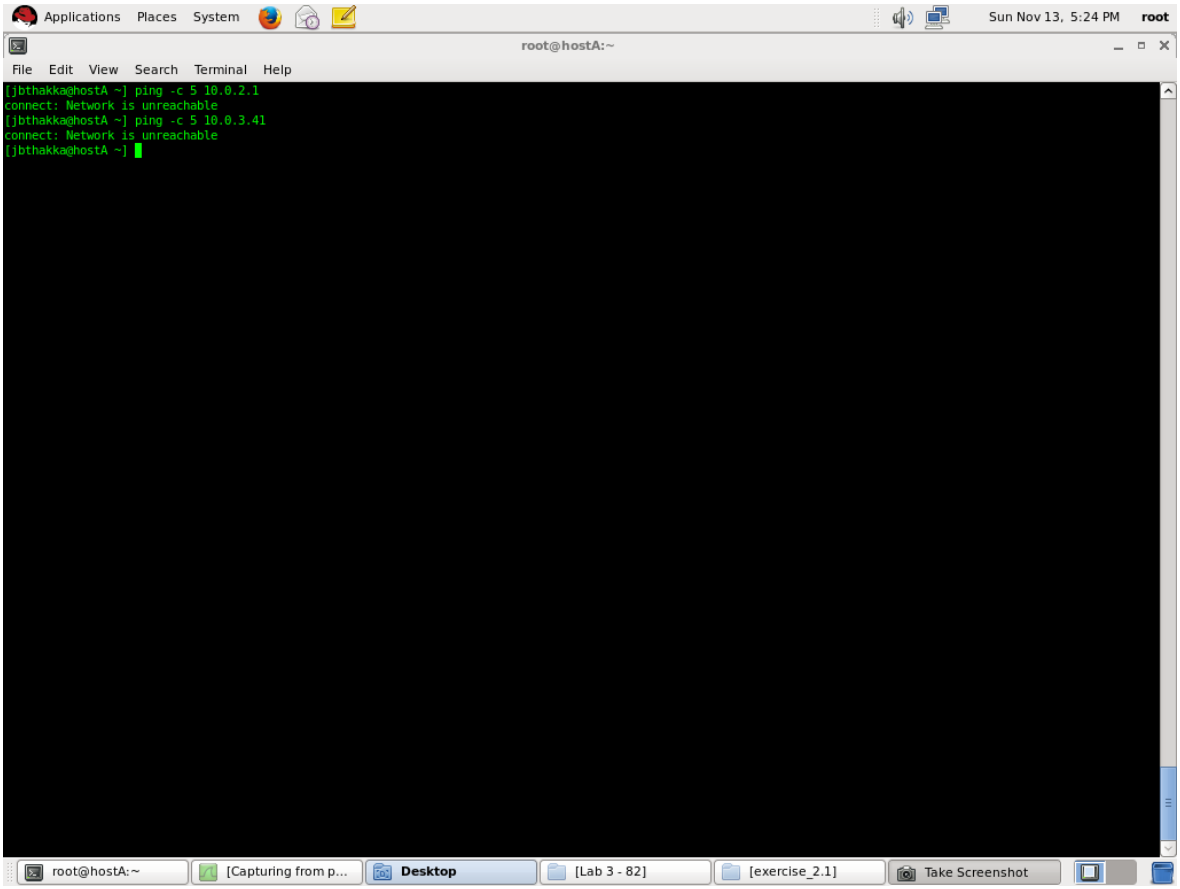
Yes, I can see the impact of scaling factor. Since the lower the scaling factor, the lower the network quality. So, the scaling factor generally worsens the throughput if it is lower.

Part 2: Static Routing on the Racks
Exercise 2.1:

1. We can ping PC B, but we cannot reach PC D and Router A, as seen below in the screenshots.

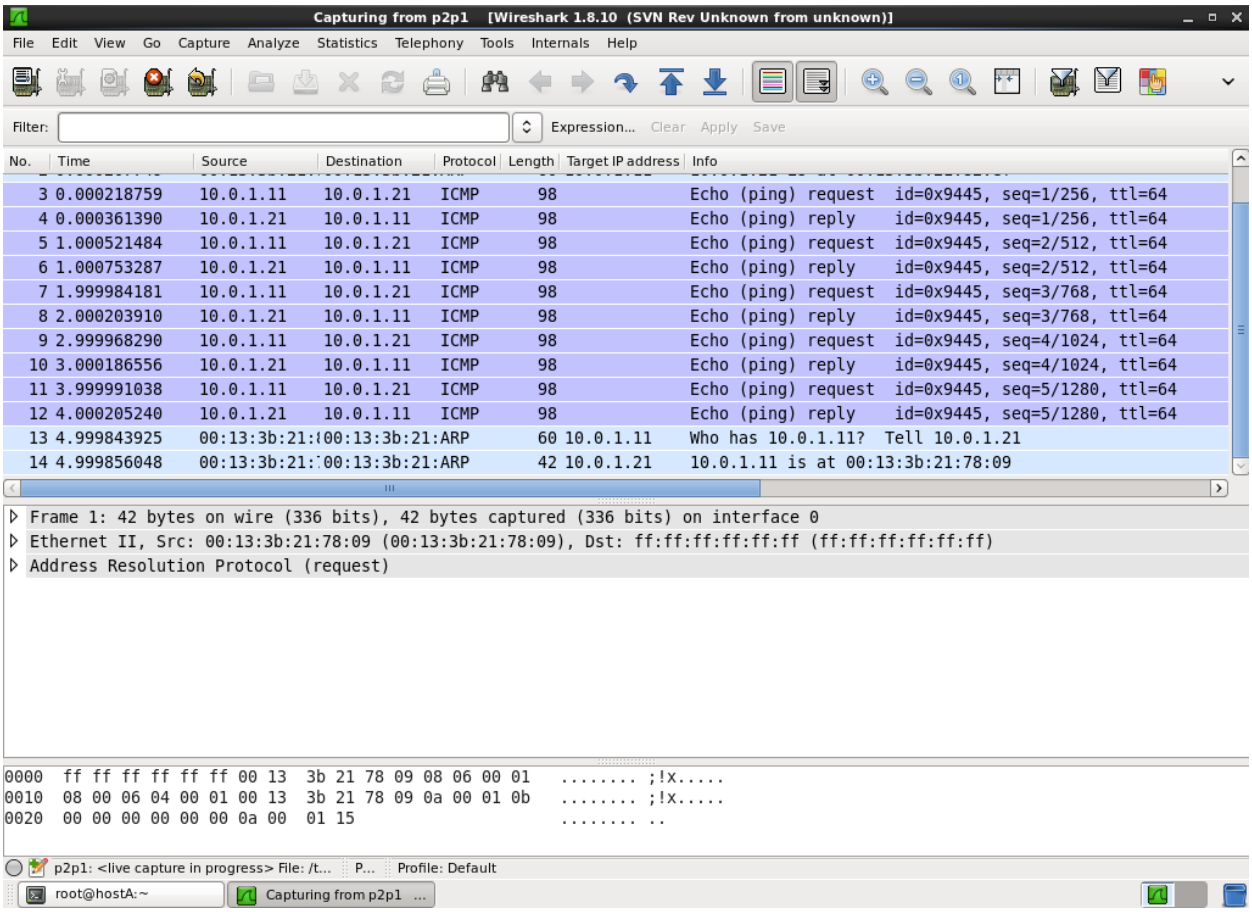


ping to PC B



ping to PC D and router A.

2. The packets to ping PC B are captured by Wireshark. The screenshot for the same is attached below:



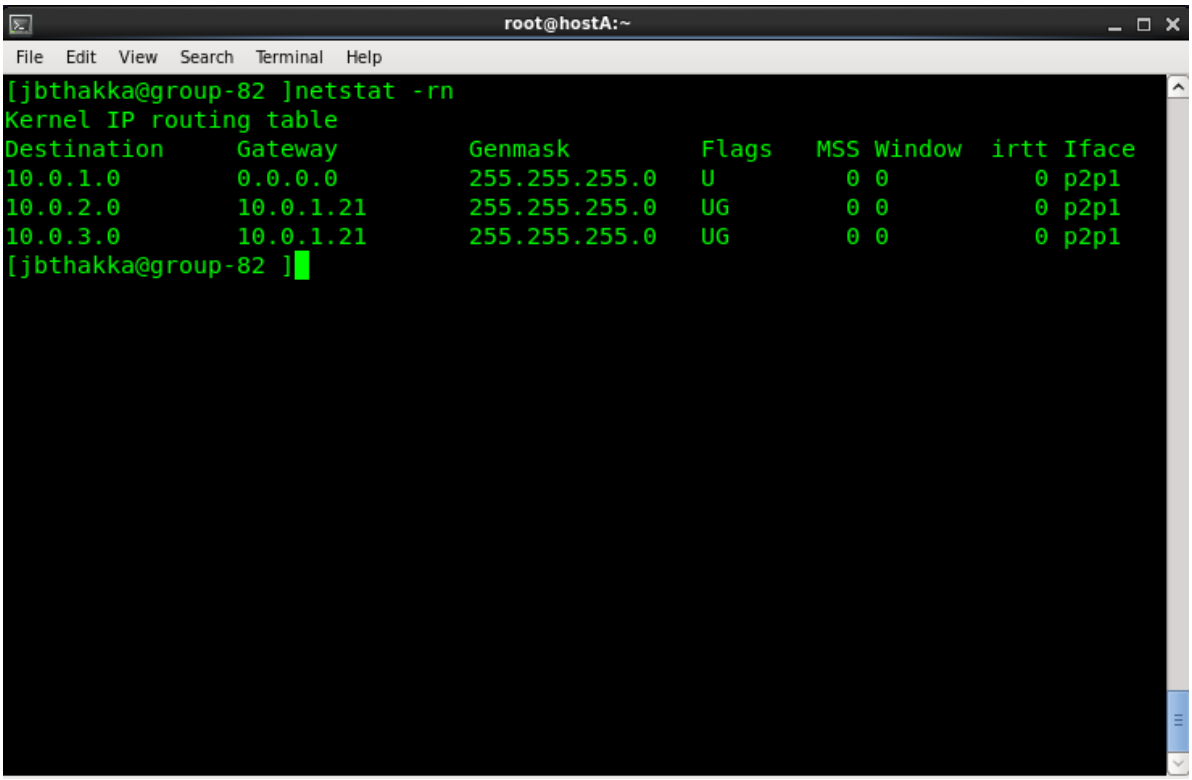
3. We see the ARP packets initially, before PC A pings PC B – this is because PC A needs to broadcast to the network if any host with PC B's IP Address exists. (screenshot below captured from the pcap we saved from the experiment since we did not take a screenshot with the ARP packets in it.)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	SpeedDra_21:78:09	Broadcast	ARP	42	Who has 10.0.1.21? Tell 10.0.1.11
2	0.000207749	SpeedDra_21:82:ef	SpeedDra_21:78:09	ARP	60	10.0.1.21 is at 00:13:3b:21:82:ef

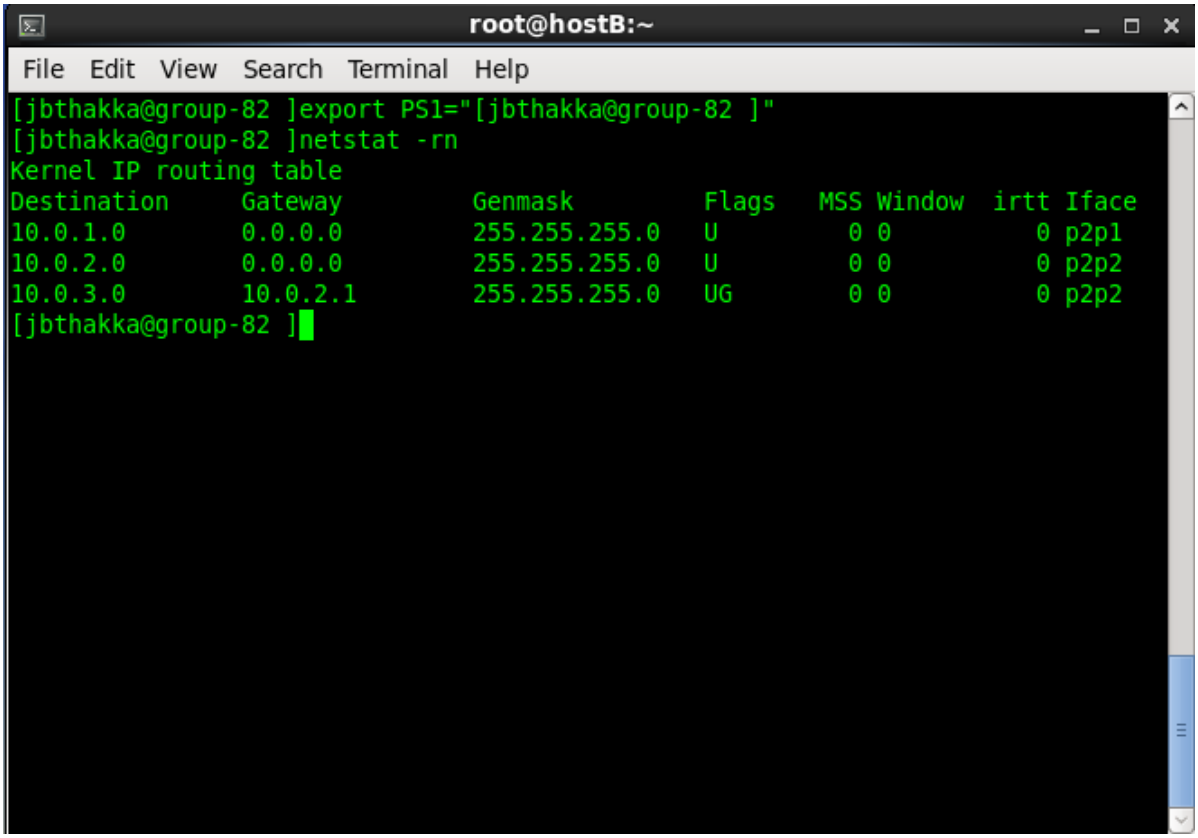
4. Yes, the PC D and Router A were not reachable because the PC A did not have the routes configured that would route the packets to PC D or Router A. Since, PC B was the intermediary, it would need to forward packets from PC A to those two hosts.

Exercise 2.2:

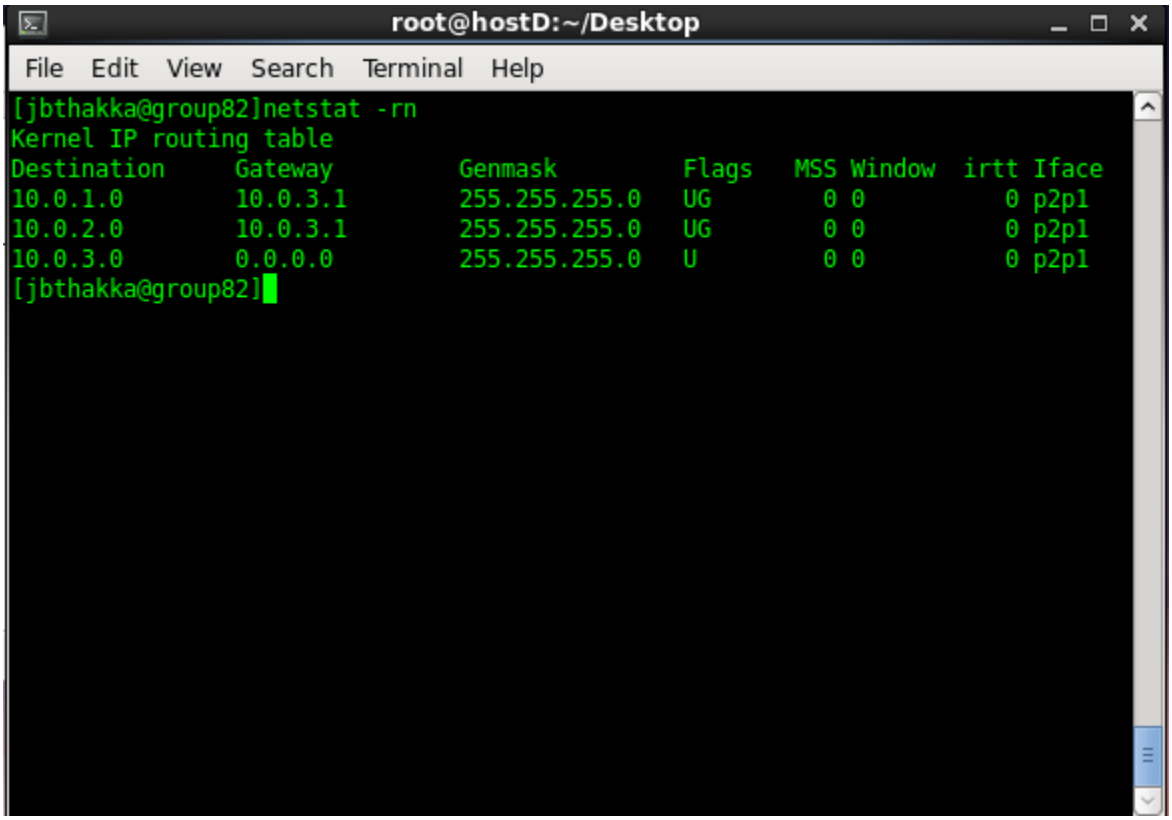
1. The routes for the PC A, PC B, RouterA and PC D are shown below:



routes set on PC A



routes set on PC B



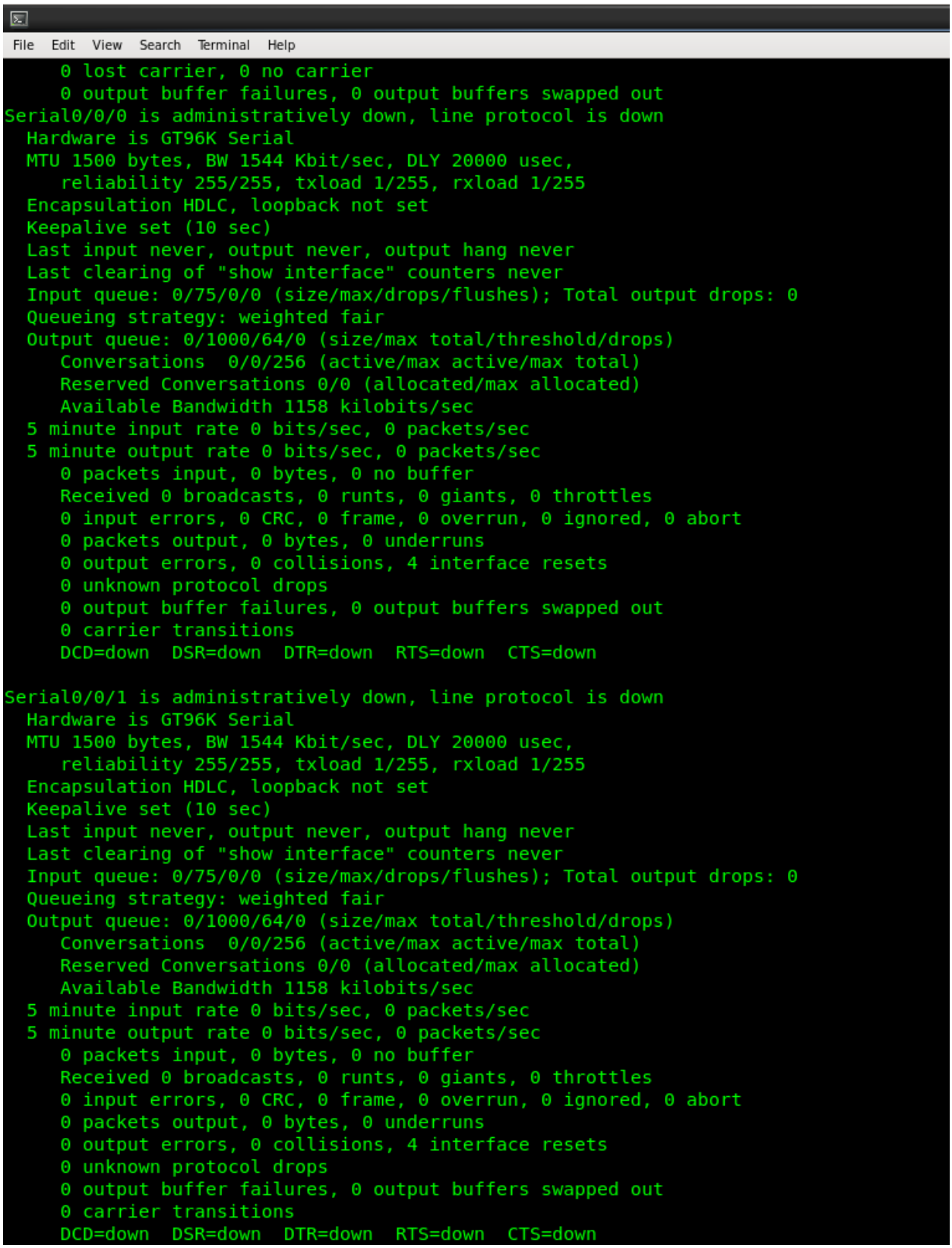
routes set on PC D

2. **PC A:** On PC A, the first hop to get out of the network is interface p2p1 on PC B. in the previous step we have already configured PC B to forward any packets that it receives for which it knows the route for – therefore the routes to reach the 10.0.2.0/24 and 10.0.3.0/24 subnet has PC B's p2p1 interface listed as the default gateway. For the 10.0.1.0/24 subnet PC A will just forward the frames to the switch A as that subnet only exists within the context of that switch.
   PC B: for PC B, the 10.0.2.0/24 subnet is reachable from the p2p2 interface, and the 10.0.1.0/24 subnet is reachable from the p2p1 interface – however, in order to reach the 10.0.3.0/24 subnet PC B will have to will have to communicate with routerA.
   PC D: PC D is connected to the 10.0.1.0/24 and 10.0.2.0/24 through the router so it will be sending the packets for them to the 10.0.3.1 interface (FastEthernet0/1) of the router which will forward it to the PC B through the 10.0.2.1 (FastEthernet0/0) interface; The packet is then used by B or forwarded by B to PC A.
   Router A: The router A receives a packet and the packets destined for 10.0.2.0/24 are forwarded out for FastEthernet0/0 interface and the packets meant for 10.0.3.0/24 are forwarded out of the FastEthernet0/1 interface; However, since the router is not directly connected to the 10.0.1.0/24 subnet it forwards those packets to the p2p2 interface of PC B, since that is the first hop address of a host towards that subnet. PC B then forwards the packet out of the p2p1 interface into the switch.

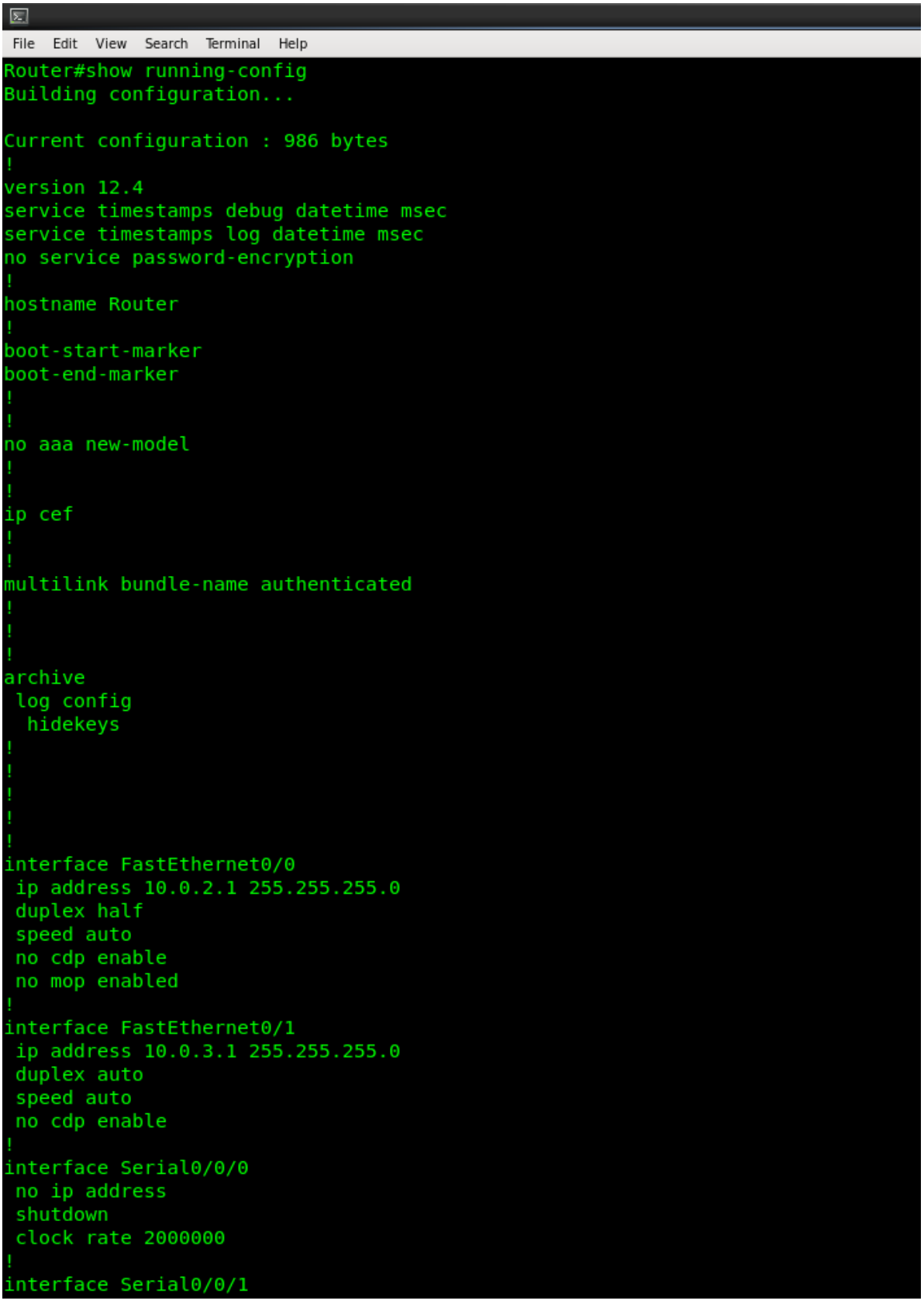
Exercise 2.3:

The `show interfaces` command retruns the following output:

```
Router#show interfaces
FastEthernet0/0 is up, line protocol is up
  Hardware is MV96340 Ethernet, address is 0017.95ac.b930 (bia 0017.95ac.b930)
  Internet address is 10.0.2.1/24
  MTU 1500 bytes, BW 100000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Half-duplex, 100Mb/s, 100BaseTX/FX
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:18:56, output 00:00:04, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     360 packets input, 34832 bytes
     Received 1 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog
     0 input packets with dribble condition detected
     775 packets output, 50116 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
FastEthernet0/1 is up, line protocol is up
  Hardware is MV96340 Ethernet, address is 0017.95ac.b931 (bia 0017.95ac.b931)
  Internet address is 10.0.3.1/24
  MTU 1500 bytes, BW 100000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s, 100BaseTX/FX
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:19:01, output 00:00:09, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     467 packets input, 45268 bytes
     Received 1 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog
     0 input packets with dribble condition detected
     1158 packets output, 82662 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
 --More--
```


File Edit View Search Terminal Help
0 lost carrier, 0 no carrier
0 output buffer failures, 0 output buffers swapped out
Serial0/0/0 is administratively down, line protocol is down
Hardware is GT96K Serial
MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set
Keepalive set (10 sec)
Last input never, output never, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
Conversations 0/0/256 (active/max active/max total)
Reserved Conversations 0/0 (allocated/max allocated)
Available Bandwidth 1158 kilobits/sec
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
0 packets output, 0 bytes, 0 underruns
0 output errors, 0 collisions, 4 interface resets
0 unknown protocol drops
0 output buffer failures, 0 output buffers swapped out
0 carrier transitions
DCD=down DSR=down DTR=down RTS=down CTS=down
Serial0/0/1 is administratively down, line protocol is down
Hardware is GT96K Serial
MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set
Keepalive set (10 sec)
Last input never, output never, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
Conversations 0/0/256 (active/max active/max total)
Reserved Conversations 0/0 (allocated/max allocated)
Available Bandwidth 1158 kilobits/sec
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
0 packets output, 0 bytes, 0 underruns
0 output errors, 0 collisions, 4 interface resets
0 unknown protocol drops
0 output buffer failures, 0 output buffers swapped out
0 carrier transitions
DCD=down DSR=down DTR=down RTS=down CTS=down

The `show running-config` command returns the following output:



```
interface FastEthernet0/0
 ip address 10.0.2.1 255.255.255.0
 duplex half
 speed auto
 no cdp enable
 no mop enabled
!
interface FastEthernet0/1
 ip address 10.0.3.1 255.255.255.0
 duplex auto
 speed auto
 no cdp enable
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
 clock rate 2000000
 no cdp enable
!
ip forward-protocol nd
ip route 10.0.1.0 255.255.255.0 10.0.2.22
!
!
ip http server
!
snmp-server community Team RO 33
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 password vtpassword
 login
!
scheduler allocate 20000 1000
no process cpu extended
no process cpu autoprofile hog
!
end
```

Exercise 2.4:

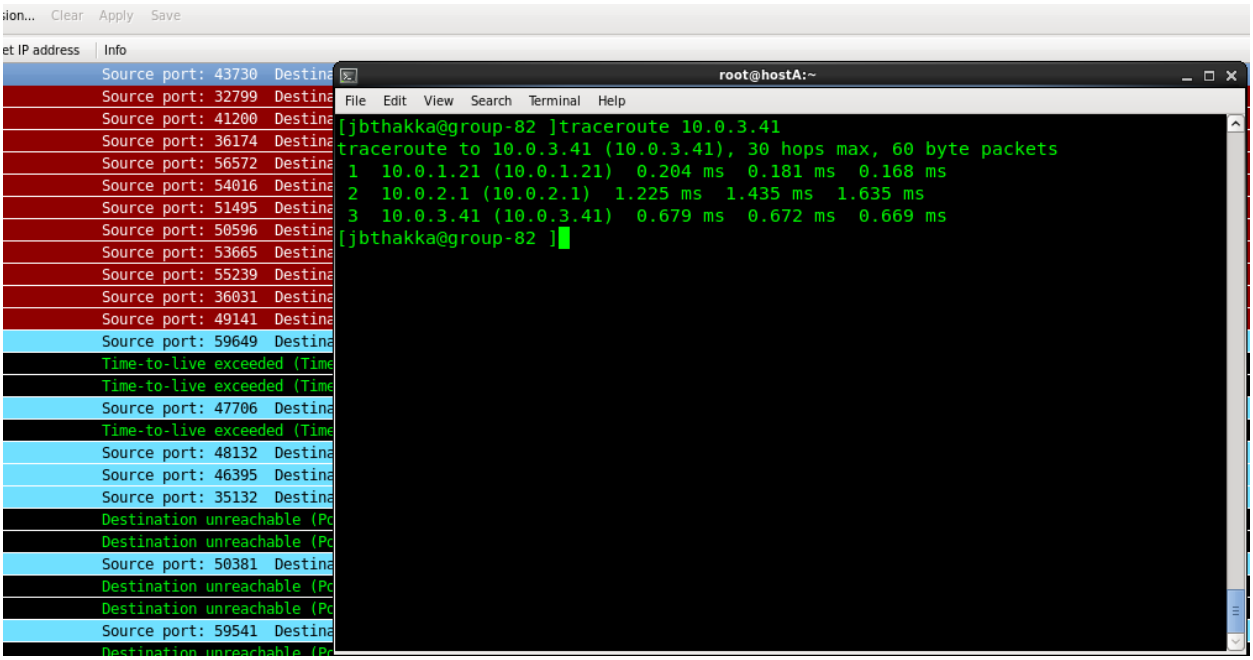
1. We forgot to take the screenshot before adding the route – the command shows 1st two entries only, as the router A is only aware of the 10.0.2.0/24 and 10.0.3.0/24 subnets die to being directly connected to them. After adding the command:

```
Router#
Router#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 3 subnets
C       10.0.2.0 is directly connected, FastEthernet0/0
C       10.0.3.0 is directly connected, FastEthernet0/1
S       10.0.1.0 [1/0] via 10.0.2.22
Router#
```

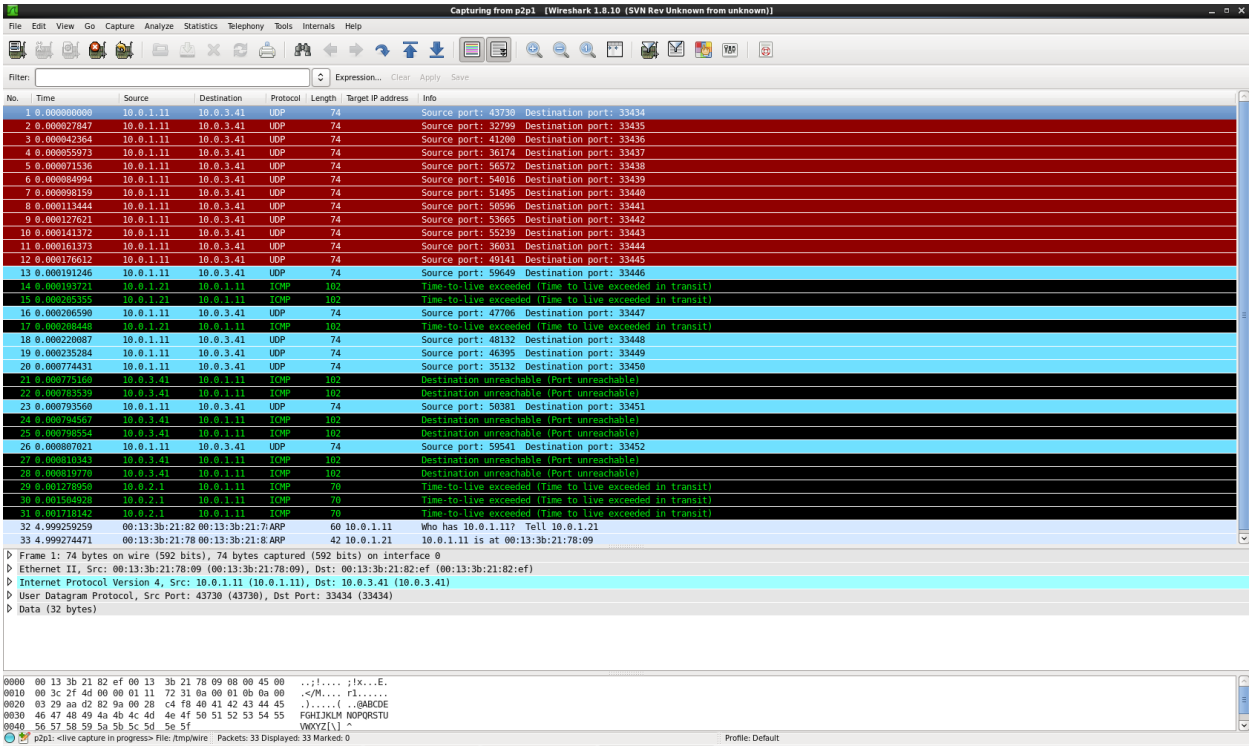
   route on the Cisco Router after adding the route
2. The routing table shows the following fields:
   a. `C` or `S` – this denotes whether the subnet is reachable because the router is directly connected to it (i.e. `FastEthernet0/0` or `FastEthernet0/1` have an IP address in that subnet – as in the case of the third entry, the field is set to `S`, which indicates the route has been added statically.
   b. `10.0.2.0 is directly connected, FastEthernet0/0` – this indicates that the route is directly connected
   c. `10.0.1.0 [1/0] via 10.0.2.22 –` denotes that the 10.0.1.0/24 network si reachable via the 10.0.2.22 first hop address.
3. **Router A:** The router A receives a packet and the packets destined for 10.0.2.0/24 are forwarded out for FastEthernet0/0 interface and the packets meant for 10.0.3.0/24 are forwarded out of the FastEthernet0/1 interface; However, since the router is not directly connected to the 10.0.1.0/24 subnet it forwards those packets to the p2p2 interface of PC B, since that is the first hop address of a host towards that subnet. PC B then forwards the packet out of the p2p1 interface into the switch.

Exercise 2.5:

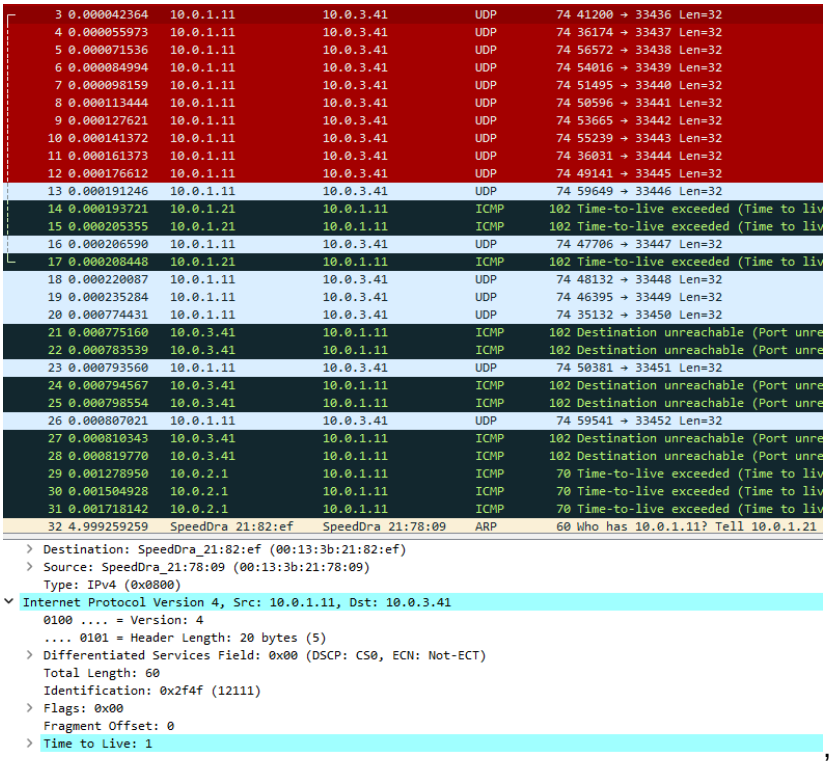
When performing the traceroute we see the following result in the terminal:



The wireshark output for the traceroute command is shown below:



In the above packet capture, we see the PC A sending 12x32 bit UDP packets of different TTLs. The first 3 UDP packets are sent with a TTL of 1,

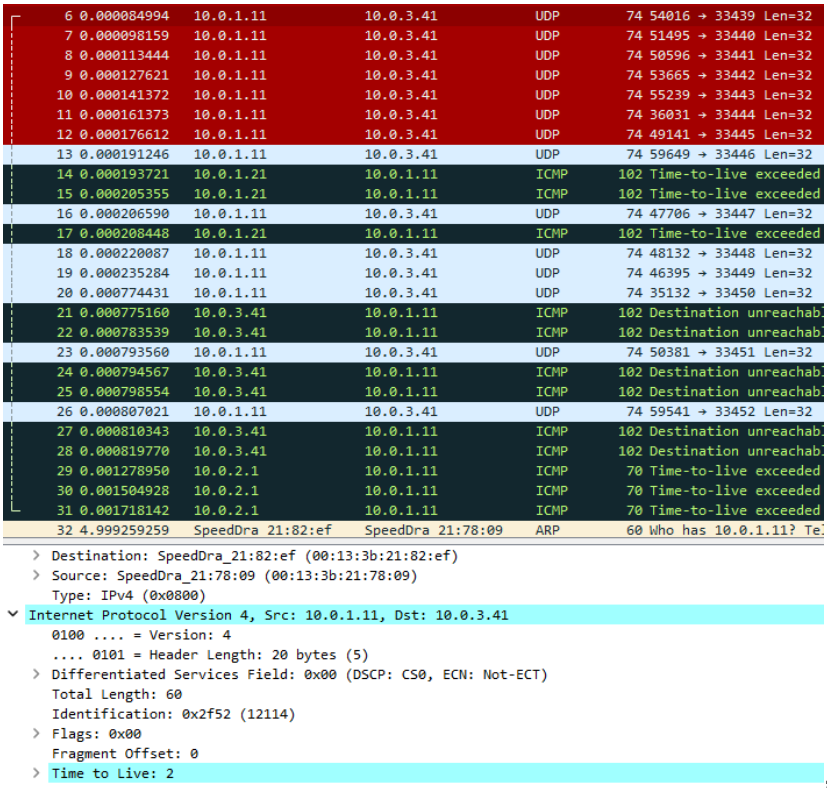


3	0.000042364	10.0.1.11	10.0.3.41	UDP	74 41200 → 33436 Len=32
4	0.000055973	10.0.1.11	10.0.3.41	UDP	74 36174 → 33437 Len=32
5	0.000071536	10.0.1.11	10.0.3.41	UDP	74 56572 → 33438 Len=32
6	0.000084994	10.0.1.11	10.0.3.41	UDP	74 54016 → 33439 Len=32
7	0.000098159	10.0.1.11	10.0.3.41	UDP	74 51495 → 33440 Len=32
8	0.000113444	10.0.1.11	10.0.3.41	UDP	74 50596 → 33441 Len=32
9	0.000127621	10.0.1.11	10.0.3.41	UDP	74 53665 → 33442 Len=32
10	0.000141372	10.0.1.11	10.0.3.41	UDP	74 55239 → 33443 Len=32
11	0.000161373	10.0.1.11	10.0.3.41	UDP	74 36031 → 33444 Len=32
12	0.000176612	10.0.1.11	10.0.3.41	UDP	74 49141 → 33445 Len=32
13	0.000191246	10.0.1.11	10.0.3.41	UDP	74 59649 → 33446 Len=32
14	0.000193721	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to liv
15	0.000205355	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to liv
16	0.000206590	10.0.1.11	10.0.3.41	UDP	74 47706 → 33447 Len=32
17	0.000208448	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to liv
18	0.000220087	10.0.1.11	10.0.3.41	UDP	74 48132 → 33448 Len=32
19	0.000235284	10.0.1.11	10.0.3.41	UDP	74 46395 → 33449 Len=32
20	0.000774431	10.0.1.11	10.0.3.41	UDP	74 35132 → 33450 Len=32
21	0.000775160	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unre
22	0.000783539	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unre
23	0.000793560	10.0.1.11	10.0.3.41	UDP	74 50381 → 33451 Len=32
24	0.000794567	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unre
25	0.000798554	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unre
26	0.000807021	10.0.1.11	10.0.3.41	UDP	74 59541 → 33452 Len=32
27	0.000810343	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unre
28	0.000819770	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unre
29	0.001278950	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded (Time to liv
30	0.001504928	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded (Time to liv
31	0.001718142	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded (Time to liv
32	4.999259259	SpeedDra 21:82:ef	SpeedDra 21:78:09	ARP	60 Who has 10.0.1.11? Tell 10.0.1.21

```
> Destination: SpeedDra_21:82:ef (00:13:3b:21:82:ef)
> Source: SpeedDra_21:78:09 (00:13:3b:21:78:09)
  Type: IPv4 (0x0800)
v Internet Protocol Version 4, Src: 10.0.1.11, Dst: 10.0.3.41
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
  Total Length: 60
  Identification: 0x2f4f (12111)
> Flags: 0x00
  Fragment Offset: 0
> Time to Live: 1
```

,

the next three with TTL of 2

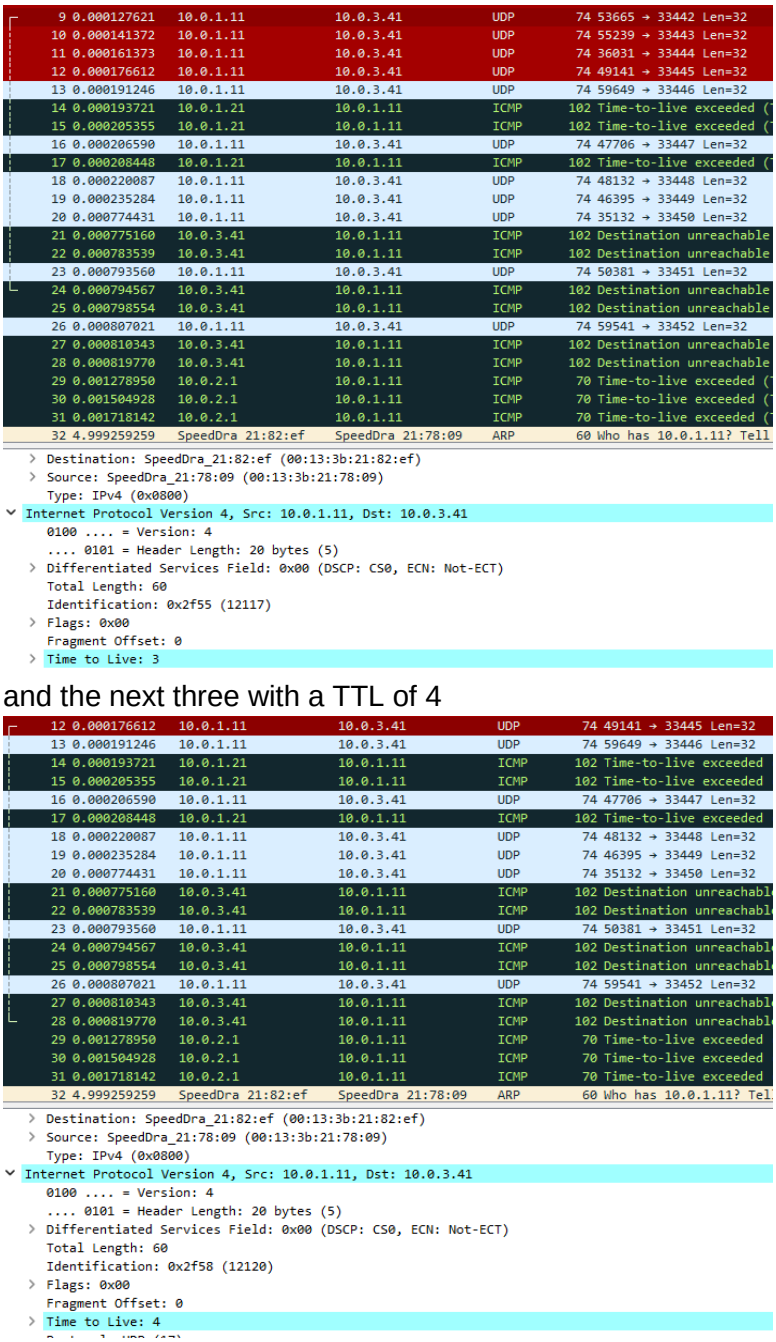


6	0.000084994	10.0.1.11	10.0.3.41	UDP	74 54016 → 33439 Len=32
7	0.000098159	10.0.1.11	10.0.3.41	UDP	74 51495 → 33440 Len=32
8	0.000113444	10.0.1.11	10.0.3.41	UDP	74 50596 → 33441 Len=32
9	0.000127621	10.0.1.11	10.0.3.41	UDP	74 53665 → 33442 Len=32
10	0.000141372	10.0.1.11	10.0.3.41	UDP	74 55239 → 33443 Len=32
11	0.000161373	10.0.1.11	10.0.3.41	UDP	74 36031 → 33444 Len=32
12	0.000176612	10.0.1.11	10.0.3.41	UDP	74 49141 → 33445 Len=32
13	0.000191246	10.0.1.11	10.0.3.41	UDP	74 59649 → 33446 Len=32
14	0.000193721	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded
15	0.000205355	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded
16	0.000206590	10.0.1.11	10.0.3.41	UDP	74 47706 → 33447 Len=32
17	0.000208448	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded
18	0.000220087	10.0.1.11	10.0.3.41	UDP	74 48132 → 33448 Len=32
19	0.000235284	10.0.1.11	10.0.3.41	UDP	74 46395 → 33449 Len=32
20	0.000774431	10.0.1.11	10.0.3.41	UDP	74 35132 → 33450 Len=32
21	0.000775160	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachabl
22	0.000783539	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachabl
23	0.000793560	10.0.1.11	10.0.3.41	UDP	74 50381 → 33451 Len=32
24	0.000794567	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachabl
25	0.000798554	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachabl
26	0.000807021	10.0.1.11	10.0.3.41	UDP	74 59541 → 33452 Len=32
27	0.000810343	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachabl
28	0.000819770	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachabl
29	0.001278950	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded
30	0.001504928	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded
31	0.001718142	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded
32	4.999259259	SpeedDra 21:82:ef	SpeedDra 21:78:09	ARP	60 Who has 10.0.1.11? Te

```
> Destination: SpeedDra_21:82:ef (00:13:3b:21:82:ef)
> Source: SpeedDra_21:78:09 (00:13:3b:21:78:09)
  Type: IPv4 (0x0800)
v Internet Protocol Version 4, Src: 10.0.1.11, Dst: 10.0.3.41
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
  Total Length: 60
  Identification: 0x2f52 (12114)
> Flags: 0x00
  Fragment Offset: 0
> Time to Live: 2
```

,

the next three with a TTL of 3



and the next three with a TTL of 4

the 1st packet with the TTL=1 reaches the first router (10.0.2.21), and it looks at the TTL as being expired, so it drops those UDP packets and sends back an ICMP Time exceeded packet back to the sender – this happens two more times as it receives the 1st three packets; for each of those packets we see a logical request-response link drawn by Wireshark for us, as shown below (Request packet 1 – Response packet 14, Request packet 2 – Response packet 15, Request packet 3 – Response packet 17(This is the highlighted one)):

1	0.000000000	10.0.1.11	10.0.3.41	UDP	74 43730 → 33434 Len=32
2	0.000027847	10.0.1.11	10.0.3.41	UDP	74 32799 → 33435 Len=32
3	0.000042364	10.0.1.11	10.0.3.41	UDP	74 41200 → 33436 Len=32
4	0.000055973	10.0.1.11	10.0.3.41	UDP	74 36174 → 33437 Len=32
5	0.000071536	10.0.1.11	10.0.3.41	UDP	74 56572 → 33438 Len=32
6	0.000084994	10.0.1.11	10.0.3.41	UDP	74 54016 → 33439 Len=32
7	0.000098159	10.0.1.11	10.0.3.41	UDP	74 51495 → 33440 Len=32
8	0.000113444	10.0.1.11	10.0.3.41	UDP	74 50596 → 33441 Len=32
9	0.000127621	10.0.1.11	10.0.3.41	UDP	74 53665 → 33442 Len=32
10	0.000141372	10.0.1.11	10.0.3.41	UDP	74 55239 → 33443 Len=32
11	0.000161373	10.0.1.11	10.0.3.41	UDP	74 36031 → 33444 Len=32
12	0.000176612	10.0.1.11	10.0.3.41	UDP	74 49141 → 33445 Len=32
13	0.000191246	10.0.1.11	10.0.3.41	UDP	74 59649 → 33446 Len=32
14	0.000193721	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
15	0.000205355	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
16	0.000206590	10.0.1.11	10.0.3.41	UDP	74 47706 → 33447 Len=32
17	0.000208448	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)

Now, this process is repeated again for the TTL=2 UDP packets and the Router A's `FastEthernet0/0` Interface (Request packet 4 – Response packet 29, Request packet 5 – Response packet 30, Request packet 6 – Response packet 31(This is the highlighted one)):

4	0.000055973	10.0.1.11	10.0.3.41	UDP	74 36174 → 33437 Len=32
5	0.000071536	10.0.1.11	10.0.3.41	UDP	74 56572 → 33438 Len=32
6	0.000084994	10.0.1.11	10.0.3.41	UDP	74 54016 → 33439 Len=32
7	0.000098159	10.0.1.11	10.0.3.41	UDP	74 51495 → 33440 Len=32
8	0.000113444	10.0.1.11	10.0.3.41	UDP	74 50596 → 33441 Len=32
9	0.000127621	10.0.1.11	10.0.3.41	UDP	74 53665 → 33442 Len=32
10	0.000141372	10.0.1.11	10.0.3.41	UDP	74 55239 → 33443 Len=32
11	0.000161373	10.0.1.11	10.0.3.41	UDP	74 36031 → 33444 Len=32
12	0.000176612	10.0.1.11	10.0.3.41	UDP	74 49141 → 33445 Len=32
13	0.000191246	10.0.1.11	10.0.3.41	UDP	74 59649 → 33446 Len=32
14	0.000193721	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
15	0.000205355	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
16	0.000206590	10.0.1.11	10.0.3.41	UDP	74 47706 → 33447 Len=32
17	0.000208448	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
18	0.000220087	10.0.1.11	10.0.3.41	UDP	74 48132 → 33448 Len=32
19	0.000235284	10.0.1.11	10.0.3.41	UDP	74 46395 → 33449 Len=32
20	0.000774431	10.0.1.11	10.0.3.41	UDP	74 35132 → 33450 Len=32
21	0.000775160	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
22	0.000783539	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
23	0.000793560	10.0.1.11	10.0.3.41	UDP	74 50381 → 33451 Len=32
24	0.000794567	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
25	0.000798554	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
26	0.000807021	10.0.1.11	10.0.3.41	UDP	74 59541 → 33452 Len=32
27	0.000810343	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
28	0.000819770	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
29	0.001278950	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)
30	0.001504928	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)
31	0.001718142	10.0.2.1	10.0.1.11	ICMP	70 Time-to-live exceeded (Time to live exceeded in transit)

Also, for TTL=3 packets and PC D's response, we see the same behavior (Request packet 7 – Response packet 21, Request packet 8 – Response packet 22, Request packet 9 – Response packet 24(This is the highlighted one)):

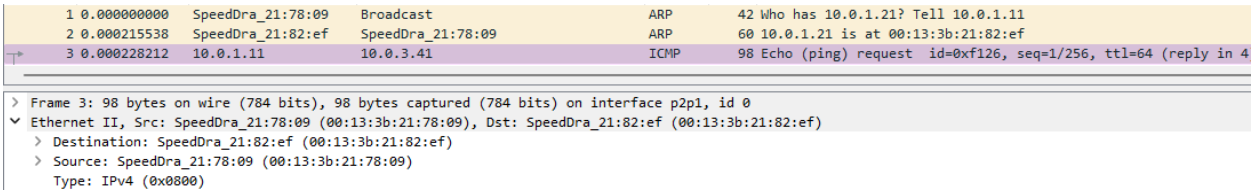
9	0.000127621	10.0.1.11	10.0.3.41	UDP	74 53665 → 33442 Len=32
10	0.000141372	10.0.1.11	10.0.3.41	UDP	74 55239 → 33443 Len=32
11	0.000161373	10.0.1.11	10.0.3.41	UDP	74 36031 → 33444 Len=32
12	0.000176612	10.0.1.11	10.0.3.41	UDP	74 49141 → 33445 Len=32
13	0.000191246	10.0.1.11	10.0.3.41	UDP	74 59649 → 33446 Len=32
14	0.000193721	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
15	0.000205355	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
16	0.000206590	10.0.1.11	10.0.3.41	UDP	74 47706 → 33447 Len=32
17	0.000208448	10.0.1.21	10.0.1.11	ICMP	102 Time-to-live exceeded (Time to live exceeded in transit)
18	0.000220087	10.0.1.11	10.0.3.41	UDP	74 48132 → 33448 Len=32
19	0.000235284	10.0.1.11	10.0.3.41	UDP	74 46395 → 33449 Len=32
20	0.000774431	10.0.1.11	10.0.3.41	UDP	74 35132 → 33450 Len=32
21	0.000775160	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
22	0.000783539	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
23	0.000793560	10.0.1.11	10.0.3.41	UDP	74 50381 → 33451 Len=32
24	0.000794567	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)
25	0.000798554	10.0.3.41	10.0.1.11	ICMP	102 Destination unreachable (Port unreachable)

Surprisingly, we see the Time exceeded responses from the PC D came in before the responses for Router A, even though the router A lies between PC A and PC D; I believe this could probably be explained by UDPs unordered delivery. The sender, PC A, estimates the

distance from PC A using the times at which it received the ICMP time exceeded responses from each of those routers for each different TTL (PC B did not send back a TTL2 packet but Router A did; so, router A must be 2 TTLs away at least) and it timer that it sends at the beginning of the transmission of the packet.

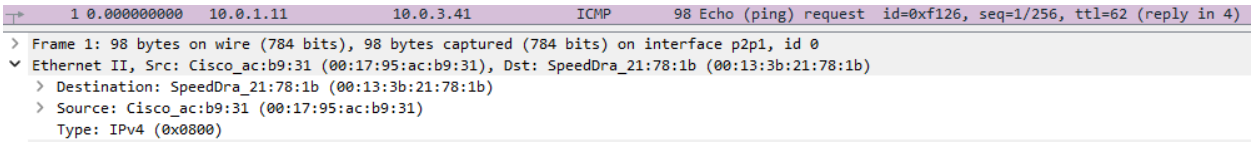
Exercise 2.6:

Source and Destination Address at A:



Here we see when PC A sends the ICMP Echo Request it sets the destination mac address as the mac address of its next hop router which is the p2p1 interface of PC B. The source here is mac address of A (00:13:3b:21:78:09) and destination is the mac address of B (00:17:95:ac:b9:31).

Source and Destination Address at D:

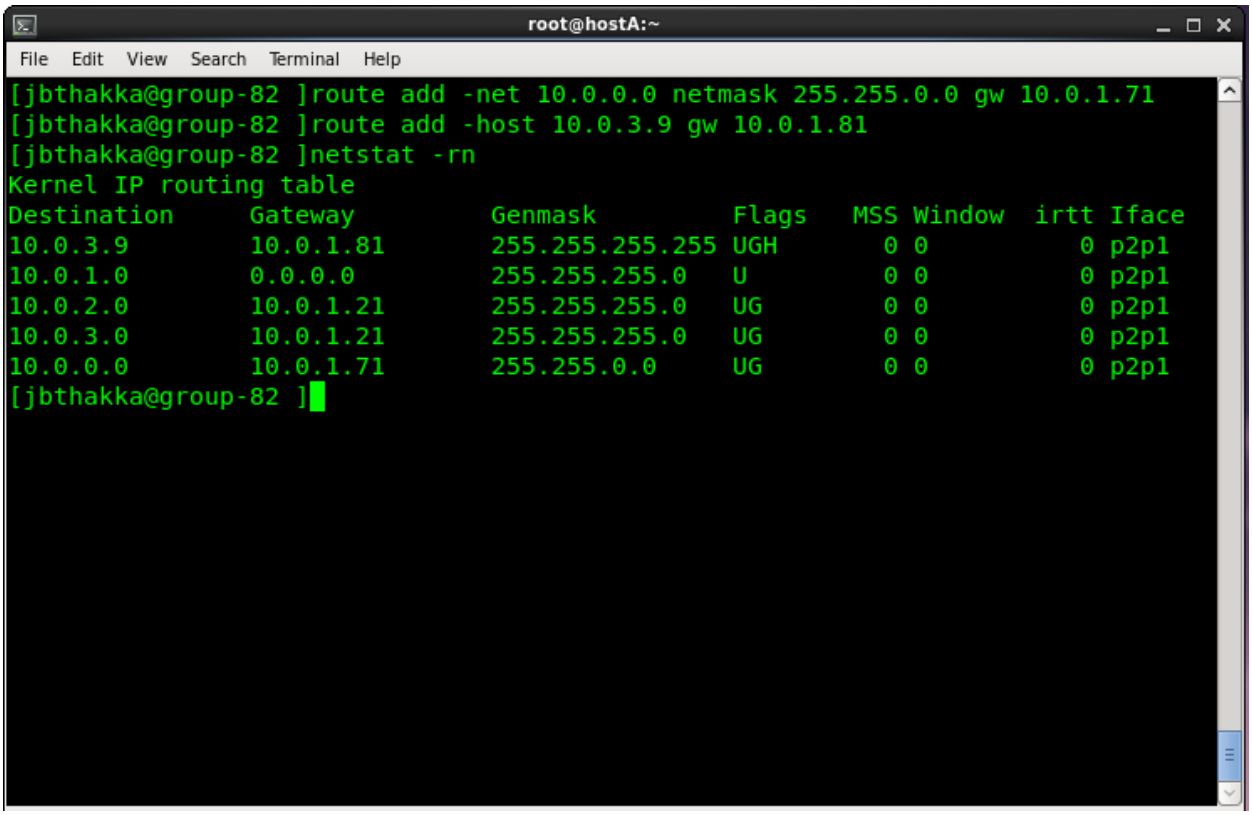


Here we see the source mac address is the mac address of the **`FastEthernet0/1`** interface of the Cisco Router (00:17:95:ac:b9:31), which we can confirm from the screen shot of the **`show interface`** command. The destination mac address is the mac address of the p2p1 interface of PC D (00:13:3b:21:78:1b).

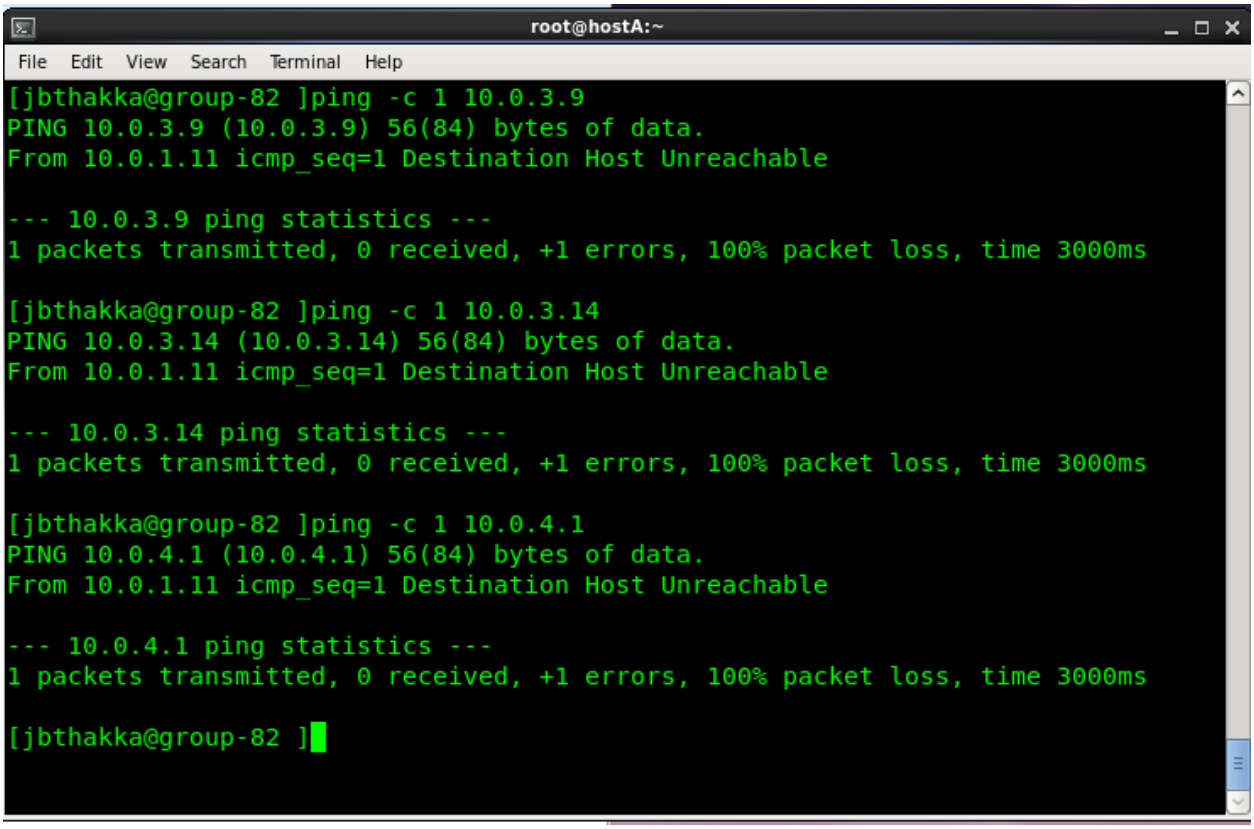
The inverse happens when the ICMP Echo Response is sent from PC D to PC A. This implies that the mac addresses are re-written to reflect the new source and destination during subsequent hops in the routing of a packet.

Exercise 2.7:

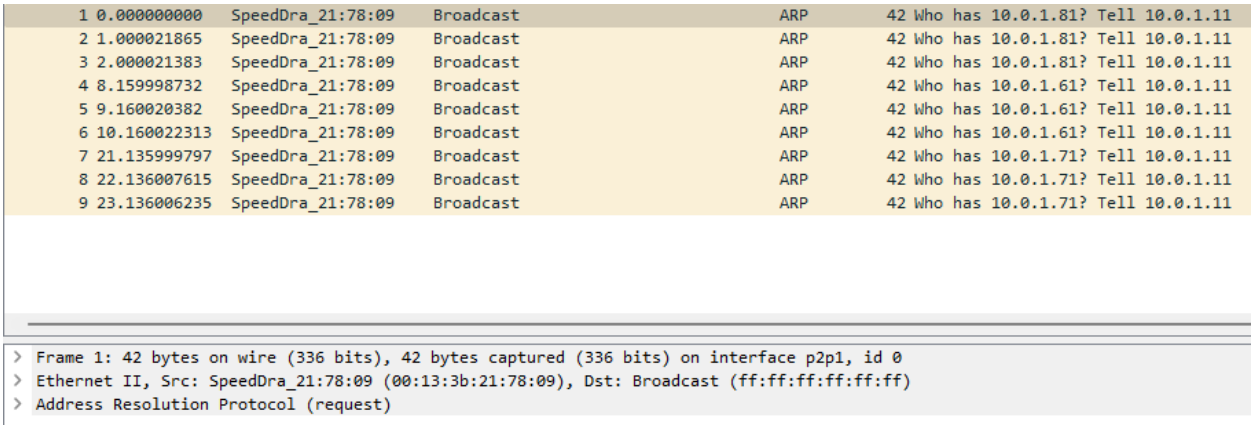
The routing table of A is shown below:



The ping returns the following response:



The Wireshark output of the ping commands is as follows:



1	0.000000000	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.81? Tell 10.0.1.11
2	1.000021865	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.81? Tell 10.0.1.11
3	2.000021383	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.81? Tell 10.0.1.11
4	8.159998732	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.61? Tell 10.0.1.11
5	9.160020382	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.61? Tell 10.0.1.11
6	10.160022313	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.61? Tell 10.0.1.11
7	21.135999797	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.71? Tell 10.0.1.11
8	22.136007615	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.71? Tell 10.0.1.11
9	23.136006235	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.71? Tell 10.0.1.11

1. The number of matches is as follows:
    a. 10.0.3.9 – 3 Matches: 10.0.0.0/16, 10.0.3.9/32 and 10.0.3.0/24
    b. 10.0.3.14 – 2 Matches: 10.0.0.0/16, 10.0.3.0/24
    c. 10.0.4.1 – 1 Match: 10.0.0.0/16
2. The Wireshark output is the demonstration of how the PC A handles multiple matches in the routing table i.e., by longest prefix matching of the destination IP address.

1	0.000000000	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.81? Tell 10.0.1.11
2	1.000021865	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.81? Tell 10.0.1.11
3	2.000021383	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.81? Tell 10.0.1.11
4	8.159998732	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.61? Tell 10.0.1.11
5	9.160020382	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.61? Tell 10.0.1.11
6	10.160022313	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.61? Tell 10.0.1.11
7	21.135999797	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.71? Tell 10.0.1.11
8	22.136007615	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.71? Tell 10.0.1.11
9	23.136006235	SpeedDra_21:78:09	Broadcast	ARP	42 Who has 10.0.1.71? Tell 10.0.1.11

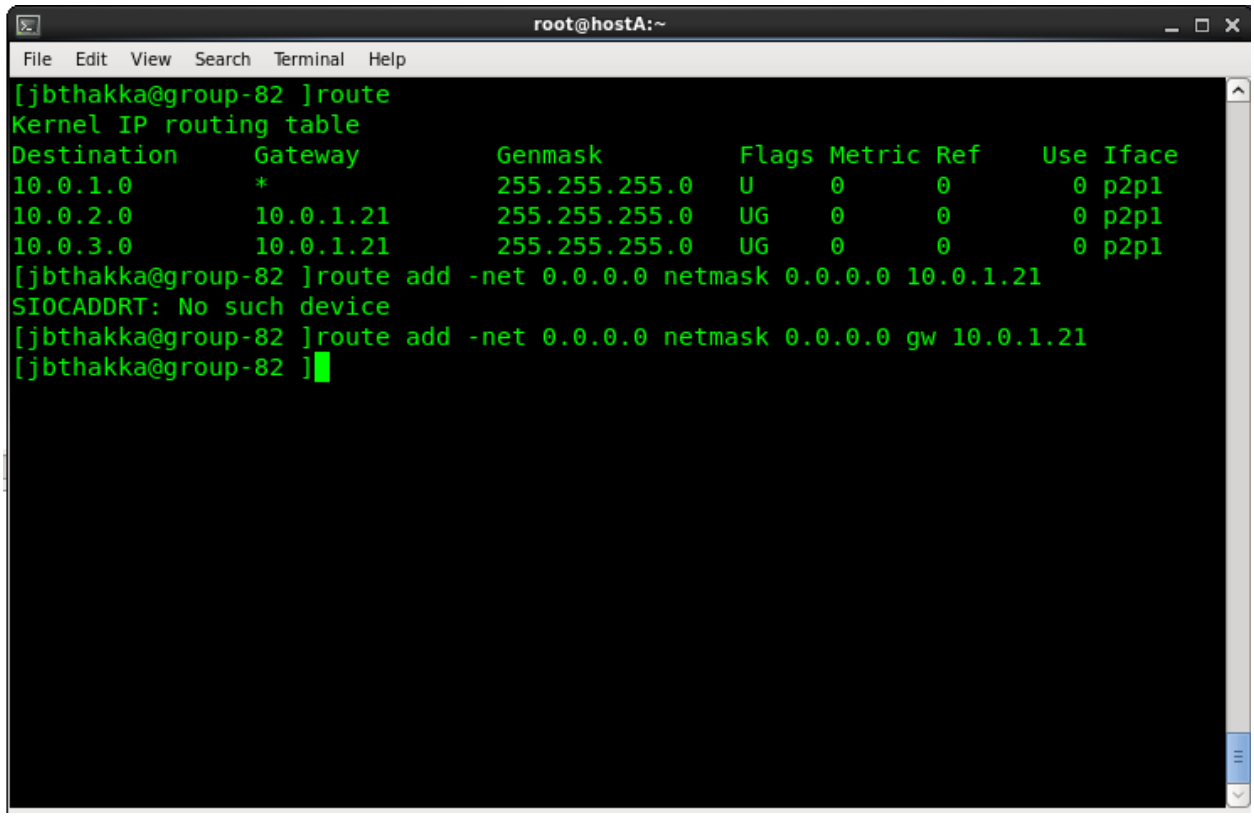
The first 3 ARP requests are sent out in response to the ping command to 10.0.3.9 – We see the host sending the ARP requests to find the gateway of the host associated with the route of the IP address 10.0.3.9. Since, 10.0.1.81 is the longest prefix match of the first route we added to the PC using `route add –host 10.0.3.9 gw 10.0.1.81` command, the PC is trying to find that host to send the ICMP Echo Request packet.

For 10.0.3.14, the longest prefix match is the gateway 10.0.1.61 – specified by the command `route add –net 10.0.3.0 netmask 255.255.255.0 gw 10.0.1.61`

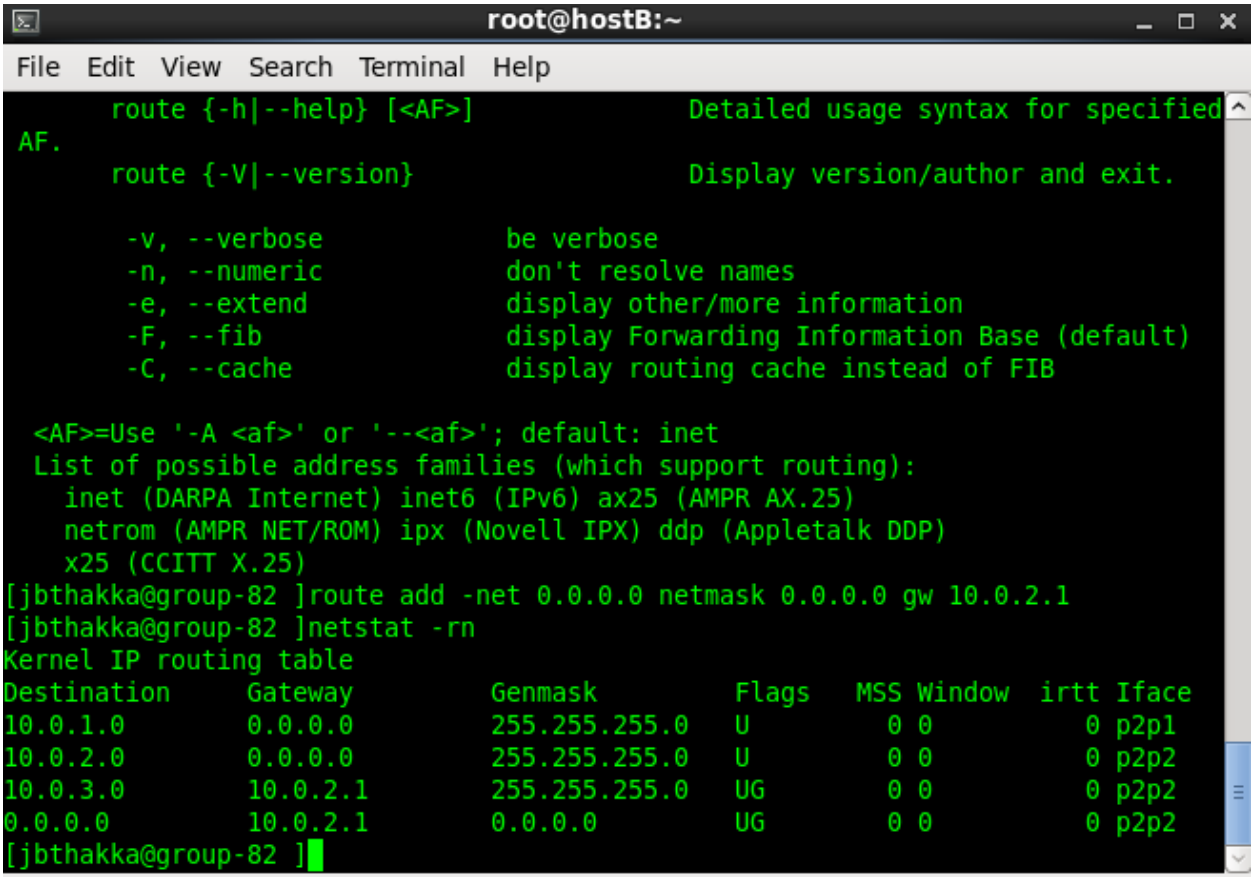
Finally, for 10.0.4.1 the only matching is the route specified for 10.0.0.0/16 i.e., `10.0.1.71`

Exercise 2.8:

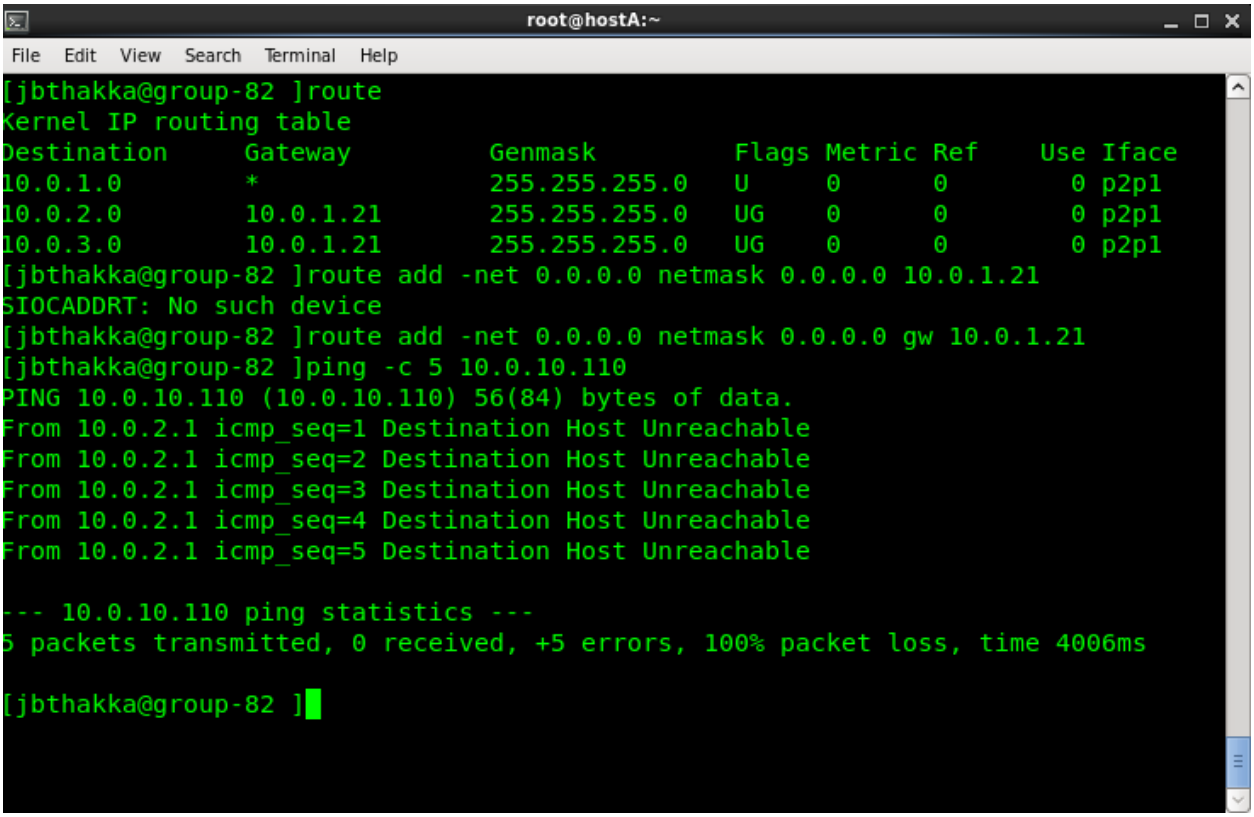
The route on PC A is set as shown below:



The routes on PC B are set as shown below:



1. When the ping command is issued on PC A we get the following message – destination host unreachable from the FastEthernet0/0 interface on Router A.



2. The ICMP Echo Request message travels from PC A to PC B to Router A, and then Router A sends a **`Destination Host Unreachable`** response when it can no longer forward the packet any longer because of no existing paths.
3. There are no ICMP Echo Replies received by A – just **`ICMP Destination Unreachable (Host Unreachable)`** packets from the Router A (10.0.2.1).