Q1.a) IP Address (v4) -> 10.0.2.15
v6 -> fe80::82b8:5edf:15bb:7df1

```
abhirup@ComputerNetworks:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.2.15  netmask 255.255.255.0  broadcast 10.0.2.255
        inet6 fe80::82b8:5edf:15bb:7df1  prefixlen 64  scopeid 0x20<link>
        ether 08:00:27:02:f6:19  txqueuelen 1000  (Ethernet)
        RX packets 5095  bytes 4825545 (4.8 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 2933  bytes 448299 (448.2 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 839  bytes 92351 (92.3 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 839  bytes 92351 (92.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

b) IP on website -> 103.25.231.126

The 2 IPs are different. The IP we see in ifconfig is a **‘Private IP’** of the device. It is unique in the Local Area Network. However, the IP that the website is showing is the **‘Public IP**’ of the device which the device gets from its router which is provided by your ISP. This IP, for that period of time when your device is connected to the internet, is unique in the entire world. Thus, the 2 IPs are different.

Q2) IP Address Before Change:-

```
abhirup@ComputerNetworks:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.2.15  netmask 255.255.255.0  broadcast 10.0.2.255
        inet6 fe80::82b8:5edf:15bb:7df1  prefixlen 64  scopeid 0x20<link>
        ether 08:00:27:02:f6:19  txqueuelen 1000  (Ethernet)
        RX packets 28  bytes 7898 (7.8 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 86  bytes 10621 (10.6 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 117  bytes 10134 (10.1 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 117  bytes 10134 (10.1 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

After Change:-

```
abhirup@ComputerNetworks:~$ sudo ifconfig enp0s3 1.1.1.1
[sudo] password for abhirup:
abhirup@ComputerNetworks:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 1.1.1.1  netmask 255.0.0.0  broadcast 1.255.255.255
        inet6 fe80::82b8:5edf:15bb:7df1  prefixlen 64  scopeid 0x20<link>
        ether 08:00:27:02:f6:19  txqueuelen 1000  (Ethernet)
        RX packets 28  bytes 7898 (7.8 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 96  bytes 12093 (12.0 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 117  bytes 10134 (10.1 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 117  bytes 10134 (10.1 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

Revert:-

```
abhirup@ComputerNetworks:~$ sudo ifconfig enp0s3 10.0.2.15
abhirup@ComputerNetworks:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.2.15  netmask 255.0.0.0  broadcast 10.255.255.255
        inet6 fe80::82b8:5edf:15bb:7df1  prefixlen 64  scopeid 0x20<link>
        ether 08:00:27:02:f6:19  txqueuelen 1000  (Ethernet)
        RX packets 28  bytes 7898 (7.8 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 112  bytes 14121 (14.1 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 119  bytes 10274 (10.2 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 119  bytes 10274 (10.2 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

Q3.a) (Using VM)
Server Side:-

```
abhirup@LAPTOP-JAI869JM:/mnt/c/Users/Abhirup Das$ nc -lv 1234
Listening on 0.0.0.0 1234
Connection received on LAPTOP-JAI869JM.mshome.net 53581
hey
bye
```

Client Side:-

```
abhirup@ComputerNetworks:~$ nc -v 172.21.210.120 1234
Connection to 172.21.210.120 1234 port [tcp/*] succeeded!
hey
bye
```

b) State of TCP Connection at Client Side:-

```
abhirup@ComputerNetworks:~$ netstat -t
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 ComputerNetworks:60356  172.21.210.120:1234     ESTABLISHED
```

State - ESTABLISHED

Q4.a)

```
abhirup@ComputerNetworks:~$ nslookup -type=soa google.in
Server:         127.0.0.53
Address:        127.0.0.53#53

Non-authoritative answer:
google.in
        origin = ns1.google.com
        mail addr = dns-admin.google.com
        serial = 665267952
        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

abhirup@ComputerNetworks:~$ nslookup google.in ns1.google.com
Server:         ns1.google.com
Address:        216.239.32.10#53

Name:   google.in
Address: 142.250.194.228
Name:   google.in
Address: 2404:6800:4002:825::2004
```

To get the authoritative result, we need to get the ‘primary authoritative name server’ for that particular website(google.in). We get this server by adding the ‘-type=soa’ flag. Then, we perform the lookup but by specifying the DNS server you want to query, which you get from the output of the previous command. Thus, an authoritative result is obtained.

b) The entry would expire from the local DNS server after **300 seconds** or **5 minutes.**

```
abhirup@ComputerNetworks:~$ dig  google.in

; <<>> DiG 9.18.28-0ubuntu0.22.04.1-Ubuntu <<>> google.in
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 39516
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 65494
;; QUESTION SECTION:
;google.in.                     IN      A

;; ANSWER SECTION:
google.in.              300     IN      A       142.250.193.4

;; Query time: 115 msec
;; SERVER: 127.0.0.53#53(127.0.0.53) (UDP)
;; WHEN: Tue Aug 27 14:47:07 IST 2024
;; MSG SIZE  rcvd: 54
```

Q5.a) No. of intermediate hosts -> 8 (because the last host is Google’s IP and we include the first hop because it’s the gateway and so, is an intermediate host)

IP Addresses:-

1) 172.21.208.1
2) 192.168.32.254
3) 192.168.1.99
4) 103.25.231.1
5) 10.119.234.162
6) 72.14.194.160
7) 142.251.54.111
8) 142.251.54.63

Average Latencies to Each Intermediate Host:-

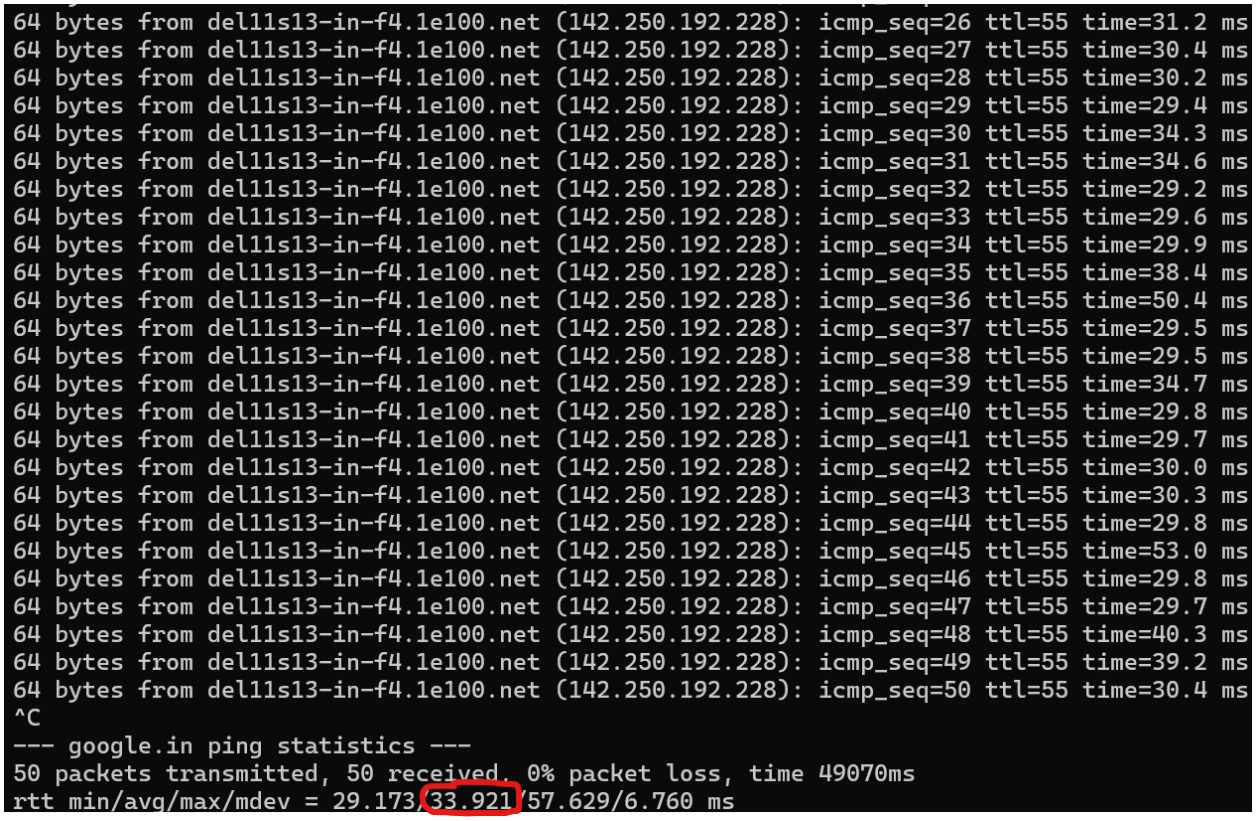
1) 172.21.208.1 -> 0.129 ms
2) 192.168.32.254 -> 5.459 ms

3) 192.168.1.99 -> 3.623 ms
4) 103.25.231.1 -> 4.64 ms
5) 10.119.234.162 -> 6.964 ms
6) 72.14.194.160 -> 29.952 ms
7) 142.251.54.111 -> 49.892 ms
8) 142.251.54.63 -> 28.784 ms

```
abhirup@LAPTOP-JAI869JM:/mnt/c/Users/Abhirup Das$ traceroute google.in
traceroute to google.in (142.250.192.228), 64 hops max
  1   172.21.208.1  0.174ms  0.097ms  0.117ms
  2   192.168.32.254  6.360ms  4.775ms  5.242ms
  3   192.168.1.99  4.396ms  3.418ms  3.055ms
  4   103.25.231.1  3.280ms  4.706ms  5.934ms
  5   *  *  *
  6   10.119.234.162  7.995ms  6.989ms  5.907ms
  7   72.14.194.160  32.915ms  31.621ms  25.320ms
  8   142.251.54.111  49.611ms  49.428ms  50.641ms
  9   142.251.54.63  29.192ms  28.445ms  28.714ms
 10   142.250.192.228  32.511ms  31.204ms  32.378ms
```

b) Average Latency -> 33.921 ms

```
abhirup@LAPTOP-JAI869JM:/mnt/c/Users/Abhirup Das$ ping google.in
PING google.in (142.250.192.228) 56(84) bytes of data.
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=1 ttl=55 time=30.2 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=2 ttl=55 time=33.8 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=3 ttl=55 time=30.5 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=4 ttl=55 time=57.6 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=5 ttl=55 time=30.4 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=6 ttl=55 time=30.3 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=7 ttl=55 time=44.7 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=8 ttl=55 time=32.1 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=9 ttl=55 time=30.9 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=10 ttl=55 time=30.3 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=11 ttl=55 time=30.3 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=12 ttl=55 time=32.6 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=13 ttl=55 time=43.9 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=14 ttl=55 time=30.9 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=15 ttl=55 time=30.4 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=16 ttl=55 time=45.8 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=17 ttl=55 time=30.7 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=18 ttl=55 time=30.9 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=19 ttl=55 time=30.0 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=20 ttl=55 time=30.4 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=21 ttl=55 time=38.1 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=22 ttl=55 time=46.3 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=23 ttl=55 time=30.5 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=24 ttl=55 time=30.0 ms
64 bytes from del11s13-in-f4.1e100.net (142.250.192.228): icmp_seq=25 ttl=55 time=31.2 ms
```



c) Sum of ping latencies of intermediate hosts : 129.443 ms

This is significantly larger than the average latency in pinging google.in. So, no, they are not matching. This is because the latencies shown for each of the intermediate hosts is the time taken for a packet to go from the source to this intermediate host, not from the host just before it in the traceroute. These intermediate hosts are crucial for establishing the next address to go to, until we reach our final destination. When one host has been reached, the time taken is shown, and then another packet is sent to the next host. Finally, the last time written in the traceroute is the time that's actually taken to ping google.in, when all the intermediate connections have been established.

d) Maximum ping latency : 49.892 ms

This latency is also larger than the average latency in pinging google.in. Again, just like in c), this is because the latencies shown for each of the intermediate hosts is the time taken for a packet to go from the source to this intermediate host, not from the host just before it in the traceroute. So, when all the intermediate connections have been established, google.in is pinged and that time taken is independent of any of the times taken to go to the intermediate hosts. So, the 2 don't correlate.

e) The 3 different entries for a single hop represent the times taken by each of the 3 packets, sent by the source, to that ‘hop’. These 3 times remove any inconsistency, so that even if 1 packet takes slightly longer, the other 2 give a fairer picture of the latency to reach that ‘hop’.

f) Average latency to stanford.edu -> 294.987 ms

```
abhirup@LAPTOP-JAI869JM:/mnt/c/Users/Abhirup Das$ ping 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=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=2 ttl=241 time=293 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=3 ttl=241 time=306 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=4 ttl=241 time=287 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=5 ttl=241 time=284 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=284 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=285 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=304 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=13 ttl=241 time=322 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=14 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=15 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=16 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=17 ttl=241 time=288 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=18 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=19 ttl=241 time=287 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=20 ttl=241 time=305 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=21 ttl=241 time=312 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=22 ttl=241 time=288 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=23 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=24 ttl=241 time=295 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=25 ttl=241 time=318 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=26 ttl=241 time=347 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=27 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=28 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=29 ttl=241 time=299 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=30 ttl=241 time=320 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=31 ttl=241 time=352 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=32 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=33 ttl=241 time=290 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=34 ttl=241 time=302 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=35 ttl=241 time=313 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=36 ttl=241 time=284 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=37 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=38 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=39 ttl=241 time=293 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=40 ttl=241 time=285 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=298 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=43 ttl=241 time=285 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=44 ttl=241 time=294 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=45 ttl=241 time=317 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=46 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=47 ttl=241 time=292 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=48 ttl=241 time=302 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=49 ttl=241 time=286 ms
64 bytes from web.stanford.edu (171.67.215.200): icmp_seq=50 ttl=241 time=286 ms
^C
--- stanford.edu ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49064ms
rtt min/avg/max/mdev = 283.997/294.987/351.675/15.569 ms
```

g) (Ignoring * * * hosts as mentioned in part a) - 11 hosts for stanford and 9 for google

```
abhirup@LAPTOP-JAI869JM:/mnt/c/Users/Abhirup Das$ traceroute stanford.edu
traceroute to stanford.edu (171.67.215.200), 64 hops max
  1   172.21.208.1  0.299ms  0.135ms  0.172ms
  2   192.168.32.254  29.698ms  6.887ms  5.328ms
  3   192.168.1.99  4.036ms  3.013ms  3.356ms
  4   103.25.231.1  4.156ms  9.535ms  21.671ms
  5   10.1.209.201  29.300ms  28.921ms  39.641ms
  6   10.1.200.137  30.067ms  28.604ms  28.314ms
  7   10.255.238.122  72.611ms  47.570ms  48.634ms
  8   180.149.48.18  31.342ms  38.532ms  31.052ms
  9   *  *  *
 10   *  *  *
 11   *  *  *
 12   *  *  *
 13   *  *  *
 14   *  *  *
 15   *  *  *
 16   *  *  *
 17   *  *  *
 18   *  *  *
 19   *  *  *
 20   *  *  *
 21   *  *  *
 22   *  *  *
 23   *  *  *
 24   171.66.255.200  289.113ms  288.553ms  289.871ms
 25   171.64.255.232  283.169ms  282.152ms  283.101ms
 26   171.67.215.200  286.683ms  283.921ms  283.566ms
```

h) There could be a multitude of reasons for the difference:-

- The number of intermediate hosts is much larger for stanford.edu, thus taking a longer time to ping the website. If any of these hosts are congested, it could take a longer time.

- The location of the servers themselves within the U.S. can have a big impact on the latency. An intermediate host that's near the google.in server and can be accessed quickly could lead to a faster latency for google but slower for stanford.edu if there isn't as close an intermediate host for it.

Q6) 127.0.0.1 is the loopback address. The way to ensure 100% packet loss when pinging it, is by ensuring that the address can't be reached. We can do this by disabling the loopback interface (by the command 'ifconfig lo down'). Then, any ping to 127.0.0.1 will simply be lost since its disabled.

```
abhirup@ComputerNetworks:~$ sudo ifconfig lo down
abhirup@ComputerNetworks:~$ 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 ---
5 packets transmitted, 0 received, 100% packet loss, time 4186ms
```