

CSE 232: Programming Assignment 1

Using Command-Line Utilities for Network Debugging

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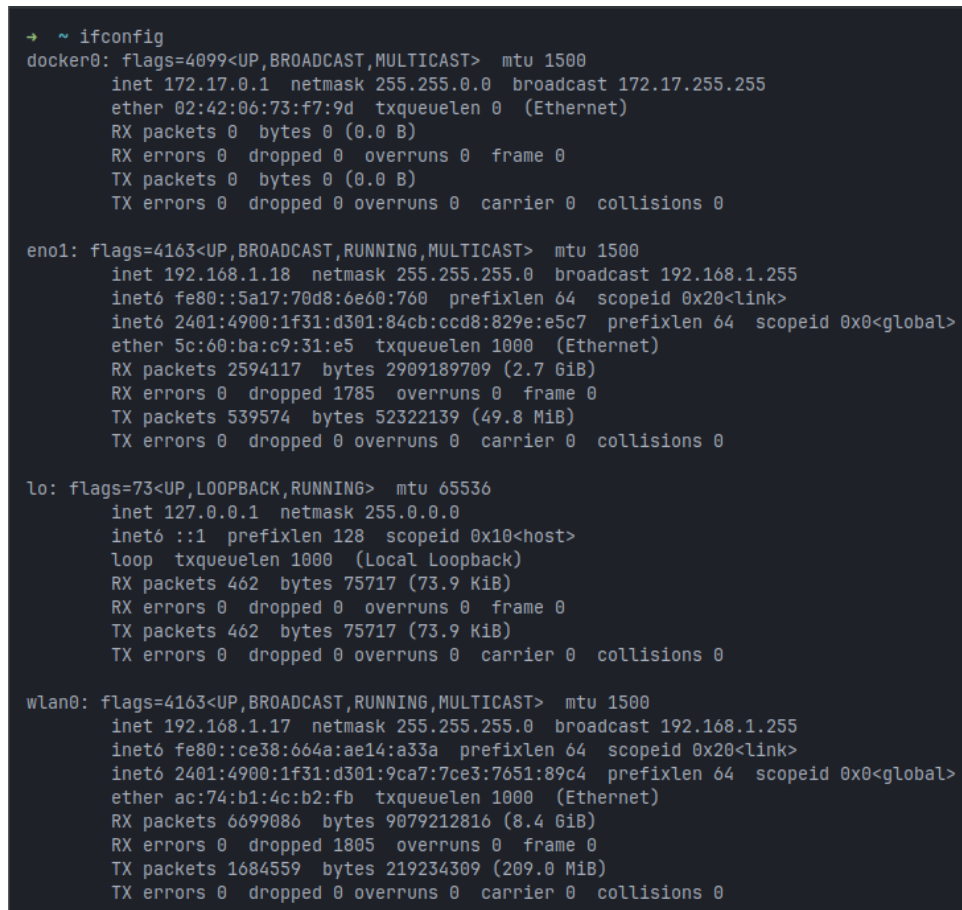
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1 IP Address of Network Interface

Command Used:

ifconfig

Screenshot:



```
→ ~ ifconfig
docker0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.17.0.1 netmask 255.255.0.0 broadcast 172.17.255.255
    ether 02:42:06:73:f7:9d txqueuelen 0 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

eno1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.18 netmask 255.255.255.0 broadcast 192.168.1.255
    inet6 fe80::5a17:70d8:6e60:760 prefixlen 64 scopeid 0x20<link>
    inet6 2401:4900:1f31:d301:84cb:ccd8:829e:e5c7 prefixlen 64 scopeid 0x0<global>
    ether 5c:60:ba:c9:31:e5 txqueuelen 1000 (Ethernet)
    RX packets 2594117 bytes 2909189709 (2.7 GiB)
    RX errors 0 dropped 1785 overruns 0 frame 0
    TX packets 539574 bytes 52322139 (49.8 MiB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 462 bytes 75717 (73.9 KiB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 462 bytes 75717 (73.9 KiB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.17 netmask 255.255.255.0 broadcast 192.168.1.255
    inet6 fe80::ce38:664a:ae14:a33a prefixlen 64 scopeid 0x20<link>
    inet6 2401:4900:1f31:d301:9ca7:7ce3:7651:89c4 prefixlen 64 scopeid 0x0<global>
    ether ac:74:b1:4c:b2:fb txqueuelen 1000 (Ethernet)
    RX packets 6699086 bytes 9079212816 (8.4 GiB)
    RX errors 0 dropped 1805 overruns 0 frame 0
    TX packets 1684559 bytes 219234309 (209.0 MiB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Figure 1: IP address of network interface

2 IP Address from Webpage

Website Used: <https://www.whatismyip.com>

Observation: The IP address on terminal 192.168.1.17 differs from the IP address on the website 122.179.207.70.

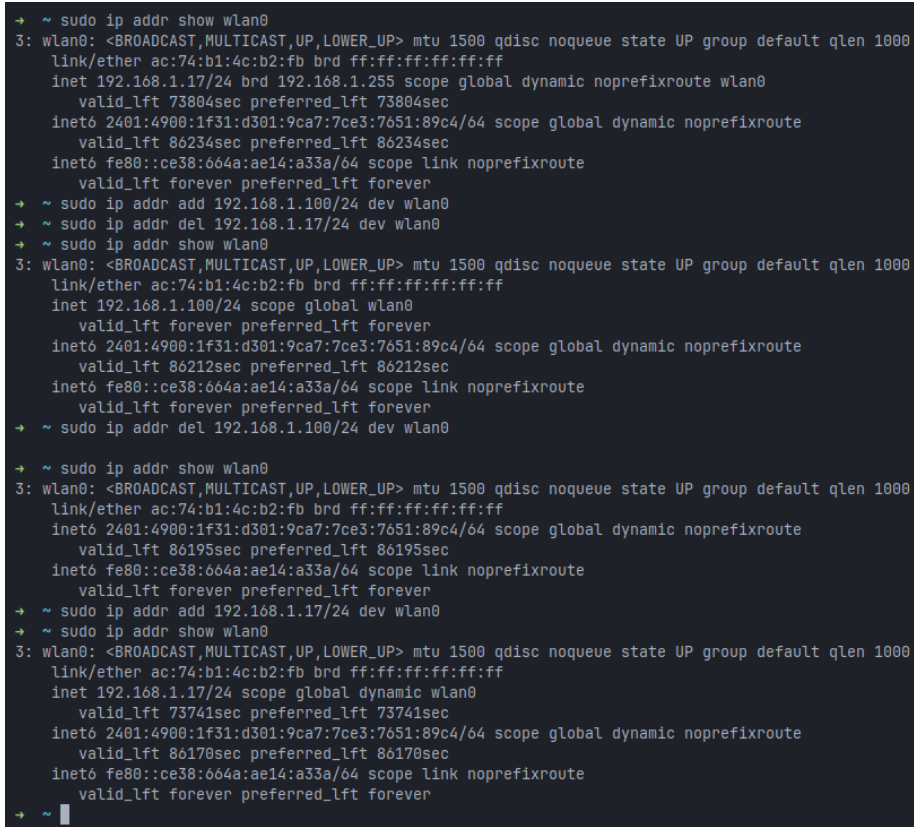
Explanation: The IP address from ifconfig is a private IP address assigned to my device within the local network (LAN). The IP address shown on the website is the public IP address assigned to my network by the Internet Service Provider (ISP). This difference occurs due to Network Address Translation (NAT), which allows multiple devices on a local network to share a single public IP address when accessing the internet.

3 Changing the IP Address

Command Used:

```
sudo ip addr show wlan0
sudo ip addr add 192.168.1.100/24 dev wlan0
sudo ip addr del 192.168.1.17/24 dev wlan0
sudo ip addr show wlan0
sudo ip addr del 192.168.1.100/24 dev wlan0
sudo ip addr add 192.168.1.17/24 dev wlan0
sudo ip addr show wlan0
```

Screenshot:



```
→ ~ sudo ip addr show wlan0
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether ac:74:b1:4c:b2:fb brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.17/24 brd 192.168.1.255 scope global dynamic noprefixroute wlan0
        valid_lft 73804sec preferred_lft 73804sec
    inet6 2401:4900:1f31:d301:9ca7:7ce3:7651:89c4/64 scope global dynamic noprefixroute
        valid_lft 86234sec preferred_lft 86234sec
    inet6 fe80::ce38:664a:ae14:a33a/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
→ ~ sudo ip addr add 192.168.1.100/24 dev wlan0
→ ~ sudo ip addr del 192.168.1.17/24 dev wlan0
→ ~ sudo ip addr show wlan0
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether ac:74:b1:4c:b2:fb brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.100/24 scope global wlan0
        valid_lft forever preferred_lft forever
    inet6 2401:4900:1f31:d301:9ca7:7ce3:7651:89c4/64 scope global dynamic noprefixroute
        valid_lft 86212sec preferred_lft 86212sec
    inet6 fe80::ce38:664a:ae14:a33a/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
→ ~ sudo ip addr del 192.168.1.100/24 dev wlan0

→ ~ sudo ip addr show wlan0
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether ac:74:b1:4c:b2:fb brd ff:ff:ff:ff:ff:ff
    inet6 2401:4900:1f31:d301:9ca7:7ce3:7651:89c4/64 scope global dynamic noprefixroute
        valid_lft 86195sec preferred_lft 86195sec
    inet6 fe80::ce38:664a:ae14:a33a/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
→ ~ sudo ip addr add 192.168.1.17/24 dev wlan0
→ ~ sudo ip addr show wlan0
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether ac:74:b1:4c:b2:fb brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.17/24 scope global dynamic wlan0
        valid_lft 73741sec preferred_lft 73741sec
    inet6 2401:4900:1f31:d301:9ca7:7ce3:7651:89c4/64 scope global dynamic noprefixroute
        valid_lft 86170sec preferred_lft 86170sec
    inet6 fe80::ce38:664a:ae14:a33a/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
→ ~ █
```

Figure 2: IP address change

4 Setting up a TCP Client/Server Connection

Command Used:

```
nc -v -l -p 1234 (on server)
nc localhost 1234 (on client)
```

Screenshot:



The screenshot shows two terminal windows. The top window, titled 'nc -v -l -p 1234', is running a netcat listener. It shows a connection from 127.0.0.1:36388 and receives the messages 'hello', 'this is from client side', and 'this is form local host'. The bottom window, titled 'nc localhost 1234', is running a netcat client. It sends the same three messages to the server.

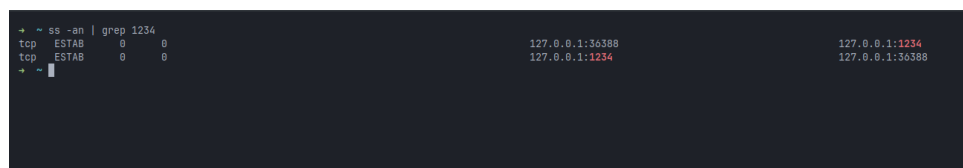
Figure 3: TCP client/server connection

5 TCP Connection State

Command Used:

```
ss -an | grep 1234
```

Screenshot:



The screenshot shows a terminal window with the command 'ss -an | grep 1234' executed. The output displays two established TCP connections. The first line shows a connection from 127.0.0.1:36388 to 127.0.0.1:1234. The second line shows a connection from 127.0.0.1:1234 to 127.0.0.1:36388. The state for both connections is 'ESTAB'.

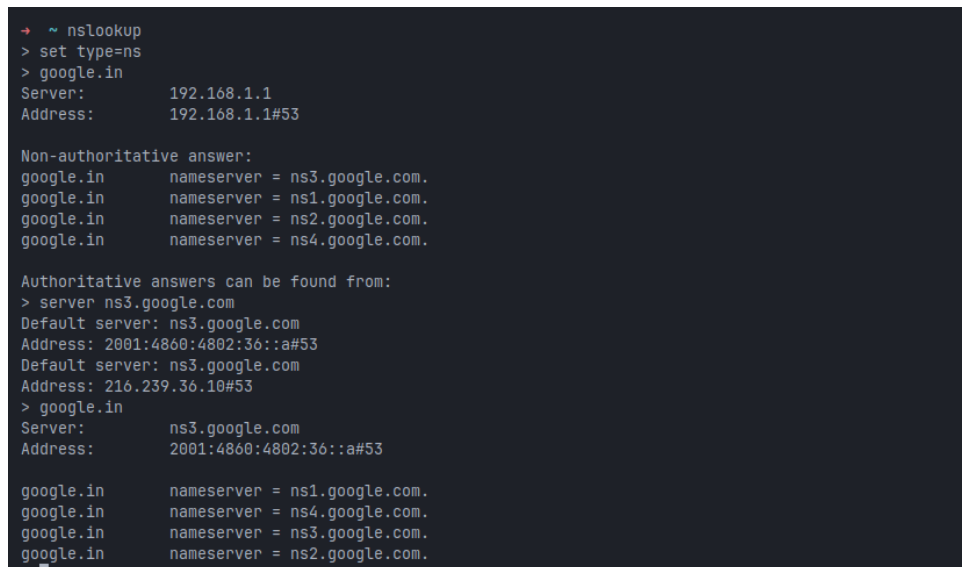
Figure 4: TCP connection state

6 Authoritative nslookup Result

Command Used:

```
nslookup
set type=ns
google.in
server ns3.google.com
google.in
```

Screenshot:



```
→ ~ nslookup
> set type=ns
> google.in
Server:      192.168.1.1
Address:     192.168.1.1#53

Non-authoritative answer:
google.in    nameserver = ns3.google.com.
google.in    nameserver = ns1.google.com.
google.in    nameserver = ns2.google.com.
google.in    nameserver = ns4.google.com.

Authoritative answers can be found from:
> server ns3.google.com
Default server: ns3.google.com
Address: 2001:4860:4802:36::a#53
Default server: ns3.google.com
Address: 216.239.36.10#53
> google.in
Server:      ns3.google.com
Address:     2001:4860:4802:36::a#53

google.in    nameserver = ns1.google.com.
google.in    nameserver = ns4.google.com.
google.in    nameserver = ns3.google.com.
google.in    nameserver = ns2.google.com.
```

Figure 5: Authoritative nslookup result

Explanation: The authoritative DNS record for `google.in` was obtained using `nslookup`. First, the query type was set to `NS` to find its authoritative name servers. Then, `ns3.google.com` was used as the DNS server to retrieve the authoritative records directly from Google’s name server.

7 Time to Live (TTL) for a Website

Command Used:

```
nslookup -debug aliexpress.com
```

TTL Observation: The Time to Live (TTL) for the DNS entry of `aliexpress.com` on the local DNS server is 571 seconds.

Explanation: The TTL value indicates the remaining time (in seconds) before the DNS entry for `aliexpress.com` will expire from the local DNS cache. After 571 seconds, the entry will be considered stale, and the DNS server will need to query an authoritative DNS server to refresh the information. This value controls how long a DNS resolver can cache a response before needing to check for an updated record.

Screenshot:

```

→ ~ nslookup -debug aliexpress.com
Server:      192.168.1.1
Address:     192.168.1.1#53

-----
      QUESTIONS:
        aliexpress.com, type = A, class = IN
      ANSWERS:
-> aliexpress.com
    internet address = 47.246.173.237
    ttl = 571
-> aliexpress.com
    internet address = 47.246.173.30
    ttl = 571
      AUTHORITY RECORDS:
      ADDITIONAL RECORDS:
-----
Non-authoritative answer:
Name:   aliexpress.com
Address: 47.246.173.237
Name:   aliexpress.com
Address: 47.246.173.30
-----
      QUESTIONS:
        aliexpress.com, type = AAAA, class = IN
      ANSWERS:
      AUTHORITY RECORDS:
-> aliexpress.com
    origin = ns1.alibabadns.com
    mail addr = hostmaster.alibabadns.com
    serial = 2018051019
    refresh = 3600
    retry = 1200
    expire = 86400
    minimum = 360
    ttl = 211
      ADDITIONAL RECORDS:
-----

```

Figure 6: Time to Live (TTL)

8 Traceroute to google.in

Command Used:

```
traceroute google.in
```

8.1 IP Addresses and Average Latency to Each Intermediate Host

- 192.168.1.1: Average latency = ≈ 0.802 ms
- 125.18.73.17: Average latency = ≈ 6.474 ms
- 125.21.160.21: Average latency = 6.665 ms
- 182.79.152.79: Average latency = ≈ 10.440 ms
- 142.250.161.56: Average latency = ≈ 11.262 ms
- 172.253.67.100: Average latency = ≈ 8.998 ms
- 192.178.83.220: Average latency = ≈ 9.938 ms
- 142.250.234.126: Average latency = ≈ 27.985 ms
- 192.178.110.245: Average latency = ≈ 22.715 ms
- 142.250.226.135: Average latency = ≈ 31.583 ms
- 142.250.214.103: Average latency = ≈ 29.811 ms
- 142.250.182.228: Average latency = ≈ 27.476 ms

Screenshot:

```
* ~ traceroute google.in
traceroute to google.in (142.250.182.228), 30 hops max, 60 byte packets
 1 _gateway (192.168.1.1) 0.594 ms 0.816 ms 0.996 ms
 2 abts-north-dynamic-255.47.161.122.airtelbroadband.in (122.161.47.255) 5.554 ms 5.691 ms 5.796 ms
 3 125.18.73.17 (125.18.73.17) 6.665 ms 125.21.160.21 (125.21.160.21) 6.393 ms 125.18.73.17 (125.18.73.17) 6.554 ms
 4 182.79.152.79 (182.79.152.79) 11.824 ms 7.535 ms 11.964 ms
 5 142.250.161.56 (142.250.161.56) 11.128 ms 10.788 ms 11.877 ms
 6 * * *
 7 172.253.67.100 (172.253.67.100) 11.764 ms 142.251.76.170 (142.251.76.170) 8.040 ms 142.250.236.54 (142.250.236.54) 7.189 ms
 8 192.178.83.220 (192.178.83.220) 7.335 ms 192.178.83.226 (192.178.83.226) 12.489 ms 192.178.83.214 (192.178.83.214) 9.991 ms
 9 142.250.234.126 (142.250.234.126) 27.392 ms 27.802 ms 142.250.230.116 (142.250.230.116) 28.760 ms
10 192.178.110.245 (192.178.110.245) 30.189 ms 172.253.68.121 (172.253.68.121) 26.500 ms 172.253.66.107 (172.253.66.107) 9.395 ms
11 142.250.226.135 (142.250.226.135) 31.931 ms 142.250.214.105 (142.250.214.105) 31.583 ms 192.178.110.245 (192.178.110.245) 27.508 ms
12 142.250.214.103 (142.250.214.103) 28.401 ms 142.251.77.69 (142.251.77.69) 28.633 ms 142.250.214.103 (142.250.214.103) 32.399 ms
13 bom07s29-in-f4.1e100.net (142.250.182.228) 27.389 ms 27.213 ms 27.628 ms
```

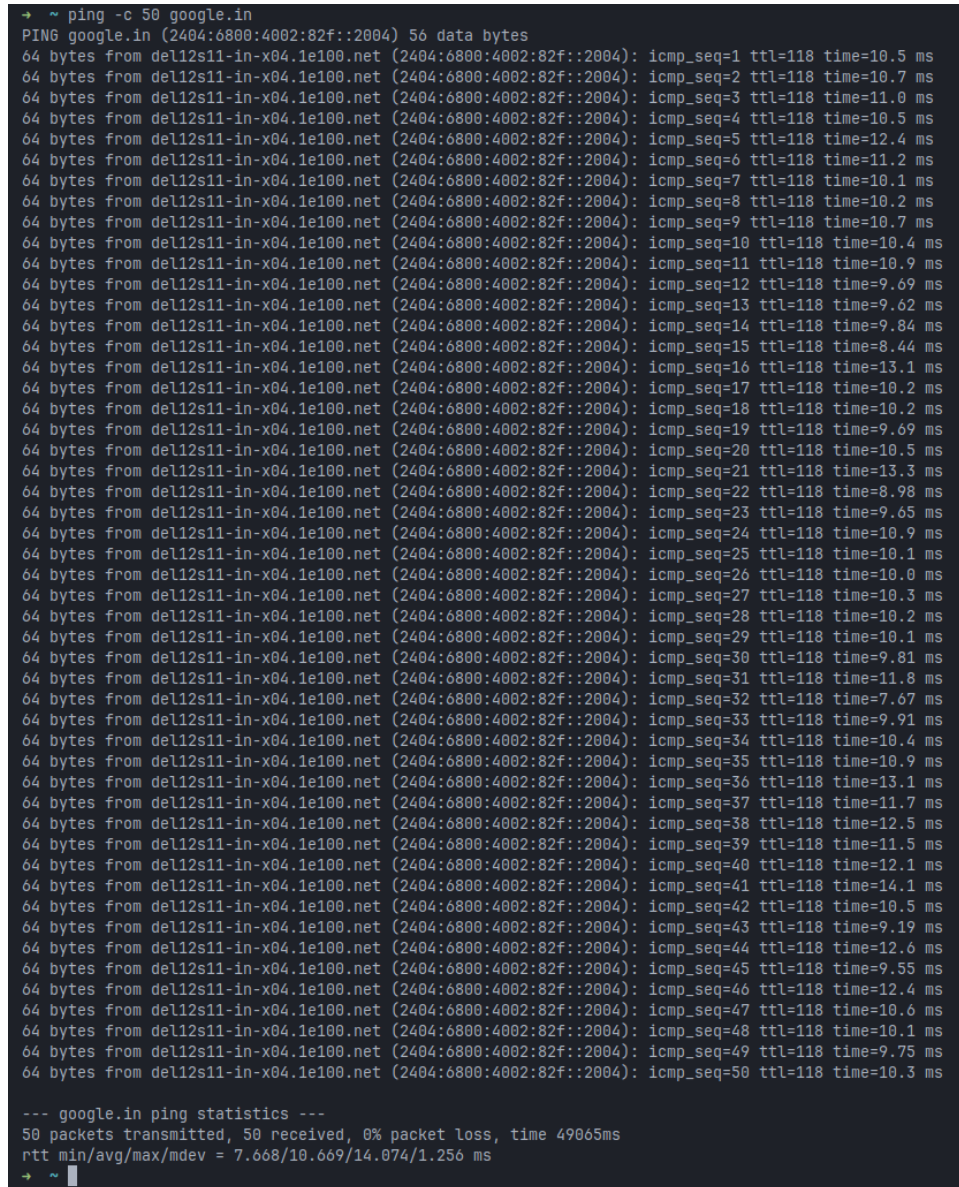
Figure 7: Traceroute to google.in

9 Ping Latency to google.in

Command Used:

```
ping -c 50 google.in
```

Screenshot:



```
→ ~ ping -c 50 google.in
PING google.in (2404:6800:4002:82f::2004) 56 data bytes
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=1 ttl=118 time=10.5 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=2 ttl=118 time=10.7 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=3 ttl=118 time=11.0 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=4 ttl=118 time=10.5 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=5 ttl=118 time=12.4 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=6 ttl=118 time=11.2 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=7 ttl=118 time=10.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=8 ttl=118 time=10.2 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=9 ttl=118 time=10.7 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=10 ttl=118 time=10.4 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=11 ttl=118 time=10.9 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=12 ttl=118 time=9.69 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=13 ttl=118 time=9.62 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=14 ttl=118 time=9.84 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=15 ttl=118 time=8.44 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=16 ttl=118 time=13.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=17 ttl=118 time=10.2 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=18 ttl=118 time=10.2 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=19 ttl=118 time=9.69 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=20 ttl=118 time=10.5 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=21 ttl=118 time=13.3 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=22 ttl=118 time=8.98 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=23 ttl=118 time=9.65 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=24 ttl=118 time=10.9 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=25 ttl=118 time=10.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=26 ttl=118 time=10.0 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=27 ttl=118 time=10.3 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=28 ttl=118 time=10.2 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=29 ttl=118 time=10.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=30 ttl=118 time=9.81 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=31 ttl=118 time=11.8 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=32 ttl=118 time=7.67 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=33 ttl=118 time=9.91 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=34 ttl=118 time=10.4 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=35 ttl=118 time=10.9 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=36 ttl=118 time=13.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=37 ttl=118 time=11.7 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=38 ttl=118 time=12.5 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=39 ttl=118 time=11.5 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=40 ttl=118 time=12.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=41 ttl=118 time=14.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=42 ttl=118 time=10.5 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=43 ttl=118 time=9.19 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=44 ttl=118 time=12.6 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=45 ttl=118 time=9.55 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=46 ttl=118 time=12.4 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=47 ttl=118 time=10.6 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=48 ttl=118 time=10.1 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=49 ttl=118 time=9.75 ms
64 bytes from del12s11-in-x04.1e100.net (2404:6800:4002:82f::2004): icmp_seq=50 ttl=118 time=10.3 ms

--- google.in ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49065ms
rtt min/avg/max/mdev = 7.668/10.669/14.074/1.256 ms
→ ~
```

Figure 8: Ping latency to google.in

Average Latency: The average latency to google.in is 10.669 ms.

10 Latency Comparison

10.1 Sum of Latencies from Intermediate Hosts

Total Latency: The sum of the latencies from all intermediate hosts is **193.149 ms**.

10.2 Comparison with Ping Latency

Ping Latency: The average latency to `google.in` from the `ping` command is **10.669 ms**.

10.3 Explanation

The sum of the latencies from the intermediate hosts is much higher than the average latency observed from the `ping` command. This is because the `ping` command measures the round-trip time, which doesn't directly add up the times from each hop. The `traceroute` provides insight into the latency at each hop, but these latencies don't sum to give the round-trip time directly.

11 Maximum Ping Latency

11.1 Maximum Latency from Intermediate Hosts

Maximum Latency: The maximum latency among the intermediate hosts is **31.583** ms from IP address 142.250.226.135.

11.2 Comparison with Ping Latency

Ping Latency: The average latency to `google.in` from the `ping` command is **10.669** ms.

11.3 Explanation

The maximum latency from the intermediate hosts is higher than the average latency observed from the `ping` command. This is because the maximum latency reflects the delay at a specific hop, while the average `ping` latency measures the overall round-trip time. These two metrics serve different purposes and thus may differ significantly.

12 Multiple Entries for a Single Hop

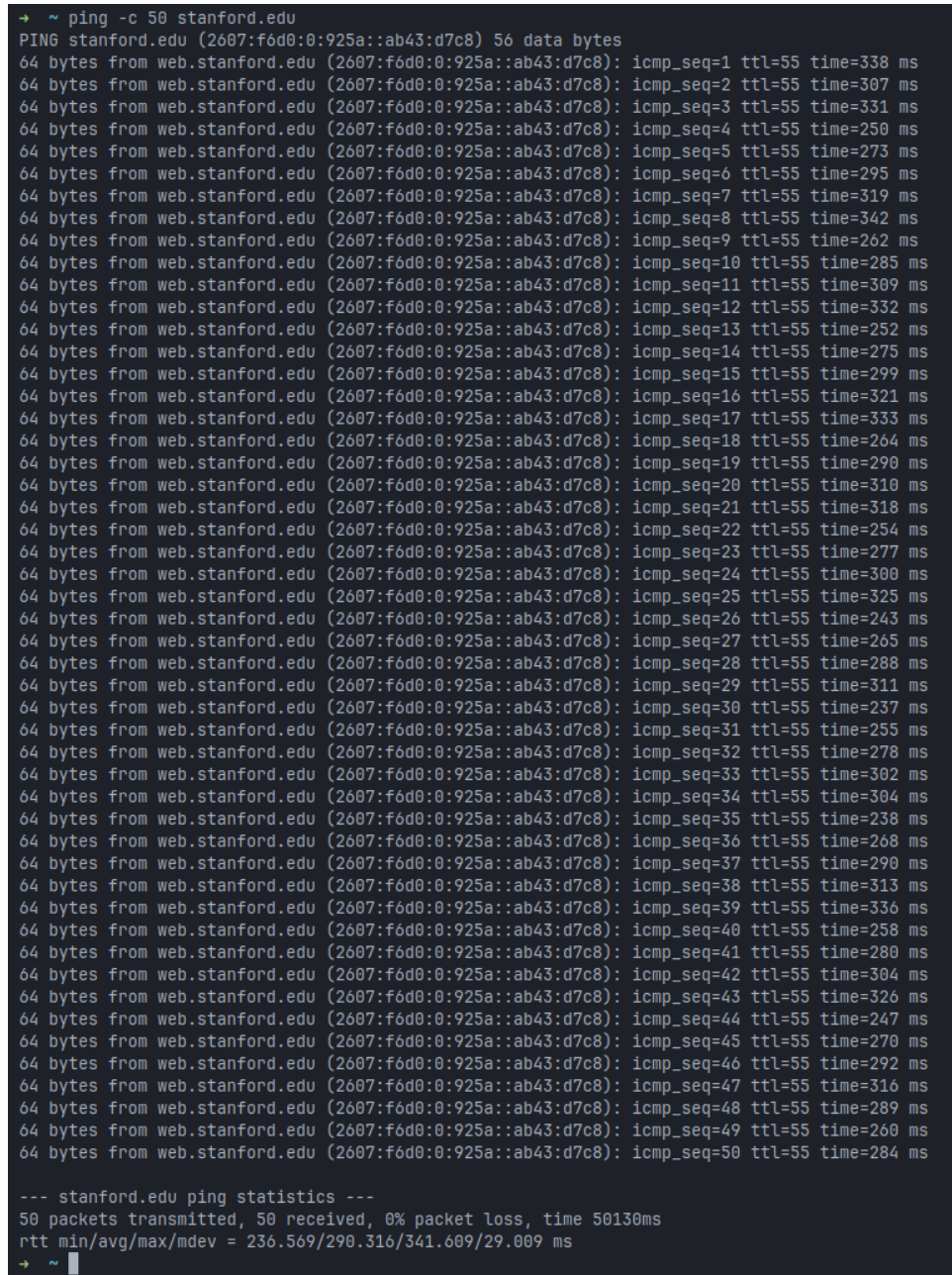
Explanation: Multiple entries for a single hop in the `traceroute` output indicate the presence of multiple potential paths or routes through the network at that particular hop. This is typically due to load balancing, where traffic is distributed across several paths to optimize network performance, or because of variations in ICMP responses from different interfaces or routes.

13 Ping Latency to stanford.edu

Command Used:

```
ping -c 50 stanford.edu
```

Screenshot:



```
→ ~ ping -c 50 stanford.edu
PING stanford.edu (2607:f6d0:0:925a::ab43:d7c8) 56 data bytes
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=1 ttl=55 time=338 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=2 ttl=55 time=307 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=3 ttl=55 time=331 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=4 ttl=55 time=250 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=5 ttl=55 time=273 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=6 ttl=55 time=295 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=7 ttl=55 time=319 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=8 ttl=55 time=342 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=9 ttl=55 time=262 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=10 ttl=55 time=285 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=11 ttl=55 time=309 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=12 ttl=55 time=332 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=13 ttl=55 time=252 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=14 ttl=55 time=275 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=15 ttl=55 time=299 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=16 ttl=55 time=321 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=17 ttl=55 time=333 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=18 ttl=55 time=264 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=19 ttl=55 time=290 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=20 ttl=55 time=310 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=21 ttl=55 time=318 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=22 ttl=55 time=254 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=23 ttl=55 time=277 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=24 ttl=55 time=300 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=25 ttl=55 time=325 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=26 ttl=55 time=243 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=27 ttl=55 time=265 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=28 ttl=55 time=288 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=29 ttl=55 time=311 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=30 ttl=55 time=237 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=31 ttl=55 time=255 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=32 ttl=55 time=278 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=33 ttl=55 time=302 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=34 ttl=55 time=304 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=35 ttl=55 time=238 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=36 ttl=55 time=268 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=37 ttl=55 time=290 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=38 ttl=55 time=313 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=39 ttl=55 time=336 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=40 ttl=55 time=258 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=41 ttl=55 time=280 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=42 ttl=55 time=304 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=43 ttl=55 time=326 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=44 ttl=55 time=247 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=45 ttl=55 time=270 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=46 ttl=55 time=292 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=47 ttl=55 time=316 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=48 ttl=55 time=289 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=49 ttl=55 time=260 ms
64 bytes from web.stanford.edu (2607:f6d0:0:925a::ab43:d7c8): icmp_seq=50 ttl=55 time=284 ms

--- stanford.edu ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 50130ms
rtt min/avg/max/mdev = 236.569/290.316/341.609/29.009 ms
→ ~
```

Figure 9: Ping latency to stanford.edu

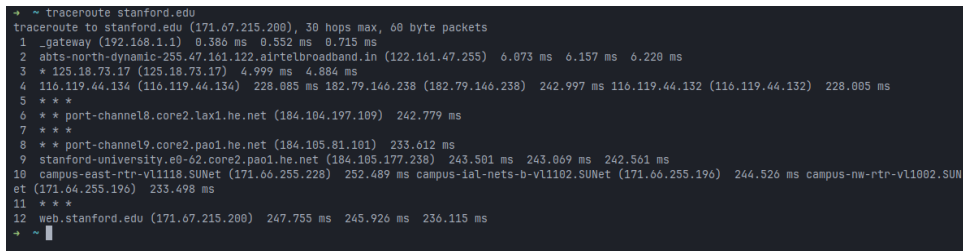
Average Latency: The average latency to stanford.edu is **290.316 ms**.

14 Traceroute to stanford.edu

Command Used:

```
traceroute stanford.edu
```

Screenshot:



```
* ~ traceroute stanford.edu
traceroute to stanford.edu (171.67.215.200), 30 hops max, 60 byte packets
 1  _gateway (192.168.1.1)  0.380 ms  0.552 ms  0.715 ms
 2  abts-north-dynamic-255.47.161.122.airtelbroadband.in (122.161.47.255)  0.073 ms  0.157 ms  0.220 ms
 3  * 125.18.73.17 (125.18.73.17)  4.999 ms  4.884 ms
 4  110.119.44.134 (110.119.44.134)  228.085 ms 182.79.140.238 (182.79.140.238)  242.997 ms 110.119.44.132 (110.119.44.132)  228.005 ms
 5  * * *
 6  * * port-channel8.core2.lax1.he.net (184.104.197.109)  242.779 ms
 7  * * *
 8  * * port-channel9.core2.pao1.he.net (184.105.81.101)  233.612 ms
 9  stanford-university.e0-62.core2.pao1.he.net (184.105.177.238)  243.501 ms 243.069 ms 242.561 ms
10  campus-east-rtr-vl1118.SUNet (171.66.255.228)  252.489 ms campus-lal-nets-b-vl1102.SUNet (171.66.255.196)  244.526 ms campus-nw-rtr-vl1002.SUN
et (171.64.255.196)  233.498 ms
11  * * *
12  web.stanford.edu (171.67.215.200)  247.755 ms 245.926 ms 236.115 ms
~ ~
```

Figure 10: Traceroute to stanford.edu

14.1 Observation

Number of Hops:

- google.in: 13 hops
- stanford.edu: 12 hops

14.2 Comparison

The traceroute to `stanford.edu` has one fewer hop compared to the traceroute to `google.in`. This indicates a slightly shorter network path to `stanford.edu` in terms of the number of devices traversed.

15 Latency Difference Explanation

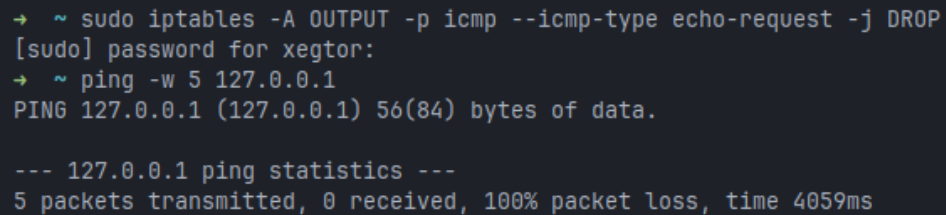
Explanation: The latency difference between `google.in` and `stanford.edu` is primarily due to geographical distance and network routing. `stanford.edu` is located in the United States, which is significantly farther from the client compared to `google.in`, likely located in India or a nearby region. The increased distance and the complexity of international network paths result in higher latency for `stanford.edu`. Additionally, factors such as server load and intermediate network congestion may further contribute to the observed latency differences.

16 Making Ping Fail for 127.0.0.1

Command Used:

```
sudo iptables -A OUTPUT -p icmp --icmp-type echo-request -j DROP
```

Screenshot:



```
→ ~ sudo iptables -A OUTPUT -p icmp --icmp-type echo-request -j DROP
[sudo] password for xegtor:
→ ~ ping -w 5 127.0.0.1
PING 127.0.0.1 (127.0.0.1) 56(84) bytes of data.

--- 127.0.0.1 ping statistics ---
5 packets transmitted, 0 received, 100% packet loss, time 4059ms
```

Figure 11: Ping failure for 127.0.0.1

16.1 Explanation

To make the `ping` command fail for `127.0.0.1` with 100% packet loss, I used the `iptables` command to drop all ICMP echo request packets sent from my system. This effectively blocks all `ping` requests to `127.0.0.1`, resulting in 100% packet loss.