Lab Report 1:

Strategy: We pinged all devices in adjacent subnets from each device in a certain subnet (e.g., pinging R2 F1/0 and R1 eth1 from PC3, PC4, PC5). In some cases, we had to edit the /etc/networking/interfaces file and ensure the default gateway to reach neighboring subnets was correct, then restart the networking service using the command: sudo /etc/init.d/networking restart. We also ran wireshark on connections that were part of the route we took in order to verify that ping requests were getting successful replies.

A. All pings were successful. The pings within this subnet had faster RTT than pings outside the subnet. Occasionally, an ARP was sent to verify which devices had a certain IP address.The below wireshark capture came from the R3-SW1 connection.

```
R3#ping 10.1.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/10/12 ms
R3#ping 10.1.3.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.3.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/22/32 ms
R3#ping 10.1.2.4

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.2.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/35/40 ms
```

17	120.117702	ca:01:31:a2:00:38	ca:01:31:a2:00:38	LOOP	60	Reply
18	128.205572	10.1.3.3	10.1.3.1	ICMP	114	Echo (ping) request id=0x0003, seq=0/0, ttl=255 (reply in 19)
19	128.206547	10.1.3.1	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0003, seq=0/0, ttl=64 (request in 18)
20	128.216483	10.1.3.3	10.1.3.1	ICMP	114	Echo (ping) request id=0x0003, seq=1/256, ttl=255 (reply in 21)
21	128.217284	10.1.3.1	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0003, seq=1/256, ttl=64 (request in 20)
22	128.228045	10.1.3.3	10.1.3.1	ICMP	114	Echo (ping) request id=0x0003, seq=2/512, ttl=255 (reply in 23)
23	128.228995	10.1.3.1	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0003, seq=2/512, ttl=64 (request in 22)
24	128.237795	10.1.3.3	10.1.3.1	ICMP	114	Echo (ping) request id=0x0003, seq=3/768, ttl=255 (reply in 25)
25	128.238755	10.1.3.1	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0003, seq=3/768, ttl=64 (request in 24)
26	128.248515	10.1.3.3	10.1.3.1	ICMP	114	Echo (ping) request id=0x0003, seq=4/1024, ttl=255 (reply in 27)
27	128.249492	10.1.3.1	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0003, seq=4/1024, ttl=64 (request in 26)
28	130.109091	ca:01:31:a2:00:38	ca:01:31:a2:00:38	LOOP	60	Reply
29	132.232801	10.1.3.3	10.1.3.2	ICMP	114	Echo (ping) request id=0x0004, seq=0/0, ttl=255 (reply in 30)
30	132.237856	10.1.3.2	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0004, seq=0/0, ttl=255 (request in 29)
31	132.248446	10.1.3.3	10.1.3.2	ICMP	114	Echo (ping) request id=0x0004, seq=1/256, ttl=255 (reply in 32)
32	132.260302	10.1.3.2	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0004, seq=1/256, ttl=255 (request in 31)
33	132.271042	10.1.3.3	10.1.3.2	ICMP	114	Echo (ping) request id=0x0004, seq=2/512, ttl=255 (reply in 34)
34	132.282112	10.1.3.2	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0004, seq=2/512, ttl=255 (request in 33)
35	132.292848	10.1.3.3	10.1.3.2	ICMP	114	Echo (ping) request id=0x0004, seq=3/768, ttl=255 (reply in 36)
36	132.302633	10.1.3.2	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0004, seq=3/768, ttl=255 (request in 35)
37	132.313354	10.1.3.3	10.1.3.2	ICMP	114	Echo (ping) request id=0x0004, seq=4/1024, ttl=255 (reply in 38)
38	132.323104	10.1.3.2	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0004, seq=4/1024, ttl=255 (request in 37)
39	133.222445	PcsCompu_2f:cf:4c	ca:01:31:a2:00:38	ARP	60	Who has 10.1.3.3? Tell 10.1.3.1
40	133.232523	ca:01:31:a2:00:38	PcsCompu_2f:cf:4c	ARP	60	10.1.3.3 is at ca:01:31:a2:00:38
41	137.190359	10.1.3.3	10.1.2.4	ICMP	114	Echo (ping) request id=0x0005, seq=0/0, ttl=255 (reply in 42)
42	137.213631	10.1.2.4	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0005, seq=0/0, ttl=254 (request in 41)
43	137.224395	10.1.3.3	10.1.2.4	ICMP	114	Echo (ping) request id=0x0005, seq=1/256, ttl=255 (reply in 44)
44	137.244863	10.1.2.4	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0005, seq=1/256, ttl=254 (request in 43)
45	137.255621	10.1.3.3	10.1.2.4	ICMP	114	Echo (ping) request id=0x0005, seq=2/512, ttl=255 (reply in 46)
46	137.276096	10.1.2.4	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0005, seq=2/512, ttl=254 (request in 45)
47	137.287004	10.1.3.3	10.1.2.4	ICMP	114	Echo (ping) request id=0x0005, seq=3/768, ttl=255 (reply in 48)
48	137.311242	10.1.2.4	10.1.3.3	ICMP	114	Echo (ping) reply id=0x0005, seq=3/768, ttl=254 (request in 47)
49	137.324923	10.1.3.3	10.1.2.4	ICMP	114	Echo (ping) request id=0x0005, seq=4/1024, ttl=255 (reply in 50)

B. The Cisco routers were able to successfully return pings, but the Ubuntu router did not.

```
R3#ping 10.1.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.2.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
R3#ping 10.1.2.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/24/40 ms
R3#ping 10.1.2.4

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.2.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/24/40 ms
R3#
```

1	0.000000	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0004, seq=0/0, ttl=254 (no response found!)
2	1.965692	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0004, seq=1/256, ttl=254 (no response found!)
3	3.981944	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0004, seq=2/512, ttl=254 (no response found!)
4	5.990751	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0004, seq=3/768, ttl=254 (no response found!)
5	7.980824	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0004, seq=4/1024, ttl=254 (no response found!)
6	29.751190	ca:03:31:f5:00:00	CDP/VTP/DTP/PAgP/UD…	CDP	357	Device ID: R4 Port ID: FastEthernet0/0
7	30.219712	ca:02:31:c1:00:1c	CDP/VTP/DTP/PAgP/UD…	CDP	357	Device ID: R2 Port ID: FastEthernet1/0
8	31.707081	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0005, seq=0/0, ttl=254 (no response found!)
9	33.697793	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0005, seq=1/256, ttl=254 (no response found!)
10	35.680575	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0005, seq=2/512, ttl=254 (no response found!)
11	37.700605	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0005, seq=3/768, ttl=254 (no response found!)
12	39.687037	10.1.3.3	10.1.2.1	ICMP	114	Echo (ping) request id=0x0005, seq=4/1024, ttl=254 (no response found!)
13	89.737188	ca:03:31:f5:00:00	CDP/VTP/DTP/PAgP/UD…	CDP	357	Device ID: R4 Port ID: FastEthernet0/0
14	90.196395	ca:02:31:c1:00:1c	CDP/VTP/DTP/PAgP/UD…	CDP	357	Device ID: R2 Port ID: FastEthernet1/0

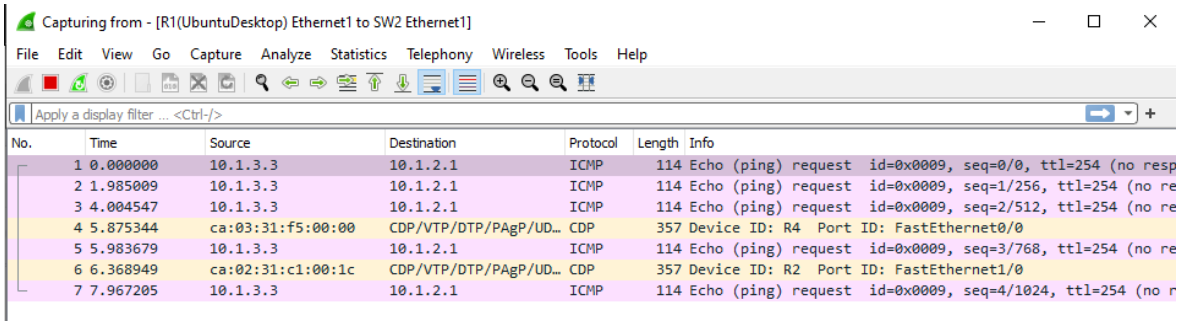
C. All routers (R1, R2, R4) were successfully able to ping all IP addresses on R3.

```
R2#ping 10.1.3.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/23/28 ms
R2#ping 10.1.4.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.4.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/19/32 ms
R2#ping 10.1.5.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.5.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/24/32 ms
R2#
```

```
R4#ping 10.1.3.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/19/24 ms
R4#ping 10.1.4.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.4.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/22/28 ms
R4#ping 10.1.5.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.5.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 24/29/40 ms
```

```
[redacted]@UbuntuDesktop:~$ ping 10.1.3.3
PING 10.1.3.3 (10.1.3.3) 56(84) bytes of data.
64 bytes from 10.1.3.3: icmp_seq=1 ttl=255 time=11.0 ms
64 bytes from 10.1.3.3: icmp_seq=2 ttl=255 time=9.33 ms
64 bytes from 10.1.3.3: icmp_seq=3 ttl=255 time=11.4 ms
64 bytes from 10.1.3.3: icmp_seq=4 ttl=255 time=4.41 ms
64 bytes from 10.1.3.3: icmp_seq=5 ttl=255 time=4.57 ms
^C
--- 10.1.3.3 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4163ms
rtt min/avg/max/mdev = 4.411/8.159/11.438/3.078 ms
[redacted]@UbuntuDesktop:~$ ping 10.1.4.1
PING 10.1.4.1 (10.1.4.1) 56(84) bytes of data.
64 bytes from 10.1.4.1: icmp_seq=1 ttl=255 time=16.2 ms
64 bytes from 10.1.4.1: icmp_seq=2 ttl=255 time=10.1 ms
64 bytes from 10.1.4.1: icmp_seq=3 ttl=255 time=7.37 ms
64 bytes from 10.1.4.1: icmp_seq=4 ttl=255 time=8.59 ms
64 bytes from 10.1.4.1: icmp_seq=5 ttl=255 time=11.8 ms
^C
--- 10.1.4.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4007ms
rtt min/avg/max/mdev = 7.375/10.839/16.245/3.089 ms
[redacted]@UbuntuDesktop:~$ ping 10.1.5.1
PING 10.1.5.1 (10.1.5.1) 56(84) bytes of data.
64 bytes from 10.1.5.1: icmp_seq=1 ttl=255 time=5.11 ms
64 bytes from 10.1.5.1: icmp_seq=2 ttl=255 time=5.49 ms
64 bytes from 10.1.5.1: icmp_seq=3 ttl=255 time=13.6 ms
64 bytes from 10.1.5.1: icmp_seq=4 ttl=255 time=8.17 ms
^C
--- 10.1.5.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3218ms
```

D. The ubuntu router in part(b) was not forwarding packets from its eth0 port to eth1. We checked R1->SW2 with wireshark, and found that packets were being directed using the following path: R3->R2->R1. SW2 sent ARP requests that R1 replied to, but the ping still received no response.When we ran wireshark from SW1 -> R2, no traffic was captured.



E. Reverse-path filtering is a possible solution to this, it allows for asymmetric routing, which solves the issue for when R3 could not route to R1.

Lab Report 2:

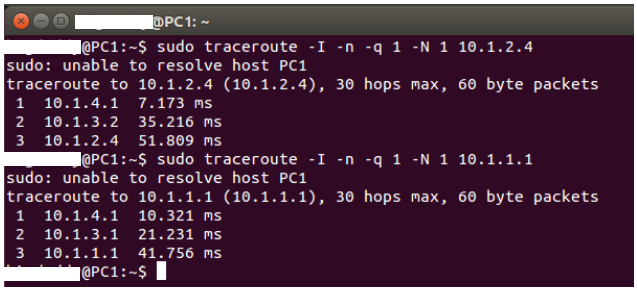
We think that R2 is only forwarding packets from the 10.1.3.0 subnet to the 10.1.2.0 subnet in one direction. We edited the /etc/sysctl.conf file to enable loose filtering by setting net.ipv4.conf.all.rp_filter=2 and enabling the default filter. After restarting the linux router, the ICMP ping from 10.1.3.3 to 10.1.2.1 successfully returned.

```
R3#ping 10.1.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/24/52 ms
```

Lab Report 3:

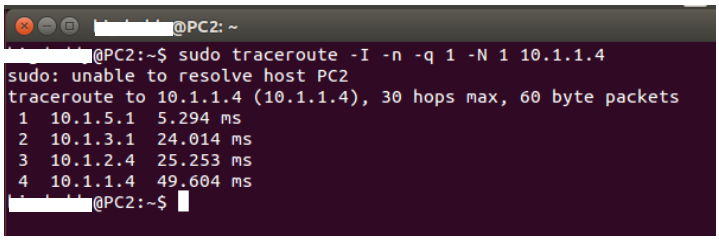
A. PC1 sent out 1 packet.
B. Route: **PC1**->R3->SW1->R2->SW2->**R4**->SW2->R1->SW1->R3->**PC1**
   It's interesting that the probe packets took an asymmetric route back.
C. PC1 received 3 reply packets from R3, R2, and R4
   i. R3 -> PC1
   ii. R2 -> SW1 -> R3 -> PC1
   iii. R4 -> SW2 -> R1 -> SW1 -> R3 -> PC1
D. Yes, they were successful. The path that was taken is a valid path to R4.

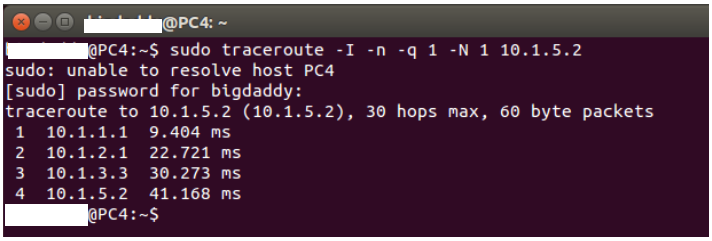
Lab Report 4:



These routes are not congruent because we added a new static route for R3 that directs traffic to the 10.1.1.0 subnet to take 10.1.3.1 as its next hop. Since R3 does not recognize the 10.1.2.0 subnet, it sends packets with that destination address to its default gateway - 10.1.3.1(R1).

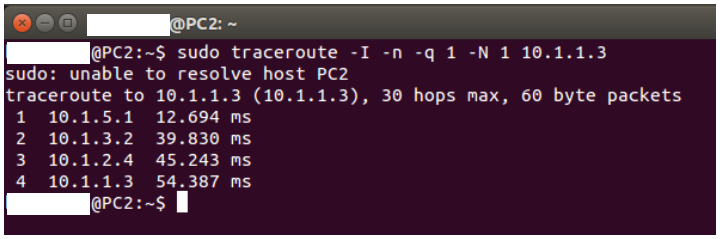
Lab Report 5:

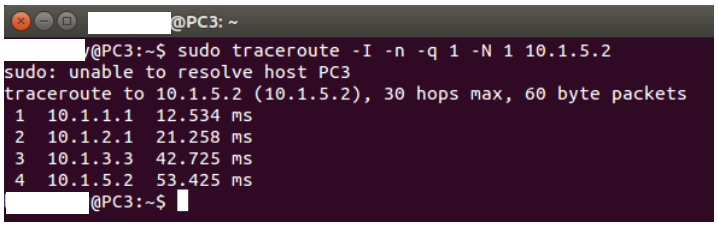




These routes are symmetric. This is because the static routes were configured in a symmetric manner. PC2's default gateway, R3, routes traffic heading to the 10.1.1.0 subnet to R1, then R1 routes to R4. Conversely, PC4's default gateway, R4, routes traffic heading to the 1.1.5.0 subnet to R1, then R1 routes to R3.

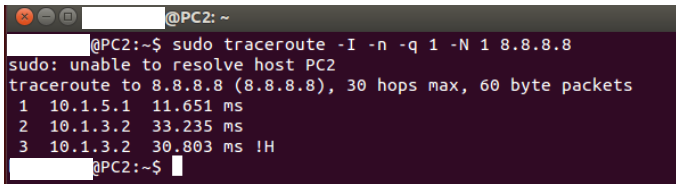
Lab Report 6:

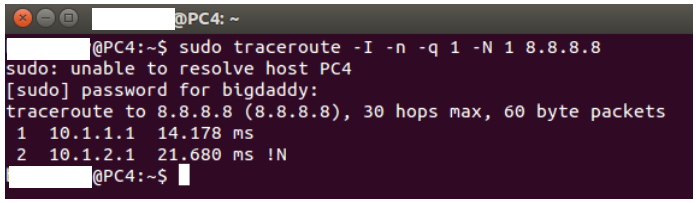




These routes are asymmetric. This is because we configured R3 to treat PC3 as its own subnet with its next hop being 10.1.3.2. Conversely, PC3's traceroute to PC2 is being routed from its default gateway, R3 to R1 since we have a static route that tells R3 to route packets heading to the 1.1.5.0 subnet to R1.

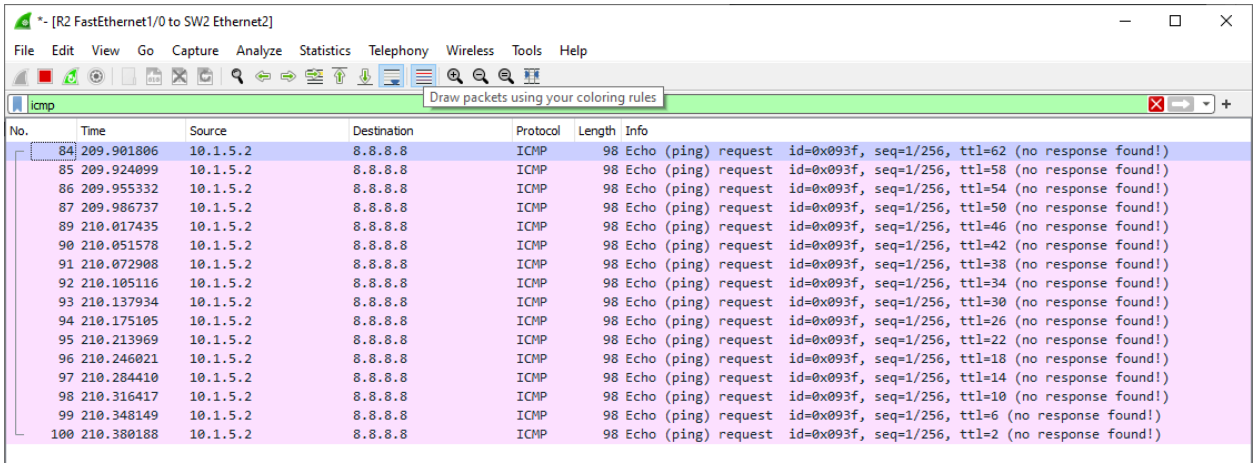
Lab Report 7:





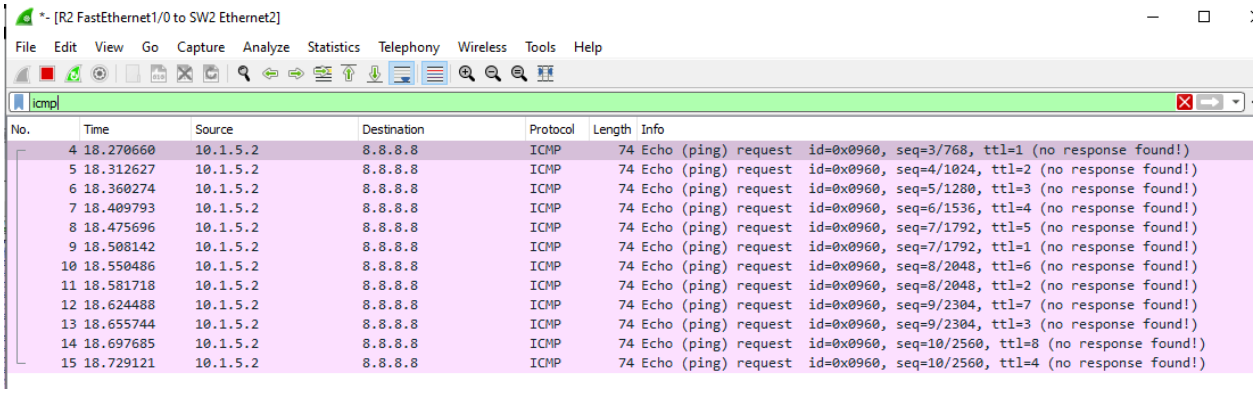
Both PC2's traceroute determined that the host is unreachable, while PC4 determined that the network was unreachable. In PC2's case, this is because its default gateway, R3, defaults to R2. Because R2 has no default gateway, it resolves as the host not being found. A similar thing happens with PC4, but in its case, its default gateway (R4) defaults to R1. Since R1 has no default gateway, it returns unresolved.

Lab Report 8:



The ping only sent out 1 packet. Wireshark captured 1 packet being sent out 17 times, albeit at different intervals. The last capture of the ICMP request (frame 100) was right before the request expired. This is observed by looking at its TTL. That is because we created a routing loop by adding a default gateway that directs traffic from R2 -> R4, and another default gateway that directs traffic from R1 -> R3. This creates a loop for our default gateways (i.e., default traffic that enters at R3 takes the path R3->R2->R4->R1->R3…).

Lab Report 9:



There are 12 packets being captured in this example. As specified in the traceroute command the max amount of hops (max ttl) will be 10. In wireshark we can see 12 packets being recorded all with the same source ip as PC2, and same id. The packets captured by wireshark are responses from the routers with the id of the packet, the sequence and the time to live of the packet. The information we see on wireshark is used to determine the amount of hops to that router, we see that a response packet with a ttl=8 is 8 hops out, we also see that another probe packet is to be sent out simultaneously and it had a max ttl of 4. We see that the sequence number is the amount of hops we are allowed, there are 10 sequences, each packet shows in which sequence they are in. The mapping we have can be seen from the table below:

Device	Sequence	TTL	Next-Hop
PC2	0	-	R3
R3	1	-	SW1
SW1	2	-	R2
R2	3	1	SW2
SW2	4	2	R4
R4	5	3	SW3
SW3	6	4	R4
SW3	7	5	R4
R4	7	1	SW2
R4	8	6	SW2
SW2	8	2	R1
SW2	9	7	R2
R1	9	3	SW1
R2	10	8	-
SW1	10	4	-