

Computer Networks Assignment 1

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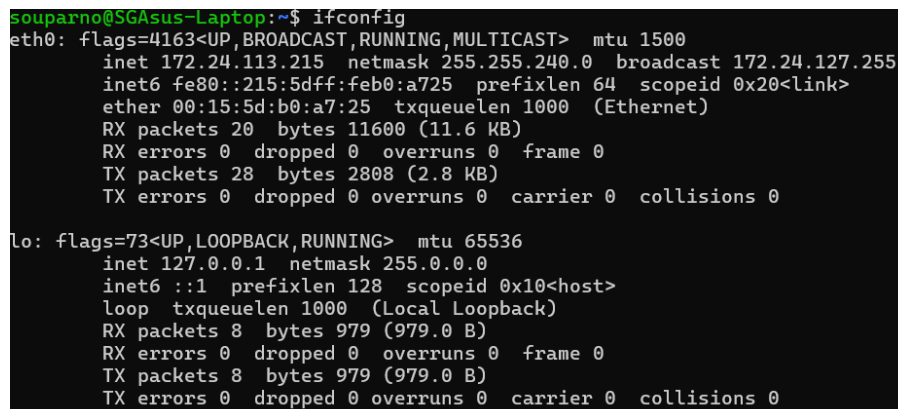
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Question 1

- (a) Learn to use the `ifconfig` command, and figure out the IP address of your network interface. Put a screenshot.
- (b) Go to the webpage <https://www.whatismyip.com> and find out what IP is shown for your machine. Are they identical or different? Why?

Solution

- (a) The IP Address using `ifconfig` is 172.24.113.215.



```
souparno@SGAsus-Laptop:~$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 172.24.113.215 netmask 255.255.240.0 broadcast 172.24.127.255
    inet6 fe80::215:5dff:feb0:a725 prefixlen 64 scopeid 0x20<link>
    ether 00:15:5d:b0:a7:25 txqueuelen 1000 (Ethernet)
    RX packets 20 bytes 11600 (11.6 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 28 bytes 2808 (2.8 KB)
    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 8 bytes 979 (979.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 8 bytes 979 (979.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Figure 1: Screenshot of the `ifconfig` command output

- (b) The IP address shown on the website is different from the IP address shown using `ifconfig`. The IP Address through <https://www.whatismyip.com> is 103.25.231.126. The IP address seen on my local machine, like 172.24.113.215, is a private IP used within the local network. However, when checking a site like <https://www.whatismyip.com>, it shows a different public IP assigned by the ISP, which is visible to the outside world. This difference occurs because the router uses Network Address Translation (NAT) to translate between private and public IP addresses.

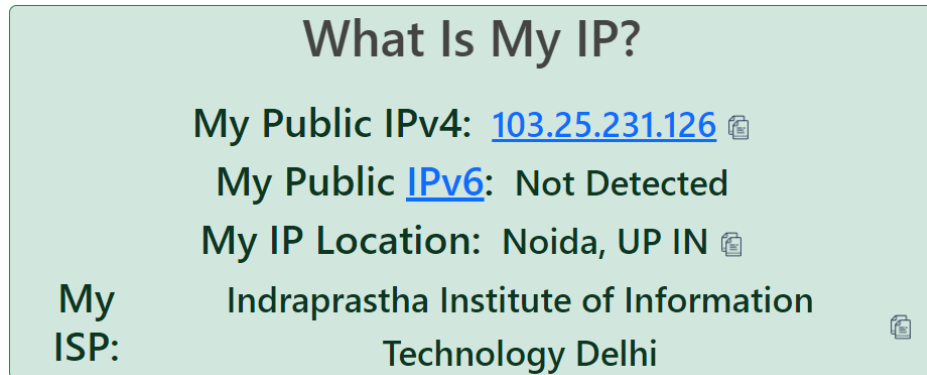


Figure 2: Screenshot of the IP address using <https://www.whatismyip.com>

Question 2

Change the IP address of your network interface using the command line. Put a screenshot that shows the change. Revert to the original IP address.

Solution

The command for changing the IP address is `sudo ifconfig eth0 192.168.1.50`. To revert back to the original IP address, use `sudo ifconfig eth0 172.24.113.215`.

```
souparno@SGAsus-Laptop:~$ sudo ifconfig eth0 192.168.1.50
[sudo] password for souparno:
souparno@SGAsus-Laptop:~$ ifconfig eht0
eht0: error fetching interface information: Device not found
souparno@SGAsus-Laptop:~$ ifconfig eth0
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.50 netmask 255.255.255.0 broadcast 192.168.1.255
    inet6 fe80::215:5dff:feb0:a725 prefixlen 64 scopeid 0x20<link>
    ether 00:15:5d:b0:a7:25 txqueuelen 1000 (Ethernet)
    RX packets 654 bytes 632472 (632.4 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 288 bytes 61698 (61.6 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

souparno@SGAsus-Laptop:~$ sudo ifconfig eth0 172.24.113.215
souparno@SGAsus-Laptop:~$ ifconfig eth0
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 172.24.113.215 netmask 255.255.0.0 broadcast 172.24.255.255
    inet6 fe80::215:5dff:feb0:a725 prefixlen 64 scopeid 0x20<link>
    ether 00:15:5d:b0:a7:25 txqueuelen 1000 (Ethernet)
    RX packets 657 bytes 632833 (632.8 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 288 bytes 61698 (61.6 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

Figure 3: Screenshot of the command to change and reverting the IP address

Question 3

- (a) Use `netcat` to set up a TCP client/server connection between your VM and host machine. If you are not using a VM, you can set up the connection with localhost. Put a screenshot.
- (b) Determine the state of this TCP connection(s) at the client node. Put a screenshot.

Solution

- (a) To establish a TCP client-server connection using `netcat`, I used the following commands: `nc -lv 3737` to set up a server listening on port 3737 and `nc 127.0.0.1 3737` to connect as a client to the server on the same port. The server command (`nc -lv 3737`) initializes the server in listening mode with verbose output, while the client command (`nc 127.0.0.1 3737`) connects to the server running on localhost. This setup allows for testing the TCP connection between the client and server on the same machine.

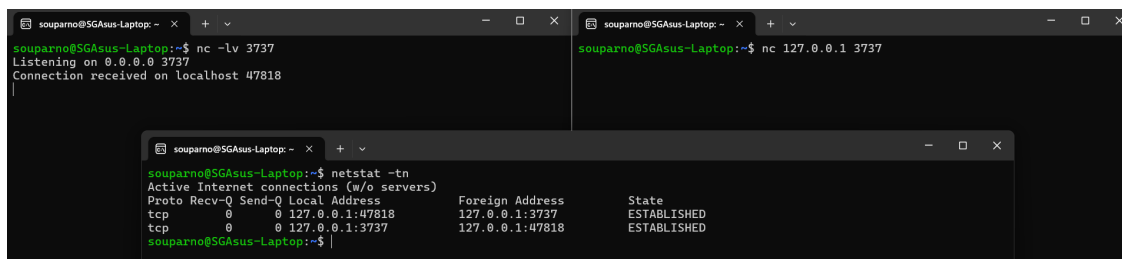
```
souparno@SGAsus-Laptop:~$ nc -lv 3737
Listening on 0.0.0.0 3737
Connection received on localhost 35990
hi
CN
```

Figure 4: Server setup using netcat

```
souparno@SGAsus-Laptop:~$ nc 127.0.0.1 3737
hi
CN
^C
```

Figure 5: Client connection to server using netcat

- (b) To determine the state of the TCP connection on the client side, first establish a connection using `netcat` with the server by running `nc -lv 3737` on the server and `nc 127.0.0.1 3737` on the client. After ensuring the connection was active, open a new terminal on the client machine and executed the command `netstat -tn`. This command listed all TCP connections with numerical addresses, showing the local and foreign addresses, as well as the state of each connection. The output confirmed the status of the connection by displaying the `ESTABLISHED` state for the relevant port.



```
souparno@SGAsus-Laptop:~$ nc -lv 3737
Listening on 0.0.0.0 3737
Connection received on localhost 47818

souparno@SGAsus-Laptop:~$ nc 127.0.0.1 3737

souparno@SGAsus-Laptop:~$ netstat -tn
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 127.0.0.1:47818         127.0.0.1:3737         ESTABLISHED
tcp        0      0 127.0.0.1:3737         127.0.0.1:47818         ESTABLISHED
```

Figure 6: Output of `netstat -tn` showing `ESTABLISHED` connection

Question 4

- (a) Get an authoritative result for `google.in` using `nslookup`. Put a screenshot. Explain how you did it.
- (b) Find out the time to live for any website on the local DNS. Put a screenshot. Explain in words (with unit) after how much time this entry would expire from the local DNS server.

Solution

- (a) The `nslookup` command I used queried DNS records for the domain `google.in` to obtain authoritative information. By setting the query type to `soa` (Start of Authority), the command requested the SOA record, which provides details about the domain's primary DNS server and its administrative settings. The output showed the SOA record information, including the name server and administrative contact. This command helped retrieve the authoritative DNS data for the domain, demonstrating how to obtain and interpret essential DNS records.

```
souparno@SGAsus-Laptop:~$ nslookup -type=soa google.in
Server:      10.255.255.254
Address:     10.255.255.254#53

Non-authoritative answer:
google.in
    origin = ns1.google.com
    mail addr = dns-admin.google.com
    serial = 668368175
    refresh = 900
    retry = 900
    expire = 1800
    minimum = 60

Authoritative answers can be found from:
ns1.google.com    internet address = 216.239.32.10
ns1.google.com    has AAAA address 2001:4860:4802:32::a

souparno@SGAsus-Laptop:~$ nslookup google.in ns1.google.com
Server:      ns1.google.com
Address:     216.239.32.10#53

Name:   google.in
Address: 142.250.194.196
Name:   google.in
Address: 2404:6800:4002:824::2004
```

Figure 7: SOA record output from `nslookup` command

- (b) The `dig` command is used to query DNS records and provides detailed information, including the Time to Live (TTL) value, which indicates how long a DNS entry is cached by the local DNS server. By running `dig <domain>`, such as `dig google.in`, the command returns the TTL value in the ANSWER SECTION of the output. This TTL value, expressed in seconds, specifies the duration for which the DNS record will be considered valid before needing to be refreshed. For example, a TTL of 241 seconds means the DNS entry will expire after 4 minutes and 1 second, prompting a new query to retrieve updated information. This helps determine the caching period of DNS records effectively.

```

soupono@SGAsus-Laptop:~$ dig google.in
; <<>> DiG 9.18.12-0ubuntu0.22.04.3-Ubuntu <<>> google.in
; global options: +cmd
; Got answer:
;->>HEADER<<- opcode: QUERY, status: NOERROR, id: 24942
; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1
;
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4000
; QUESTION SECTION:
;google.in.                IN      A
;
;; ANSWER SECTION:
google.in.                241     IN      A      142.250.192.228
;
; Query time: 0 msec
; SERVER: 10.255.255.254#53(10.255.255.254) (UDP)
; WHEN: Thu Aug 22 00:19:50 IST 2024
; MSG SIZE rcvd: 54

```

Figure 8: TTL value from dig command for google.in

Question 5

- Run the command, `traceroute google.in`. How many intermediate hosts do you see? What are the IP addresses? Compute the average latency to each intermediate host. Put a screenshot.
- Send 50 ping messages to `google.in`, Determine the average latency. Put a screenshot.
- Add up the ping latency of all the intermediate hosts obtained in (a) and compare with (b). Are they matching, explain?
- Take the maximum ping latency amongst the intermediate hosts (in (a)) and compare it with (b). Are they matching, explain?
- You may see multiple entries for a single hop while using the traceroute command. What do these entries mean?
- Send 50 ping messages to `stanford.edu`, Determine the average latency. Put a screenshot.
- Run the command, `traceroute stanford.edu`. Compare the number of hops between `google.in` and `stanford.edu` (between the traceroute result of `google.in` and `stanford.edu`).
- Can you explain the reason for the latency difference between `google.in` and `stanford.edu` (see (b) & (f))?

Solution

- Based on the `traceroute google.in` command output:

1. Number of Intermediate Hosts:

- If we exclude the first host (which is our own laptop), there are 7 intermediate hosts (ignoring the ones that show * *).

- If we include the first host, there are 8 intermediate hosts (ignoring the ones that show * *).

2. IP Addresses of Intermediate Hosts:

- **Excluding the first host (7 intermediate hosts):**

- 192.168.32.254
- 192.168.1.99
- 103.25.231.1
- 10.119.234.162
- 72.14.195.56 / 72.14.194.160
- 192.178.80.159 / 142.251.54.111
- 142.251.54.63 / 142.251.54.65

- **Including the first host (8 intermediate hosts):**

- 172.24.112.1
- 192.168.32.254
- 192.168.1.99
- 103.25.231.1
- 10.119.234.162
- 72.14.195.56 / 72.14.194.160
- 192.178.80.159 / 142.251.54.111
- 142.251.54.63 / 142.251.54.65

3. Average Latency to Each Intermediate Host:

- **Excluding the first host:**

- **192.168.32.254:** $(11.540 + 11.532 + 11.522)/3 = 11.531$ ms
- **192.168.1.99:** $(11.528 + 11.520 + 11.514)/3 = 11.520$ ms
- **103.25.231.1:** $(12.102 + 12.096 + 12.091)/3 = 12.096$ ms
- **10.119.234.162:** $(12.041 + 11.804 + 11.794)/3 = 11.880$ ms
- **72.14.195.56 / 72.14.194.160:** $(97.806 + 70.361 + 113.847)/3 = 94.671$ ms
- **192.178.80.159 / 142.251.54.111:** $(37.689 + 48.456 + 37.675)/3 = 41.273$ ms
- **142.251.54.63 / 142.251.54.65:** $(37.660 + 35.956 + 26.165)/3 = 33.927$ ms

- **Including the first host:**

- **172.24.112.1:** $(0.519 + 0.267 + 0.304)/3 = 0.363$ ms
- **192.168.32.254:** $(11.540 + 11.532 + 11.522)/3 = 11.531$ ms
- **192.168.1.99:** $(11.528 + 11.520 + 11.514)/3 = 11.520$ ms
- **103.25.231.1:** $(12.102 + 12.096 + 12.091)/3 = 12.096$ ms
- **10.119.234.162:** $(12.041 + 11.804 + 11.794)/3 = 11.880$ ms

- 72.14.195.56 / 72.14.194.160: (97.806 + 70.361 + 113.847)/3 = 94.671 ms
- 192.178.80.159 / 142.251.54.111: (37.689+48.456+37.675)/3 = 41.273 ms
- 142.251.54.63 / 142.251.54.65: (37.660 + 35.956 + 26.165)/3 = 33.927 ms

```
souparno@SGAsus-Laptop:~$ traceroute google.in
traceroute to google.in (142.250.192.228), 30 hops max, 60 byte packets
 1  SGAsus-Laptop.mshome.net (172.24.112.1)  0.519 ms  0.267 ms  0.304 ms
 2  192.168.32.254 (192.168.32.254)  11.549 ms  11.532 ms  11.522 ms
 3  auth.iiitd.edu.in (192.168.1.99)  11.528 ms  11.520 ms  11.514 ms
 4  103.25.231.1 (103.25.231.1)  12.102 ms  12.096 ms  12.091 ms
 5  * * *
 6  10.119.234.162 (10.119.234.162)  12.041 ms  11.804 ms  11.794 ms
 7  72.14.195.56 (72.14.194.160)  97.806 ms  72.14.194.160 (72.14.194.160)  70.361 ms  72.14.195.56 (72.14.195.56)  113.847 ms
 8  192.178.80.159 (192.178.80.159)  37.689 ms  142.251.54.111 (142.251.54.111)  48.456 ms  192.178.80.159 (192.178.80.159)  37.675 ms
 9  142.251.54.63 (142.251.54.63)  37.660 ms  35.956 ms  142.251.54.65 (142.251.54.65)  26.165 ms
10  dell1s13-in-f4.1e100.net (142.250.192.228)  39.510 ms  39.502 ms  39.494 ms
```

Figure 9: Traceroute command output visualization

- (b) Used the ping command to send 50 packets to `google.in` and observed the results. The average latency, as reported by the command, is 33.406 milliseconds. This value is calculated from the round-trip times of all the packets sent, giving an indication of the typical time it takes for a packet to travel to the destination and back.

```
souparno@SGAsus-Laptop:~$ ping -c 50 google.in
PING google.in (142.250.192.228) 56(84) bytes of data:
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=1 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=2 ttl=55 time=30.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=3 ttl=55 time=30.8 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=4 ttl=55 time=29.9 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=5 ttl=55 time=30.0 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=6 ttl=55 time=30.4 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=7 ttl=55 time=30.7 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=8 ttl=55 time=30.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=9 ttl=55 time=31.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=10 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=11 ttl=55 time=31.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=12 ttl=55 time=29.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=13 ttl=55 time=38.9 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=14 ttl=55 time=39.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=15 ttl=55 time=29.4 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=16 ttl=55 time=29.7 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=17 ttl=55 time=39.8 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=18 ttl=55 time=29.0 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=19 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=20 ttl=55 time=38.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=21 ttl=55 time=29.4 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=22 ttl=55 time=29.3 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=23 ttl=55 time=30.8 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=24 ttl=55 time=39.7 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=25 ttl=55 time=32.6 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=26 ttl=55 time=29.5 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=27 ttl=55 time=30.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=28 ttl=55 time=34.7 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=29 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=30 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=31 ttl=55 time=29.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=32 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=33 ttl=55 time=31.3 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=34 ttl=55 time=29.8 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=35 ttl=55 time=39.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=36 ttl=55 time=39.5 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=37 ttl=55 time=38.6 ms
```

Figure 10: Ping Results 1

```
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=38 ttl=55 time=39.4 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=39 ttl=55 time=39.3 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=40 ttl=55 time=39.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=41 ttl=55 time=45.9 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=42 ttl=55 time=39.3 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=43 ttl=55 time=29.1 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=44 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=45 ttl=55 time=49.5 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=46 ttl=55 time=29.2 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=47 ttl=55 time=29.4 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=48 ttl=55 time=29.5 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=49 ttl=55 time=32.0 ms
64 bytes from dell1s13-in-f4.1e100.net (142.250.192.228): icmp_seq=50 ttl=55 time=32.5 ms

--- google.in ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 4907ms
rtt min/avg/max/mdev = 29.081/33.406/49.527/5.215 ms
```

Figure 11: Ping Results 2

- (c) **Sum of Intermediate Host Latencies (from traceroute)(Excluding the first host):**

$$11.531 + 11.520 + 12.096 + 11.880 + 94.671 + 41.273 + 33.927 = 216.898 \text{ ms}$$

Average Ping Latency:

33.406 ms

Reason:

The sum of latencies for intermediate hosts obtained from traceroute is 216.898 ms, which is significantly higher than the average ping latency of 33.406 ms. This difference

occurs because `traceroute` accumulates delays from each intermediate hop, whereas `ping` measures the round-trip time directly to the final destination, resulting in a lower, more immediate latency.

(d) **Maximum Ping Latency Among Intermediate Hosts:**

From the `traceroute` data, the maximum latency among the intermediate hosts is 113.847 ms (for IP 72.14.195.56).

Maximum Ping Latency:

From the `ping` command data, the maximum ping latency is 49.527 ms.

Reason:

The maximum latency observed for an intermediate host (113.847 ms) is significantly higher than the maximum ping latency (49.527 ms). This discrepancy occurs because `traceroute` measures the time taken to reach each hop along the route, which can include network congestion or routing delays at specific points. The maximum ping latency, however, reflects the highest round-trip time directly to the final destination and is generally lower because it doesn't account for the individual delays at each intermediate hop.

- (e) Multiple entries for a single hop in a `traceroute` command output indicate that the command sends multiple probes (in this case three) to each hop along the route. Each probe measures the time it takes for a packet to reach that hop and return. The multiple entries show the response times for each of these probes. These times can vary due to factors like network congestion, routing changes, or packet processing delays at the intermediate routers. Seeing multiple entries allows us to get a more accurate and comprehensive understanding of the latency and reliability of each hop.
- (f) The average latency obtained by pinging `stanford.edu` 50 times came out to be 286.919 ms.


```

souparno@SGAsus-Laptop:~$ ping -c 50 stanford.edu
PING stanford.edu (171.67.215.200) 56(84) bytes of data:
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=1 ttl=241 time=291 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=2 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=3 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=4 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=5 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=6 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=7 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=8 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=9 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=10 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=11 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=12 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=13 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=14 ttl=241 time=296 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=15 ttl=241 time=287 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=16 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=17 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=18 ttl=241 time=292 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=19 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=20 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=21 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=22 ttl=241 time=292 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=23 ttl=241 time=305 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=24 ttl=241 time=290 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=25 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=26 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=27 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=28 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=29 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=30 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=31 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=32 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=33 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=34 ttl=241 time=287 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=35 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=36 ttl=241 time=289 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=37 ttl=241 time=286 ms

```

Figure 12: Ping Results 1

```

64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=38 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=39 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=40 ttl=241 time=288 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=41 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=42 ttl=241 time=288 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=43 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=44 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=45 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=46 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=47 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=48 ttl=241 time=296 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=49 ttl=241 time=302 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=50 ttl=241 time=292 ms

--- stanford.edu ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49029ms
rtt min/avg/max/mdev = 283.562/286.910/304.549/4.430 ms

```

Figure 13: Ping Results 2

(g) When we compare the number of hops between `google.in` and `stanford.edu` using the `traceroute` results (ignoring the * * * hops), we get the following:

- **Traceroute to stanford.edu:** Number of hops: 10 (ignoring the * * * hops from 9 to 24)
- **Traceroute to google.in:** Number of hops: 9

Reason: The traceroute to `stanford.edu` involves more hops (10) compared to `google.in` (9). This suggests that the route to `stanford.edu` traverses through more network nodes, which could contribute to higher latency compared to `google.in`. This is consistent with the earlier explanation that accessing Google's global network is typically faster due to its optimized infrastructure.

If we included the * * * hops in the count, the number of hops for `stanford.edu` would be significantly higher, indicating many potential points of delay or unreachable nodes along the route.

```

souparno@SGAsus-Laptop:~$ traceroute stanford.edu
traceroute to stanford.edu (171.67.215.200), 30 hops max, 60 byte packets
 1  SGAsus-Laptop.mshome.net (172.24.112.1) 0.679 ms 0.638 ms 0.625 ms
 2  192.168.32.254 (192.168.32.254) 25.693 ms 25.682 ms 25.672 ms
 3  auth.iiitd.edu.in (192.168.1.99) 11.759 ms 11.751 ms 11.740 ms
 4  103.25.231.1 (103.25.231.1) 11.918 ms 11.906 ms 11.896 ms
 5  10.1.209.201 (10.1.209.201) 32.511 ms 33.809 ms 30.301 ms
 6  10.1.200.137 (10.1.200.137) 28.967 ms 31.395 ms 31.381 ms
 7  10.255.238.122 (10.255.238.122) 50.753 ms 49.465 ms 49.041 ms
 8  100.149.48.18 (100.149.48.18) 40.026 ms 37.464 ms 39.976 ms
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  campus-ial-nets-b-vl1020.SUNet (171.66.255.232) 287.280 ms campus-east-rt-r-vl1020.SUNet (171.64.255.232) 282.962 ms
26  web.stanford.edu (171.67.215.200) 282.923 ms * *

```

Figure 14: Traceroute Results to stanford.edu

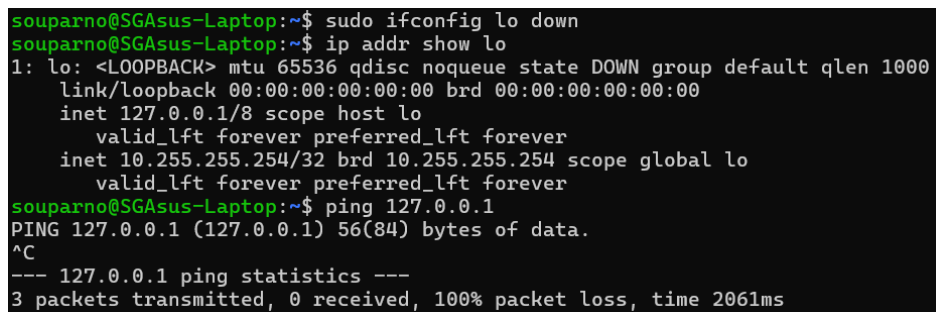
- (h) The latency difference between `google.in` and `stanford.edu` can be attributed to several factors. The average latency for `google.in` is 33.406 ms, benefiting from Google's highly optimized global network, which reduces latency through advanced infrastructure and closer geographical proximity. In contrast, `stanford.edu` has a higher average latency of 286.919 ms, due to a more complex routing path involving more network hops and potentially less optimized infrastructure. Additionally, network load and routing complexity further contribute to the increased latency for `stanford.edu`.

Question 6

Make your ping command fail for `127.0.0.1` (with 100% packet loss). Explain how you do it. Put a screenshot that it failed.

Solution

To make ping fail for `127.0.0.1` with 100% packet loss, use the command `sudo ifconfig lo down` to disable the loopback interface, effectively blocking all network traffic to `127.0.0.1`. I verified this by running `ip addr show lo` to confirm the interface was down and executed `ping 127.0.0.1`, which showed 100% packet loss. After testing, restore the interface using `sudo ifconfig lo up` and verified it was operational again with `ip addr show lo`. This sequence of commands ensures that all local communication via `127.0.0.1` is interrupted while the loopback interface is disabled.



```
souparno@SGAsus-Laptop:~$ sudo ifconfig lo down
souparno@SGAsus-Laptop:~$ ip addr show lo
1: lo: <LOOPBACK> mtu 65536 qdisc noqueue state DOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet 10.255.255.254/32 brd 10.255.255.254 scope global lo
        valid_lft forever preferred_lft forever
souparno@SGAsus-Laptop:~$ ping 127.0.0.1
PING 127.0.0.1 (127.0.0.1) 56(84) bytes of data.
^C
--- 127.0.0.1 ping statistics ---
3 packets transmitted, 0 received, 100% packet loss, time 2061ms
```

Figure 15: Output showing 100% packet loss and interface status