

CSE 232: Programming Assignment 1

Using command-line utilities for network debugging

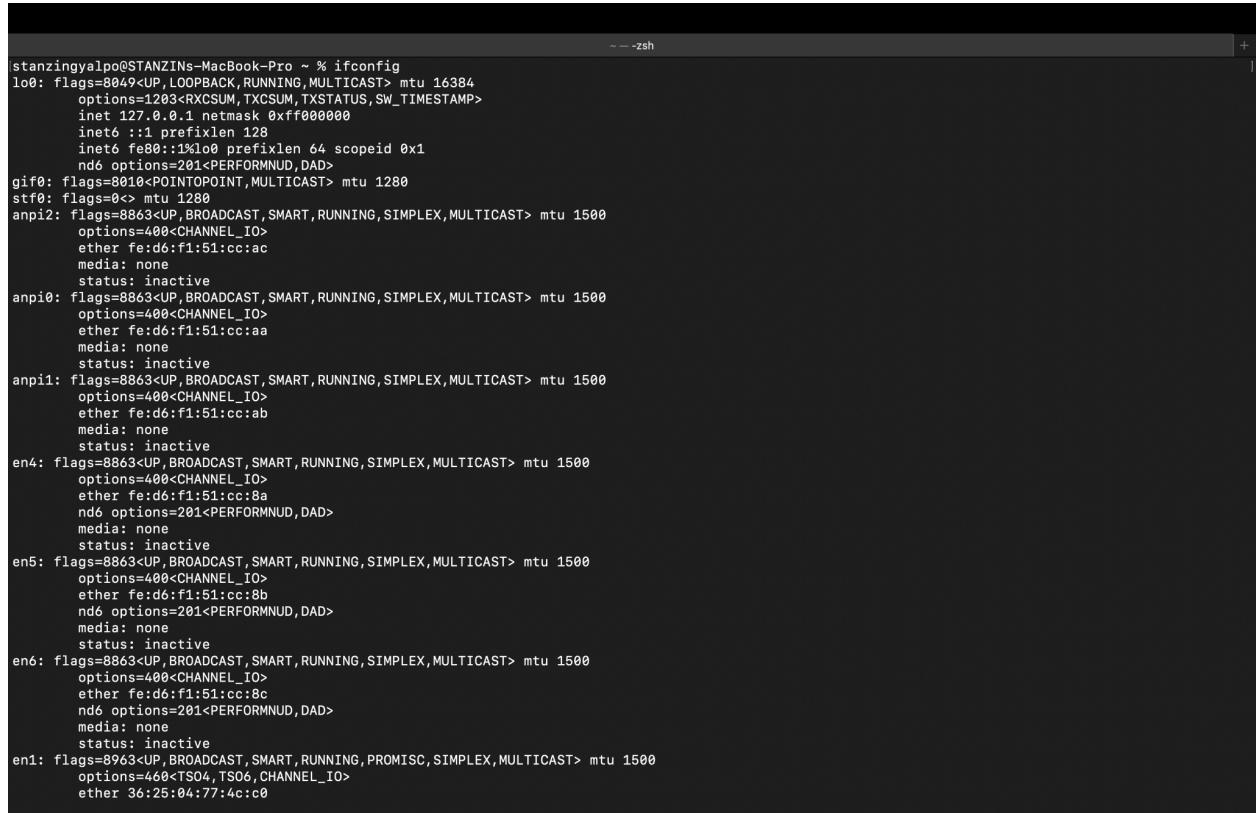
Due date: Aug 30, 2024

Total: 30 points

Github Link : https://github.com/SciFi07/CSE232_CN.git

Q1. [1 + 1]

- a) Learn to use the `ifconfig` command, and figure out the IP address of your network interface. Put a screenshot.



```
stanzingyalpo@STANZINS-MacBook-Pro ~ % ifconfig
lo0: flags=8049 mtu 16384
    options=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
    inet 127.0.0.1 netmask 0xff000000
        inet6 ::1 prefixlen 128
        inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
            nd6 options=201<PERFORMNUD,DAD>
gif0: flags=8010<POINTOPOINT,MULTICAST> mtu 1280
stf0: flags=0<>
mtu 1280
anpi2: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=400<CHANNEL_IO>
    ether fe:d6:f1:51:cc:ac
    media: none
    status: inactive
anpi0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=400<CHANNEL_IO>
    ether fe:d6:f1:51:cc:aa
    media: none
    status: inactive
anpi1: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=400<CHANNEL_IO>
    ether fe:d6:f1:51:cc:ab
    media: none
    status: inactive
en4: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=400<CHANNEL_IO>
    ether fe:d6:f1:51:cc:8a
    nd6 options=201<PERFORMNUD,DAD>
    media: none
    status: inactive
en5: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=400<CHANNEL_IO>
    ether fe:d6:f1:51:cc:b8
    nd6 options=201<PERFORMNUD,DAD>
    media: none
    status: inactive
en6: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    options=400<CHANNEL_IO>
    ether fe:d6:f1:51:cc:8c
    nd6 options=201<PERFORMNUD,DAD>
    media: none
    status: inactive
en1: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
    options=460<TS04,TS06,CHANNEL_IO>
    ether 36:25:04:77:4c:c0
```

```
~ -- zsh
ether 36:25:04:77:4c:c0
media: autoselect <full-duplex>
status: inactive
en2: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
options=460<TS04,TS06,CHANNEL_IO>
ether 36:25:04:77:4c:c4
media: autoselect <full-duplex>
status: inactive
en3: flags=8963<UP,BROADCAST,SMART,RUNNING,PROMISC,SIMPLEX,MULTICAST> mtu 1500
options=460<TS04,TS06,CHANNEL_IO>
ether 36:25:04:77:4c:c8
media: autoselect <full-duplex>
status: inactive
bridge0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=63<RXSUM,TXSUM,TS04,TS06>
ether 36:25:04:77:4c:c0
Configuration:
    id 0:0:0:0:0 priority 0 hellotime 0 fwddelay 0
    maxage 0 holdcnt 0 proto stp maxaddr 100 timeout 1200
    root id 0:0:0:0:0 priority 0 ifcost 0 port 0
    ipfilter disabled flags 0x0
member: en1 flags=3<LEARNING,DISCOVER>
    ifmaxaddr 0 port 10 priority 0 path cost 0
member: en2 flags=3<LEARNING,DISCOVER>
    ifmaxaddr 0 port 11 priority 0 path cost 0
member: en3 flags=3<LEARNING,DISCOVER>
    ifmaxaddr 0 port 12 priority 0 path cost 0
nd6 options=201<PERFORMNUD,DAD>
media: <unknown type>
status: inactive
ap1: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
ether ea:89:f3:ca:15:78
inet6 fe80::e889:f3ff:fea:1578%ap1 prefixlen 64 scopeid 0xe
nd6 options=201<PERFORMNUD,DAD>
media: autoselect (<unknown type>)
status: inactive
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
ether c8:89:f3:ca:15:78
inet6 fe80::c7e:4826:cac5:ccc2%en0 prefixlen 64 secured scopeid 0xf
inet 192.168.42.230 netmask 0xffffffff broadcast 192.168.63.255
nd6 options=201<PERFORMNUD,DAD>
media: autoselect
status: active
```

```
~ -- zsh
inet6 fe80::e889:f3ff:fea:1578%ap1 prefixlen 64 scopeid 0xe
nd6 options=201<PERFORMNUD,DAD>
media: autoselect (<unknown type>)
status: inactive
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
ether c8:89:f3:ca:15:78
inet6 fe80::c7e:4826:cac5:ccc2%en0 prefixlen 64 secured scopeid 0xf
inet 192.168.42.230 netmask 0xffffffff broadcast 192.168.63.255
nd6 options=201<PERFORMNUD,DAD>
media: autoselect
status: active
awdl0: flags=8843<UP,BROADCAST,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
ether 5e:8e:1a:2b:68:7e
inet6 fe80::5c8e:1aff:fe2b:687e%awdl0 prefixlen 64 scopeid 0x10
nd6 options=201<PERFORMNUD,DAD>
media: autoselect
status: active
llw0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
options=40<CHANNEL_IO>
ether 5e:8e:1a:2b:68:7e
inet6 fe80::5c8e:1aff:fe2b:687e%llw0 prefixlen 64 scopeid 0x11
nd6 options=201<PERFORMNUD,DAD>
media: autoselect
status: inactive
utun0: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1500
inet6 fe80::e1af:a45c:40ff:c67%utun0 prefixlen 64 scopeid 0x12
nd6 options=201<PERFORMNUD,DAD>
utun1: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380
inet6 fe80::732d:141b:62b3:b527%utun1 prefixlen 64 scopeid 0x13
nd6 options=201<PERFORMNUD,DAD>
utun2: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 2000
inet6 fe80::6ea1:c0f:3abb:9ecc%utun2 prefixlen 64 scopeid 0x14
nd6 options=201<PERFORMNUD,DAD>
utun3: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1000
inet6 fe80::ce81:b1c:bd2c:69e%utun3 prefixlen 64 scopeid 0x15
nd6 options=201<PERFORMNUD,DAD>
utun4: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380
inet6 fe80::84c3:f2c1:c2d5:edd2%utun4 prefixlen 64 scopeid 0x16
nd6 options=201<PERFORMNUD,DAD>
utun5: flags=8051<UP,POINTOPOINT,RUNNING,MULTICAST> mtu 1380
inet6 fe80::f541:8e6c:2211:9b1e%utun5 prefixlen 64 scopeid 0x17
nd6 options=201<PERFORMNUD,DAD>
stanzingyalpo$STANZINs-MacBook-Pro ~ %
```

En0 is the primary wifi in my laptop:

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
      options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
      ether c8:89:f3:ca:15:78
      inet6 fe80::c7e:4826:cac5:ccc2%en0 prefixlen 64 secured scopeid 0xf
      inet 192.168.42.230 netmask 0xffffffff broadcast 192.168.63.255
      nd6 options=201<PERFORMNUD,DAD>
      media: autoselect
      status: active
```

Inet is the ip address of the network interface: 192.168.42.230

- 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?

What Is My IP?

My Public IPv4: [103.25.231.125](https://www.whatismyip.com) 

My Public IPv6: Not Detected

My IP Location: Noida, UP IN 

My
ISP:

Indraprastha Institute of Information
Technology Delhi 

The IP address 103.25.231.125 differs from the IP address of the en0 network interface, which is 192.168.42.230. This difference arises because the en0 network interface uses a private IP address, assigned by the router to the device within the local network. The public IP address, 103.25.231.125, is assigned to the router by the ISP and is used to identify the device on the internet. Meanwhile, the router assigns private IP addresses to devices on the local network. The process that manages this translation between public and private IP addresses is called Network Address Translation (NAT).

Q.2. [1+1+1]

- a) 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.

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % sudo ifconfig en0 192.168.42.001  
[Password:  
[stanzingyalpo@STANZINs-MacBook-Pro ~ % ifconfig en0  
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500  
    options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>  
    ether c8:89:f3:ca:15:78  
    inet6 fe80::c7e:4826:cac5:ccc2%en0 prefixlen 64 secured scopeid 0xf  
    inet 192.168.42.1 netmask 0xffffffff broadcast 192.168.42.255  
    nd6 options=201<PERFORMNUD,DAD>  
    media: autoselect  
    status: active  
[stanzingyalpo@STANZINs-MacBook-Pro ~ % sudo ifconfig en0 192.168.42.230  
[stanzingyalpo@STANZINs-MacBook-Pro ~ % ifconfig en0  
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500  
    options=6460<TS04,TS06,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>  
    ether c8:89:f3:ca:15:78  
    inet6 fe80::c7e:4826:cac5:ccc2%en0 prefixlen 64 secured scopeid 0xf  
    inet 192.168.42.230 netmask 0xfffffe000 broadcast 192.168.63.255  
    nd6 options=201<PERFORMNUD,DAD>  
    media: autoselect  
    status: active  
stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

Q.3. [4]

- 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. [1+1]

Since I don't have access to a virtual machine, I'll set up the connection between my host machine and localhost by running the server on the host machine and the client on localhost. I'll do this using two separate terminals.

```
stanzingyalpo — nc -l 1234 — 80x24
~ — nc -l 1234 +
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -l 1234
hello
working
test123
□

stanzingyalpo — nc -v 127.0.0.1 1234 — 80x24
~ — nc -v 127.0.0.1 1234 +
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -v 127.0.0.1 1234
Connection to 127.0.0.1 port 1234 [tcp/search-agent] succeeded!
hello
working
test123
bye]
```

```
stanzingyalpo — nc -l 1234 — 80x24
~ — nc -l 1234
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -l 1234
hello
working
test123
bye
]
```

```
stanzingyalpo — nc -v 127.0.0.1 1234 — 80x24
~ — nc -v 127.0.0.1 1234
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -v 127.0.0.1 1234
Connection to 127.0.0.1 port 1234 [tcp/search-agent] succeeded!
hello
working
test123
bye
]
```

b) Determine the state of this TCP connection(s) at the client node. Put a screenshot. [1+1]

The image shows two terminal windows side-by-side. The top window is titled "stanzingyalpo — nc -l 1111 — 80x24" and contains the command "nc -l 1111". The bottom window is titled "stanzingyalpo — -zsh — 80x24" and contains the command "-zsh". Both windows show terminal history:

Top Window (nc -l 1111):

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -l 1234
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -l 1111
[]
```

Bottom Window (-zsh):

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -vz 127.0.0.1 1234
Connection to 127.0.0.1 port 1234 [tcp/search-agent] succeeded!
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nc -vz 127.0.0.1 1000
nc: connectx to 127.0.0.1 port 1000 (tcp) failed: Connection refused
stanzingyalpo@STANZINs-MacBook-Pro ~ % ]
```

Q.4. nslookup ([2+1] + [1+1])

- a) Get an authoritative result for “google.in” using [nslookup](#). Put a screenshot. Explain how you did it.

To obtain the authoritative result for a domain, we first need to identify its DNS server. This can be achieved using the nslookup command with the -type=ns option, which will provide the authoritative DNS server for the domain. After identifying one of these DNS servers, we can then query it directly for the domain name to get the authoritative result by appending the DNS server’s domain to the query.

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nslookup google.in
Server:          192.168.1.7
Address:         192.168.1.7#53

Non-authoritative answer:
Name:   google.in
Address: 142.250.193.4

[stanzingyalpo@STANZINs-MacBook-Pro ~ % nslookup -type=ns google.in
Server:          192.168.1.7
Address:         192.168.1.7#53

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

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
ns3.google.com  internet address = 216.239.36.10
ns4.google.com  internet address = 216.239.38.10
ns2.google.com  internet address = 216.239.34.10
ns2.google.com  has AAAA address 2001:4860:4802:34::a

[stanzingyalpo@STANZINs-MacBook-Pro ~ % nslookup google.in ns1.google.com
Server:          ns1.google.com
Address:         216.239.32.10#53

Name:   google.in
Address: 142.250.182.164

stanzingyalpo@STANZINs-MacBook-Pro ~ % ]
```

Here we can see that the authoritative result for the domain google.in is 142.250.182.164.

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.

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nslookup -debug google.in
Server:          192.168.1.7
Address:         192.168.1.7#53

-----
QUESTIONS:
    google.in, type = A, class = IN
ANSWERS:
->  google.in
    internet address = 142.250.193.4
    ttl = 299
AUTHORITY RECORDS:
ADDITIONAL RECORDS:
-----
Non-authoritative answer:
Name:   google.in
Address: 142.250.193.4

stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

Here we can see that the TTL for the domain google.in is 299 seconds, which means that the DNS record will expire from the local DNS server after 299 seconds, or 4 minutes and 59 seconds.

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % nslookup -debug iiitd.ac.in
Server:      192.168.1.7
Address:     192.168.1.7#53

-----
QUESTIONS:
    iiitd.ac.in, type = A, class = IN
ANSWERS:
->  iiitd.ac.in
    internet address = 192.168.2.127
    ttl = 3600
AUTHORITY RECORDS:
ADDITIONAL RECORDS:
-----
Name:  iiitd.ac.in
Address: 192.168.2.127

stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

Here we can see that the TTL for the domain iiitd.ac.in is 3600 seconds, which means that the DNS record will expire from the local DNS server after 3600 seconds, or 1 hour.

Q.5. [13]

- a) 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. [1+2+1]

Note that some of the intermediate hosts might not be visible; their IP addresses will come as “*”, ignore those hosts for this assignment.**

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % traceroute google.in
traceroute to google.in (142.250.193.4), 64 hops max, 40 byte packets
 1  192.168.32.254 (192.168.32.254)  91.303 ms  61.883 ms  38.812 ms
 2  vpn.iiitd.edu.in (192.168.1.99)  4.335 ms  4.021 ms  6.019 ms
 3  103.25.231.1 (103.25.231.1)  30.336 ms  16.931 ms  12.816 ms
 4  * * *
 5  10.119.234.162 (10.119.234.162)  7.750 ms  13.464 ms  7.182 ms
 6  72.14.195.56 (72.14.195.56)  38.049 ms  9.575 ms
    72.14.194.160 (72.14.194.160)  7.364 ms
 7  142.251.54.111 (142.251.54.111)  31.169 ms  28.982 ms  30.613 ms
 8  142.251.54.87 (142.251.54.87)  28.163 ms
    142.251.54.89 (142.251.54.89)  34.864 ms  30.678 ms
 9  del11s14-in-f4.1e100.net (142.250.193.4)  29.608 ms  31.503 ms  29.007 ms
stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

Jumps(intermediate hosts): 9

Jump 1: 192.168.32.254 (local router) (avg latency: 63.999ms)
Jump 2: 192.168.1.99 (vpn.iiitd.edu.in) (avg latency: 4.791ms)
Jump 3: 103.25.231.1 (avg latency: 20.027ms)
Jump 4: Data unavailable
Jump 5: 10.119.234.162 (avg latency: 9.465ms)
Jump 6: 72.14.195.56 or 72.14.194.160 (avg latency: 18.329ms)
Jump 7: 142.251.54.111 (avg latency: 30.254ms)
Jump 8: 142.251.54.87 or 142.251.54.89 (avg latency: 31.235ms)
Jump 9: 142.250.193.4 (avg latency: 30.039ms)

Total Avg Latency: 208.139ms

Avg Latency: 78.052ms

- b) Send 50 ping messages to google.in, Determine the average latency. Put a screenshot.
[1]

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % ping -c 50 google.in
PING google.in (142.250.193.4): 56 data bytes
64 bytes from 142.250.193.4: icmp_seq=0 ttl=56 time=47.585 ms
64 bytes from 142.250.193.4: icmp_seq=1 ttl=56 time=28.977 ms
64 bytes from 142.250.193.4: icmp_seq=2 ttl=56 time=37.121 ms
64 bytes from 142.250.193.4: icmp_seq=3 ttl=56 time=30.051 ms
64 bytes from 142.250.193.4: icmp_seq=4 ttl=56 time=30.535 ms
64 bytes from 142.250.193.4: icmp_seq=5 ttl=56 time=30.899 ms
64 bytes from 142.250.193.4: icmp_seq=6 ttl=56 time=30.693 ms
64 bytes from 142.250.193.4: icmp_seq=7 ttl=56 time=31.071 ms
64 bytes from 142.250.193.4: icmp_seq=8 ttl=56 time=32.448 ms
64 bytes from 142.250.193.4: icmp_seq=9 ttl=56 time=28.916 ms
64 bytes from 142.250.193.4: icmp_seq=10 ttl=56 time=29.487 ms
64 bytes from 142.250.193.4: icmp_seq=11 ttl=56 time=29.325 ms
64 bytes from 142.250.193.4: icmp_seq=12 ttl=56 time=29.175 ms
64 bytes from 142.250.193.4: icmp_seq=13 ttl=56 time=31.656 ms
64 bytes from 142.250.193.4: icmp_seq=14 ttl=56 time=30.099 ms
64 bytes from 142.250.193.4: icmp_seq=15 ttl=56 time=33.982 ms
```

```

64 bytes from 142.250.193.4: icmp_seq=37 ttl=56 time=33.819 ms
64 bytes from 142.250.193.4: icmp_seq=38 ttl=56 time=32.829 ms
64 bytes from 142.250.193.4: icmp_seq=39 ttl=56 time=29.844 ms
64 bytes from 142.250.193.4: icmp_seq=40 ttl=56 time=33.133 ms
64 bytes from 142.250.193.4: icmp_seq=41 ttl=56 time=28.883 ms
64 bytes from 142.250.193.4: icmp_seq=42 ttl=56 time=31.653 ms
64 bytes from 142.250.193.4: icmp_seq=43 ttl=56 time=29.050 ms
64 bytes from 142.250.193.4: icmp_seq=44 ttl=56 time=29.176 ms
64 bytes from 142.250.193.4: icmp_seq=45 ttl=56 time=30.085 ms
64 bytes from 142.250.193.4: icmp_seq=46 ttl=56 time=35.311 ms
64 bytes from 142.250.193.4: icmp_seq=47 ttl=56 time=29.224 ms
64 bytes from 142.250.193.4: icmp_seq=48 ttl=56 time=28.506 ms
64 bytes from 142.250.193.4: icmp_seq=49 ttl=56 time=34.990 ms

--- google.in ping statistics ---
50 packets transmitted, 50 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 27.851/31.608/47.585/3.531 ms
stanzingyalpo@STANZINs-MacBook-Pro ~ %

```

Avg latency: 31.608ms

- c) Add up the ping latency of all the intermediate hosts obtained in (a) and compare with (b). Are they matching, explain? [1+1]

The difference in latency between traceroute (78.052 ms) and ping (31.608 ms) can be explained by three factors:

1. Cumulative Roundtrip: Traceroute measures latency to each intermediate host and back, accumulating more latency than ping, which measures direct round-trip time to the destination.
2. Packet Count: Ping sends more packets (50) than traceroute (3), providing a more accurate average latency. Traceroute's smaller sample size may not fully capture network variability.
3. Network Inconsistencies: Traceroute averages three attempts per hop, leading to potential variability due to network issues, while ping's larger sample size smooths out these inconsistencies.

- d) Take the maximum ping latency amongst the intermediate hosts (in (a)) and compare it with (b). Are they matching, explain? [1+1]

Max ping latency in (a) and (b) are 63.999ms and 47.585ms.

The higher maximum latency in traceroute compared to the average latency in ping is due to network congestion and other delays affecting specific attempts, while ping averages out these

fluctuations.

- e) You may see multiple entries for a single hop while using the traceroute command. What do these entries mean? [1]

Multiple entries for a single hop in the traceroute command suggest that there are multiple paths to the destination host. At various points in the network, a router may direct traffic through different routes, each with its own latency, influenced by network conditions such as congestion and faults. Since the path may change with each packet, the latency values can vary with each attempt made by the traceroute command.

- f) Send 50 ping messages to stanford.edu, Determine the average latency. Put a screenshot. [1]

```
[stanzingyalpo@STANZINs-MacBook-Pro ~ % ping -c 50 stanford.edu
PING stanford.edu (171.67.215.200): 56 data bytes
64 bytes from 171.67.215.200: icmp_seq=0 ttl=242 time=290.078 ms
64 bytes from 171.67.215.200: icmp_seq=1 ttl=242 time=291.093 ms
64 bytes from 171.67.215.200: icmp_seq=2 ttl=242 time=300.066 ms
64 bytes from 171.67.215.200: icmp_seq=3 ttl=242 time=300.449 ms
64 bytes from 171.67.215.200: icmp_seq=4 ttl=242 time=291.077 ms
64 bytes from 171.67.215.200: icmp_seq=5 ttl=242 time=364.030 ms
64 bytes from 171.67.215.200: icmp_seq=6 ttl=242 time=288.926 ms
64 bytes from 171.67.215.200: icmp_seq=7 ttl=242 time=294.115 ms
64 bytes from 171.67.215.200: icmp_seq=8 ttl=242 time=290.920 ms
64 bytes from 171.67.215.200: icmp_seq=9 ttl=242 time=289.760 ms
64 bytes from 171.67.215.200: icmp_seq=10 ttl=242 time=288.999 ms

64 bytes from 171.67.215.200: icmp_seq=36 ttl=242 time=287.868 ms
64 bytes from 171.67.215.200: icmp_seq=37 ttl=242 time=390.744 ms
64 bytes from 171.67.215.200: icmp_seq=38 ttl=242 time=320.596 ms
64 bytes from 171.67.215.200: icmp_seq=39 ttl=242 time=289.250 ms
64 bytes from 171.67.215.200: icmp_seq=40 ttl=242 time=347.985 ms
64 bytes from 171.67.215.200: icmp_seq=41 ttl=242 time=382.701 ms
64 bytes from 171.67.215.200: icmp_seq=42 ttl=242 time=292.059 ms
64 bytes from 171.67.215.200: icmp_seq=43 ttl=242 time=290.690 ms
64 bytes from 171.67.215.200: icmp_seq=44 ttl=242 time=289.167 ms
64 bytes from 171.67.215.200: icmp_seq=45 ttl=242 time=288.574 ms
64 bytes from 171.67.215.200: icmp_seq=46 ttl=242 time=379.192 ms
64 bytes from 171.67.215.200: icmp_seq=47 ttl=242 time=290.430 ms
64 bytes from 171.67.215.200: icmp_seq=48 ttl=242 time=295.124 ms
64 bytes from 171.67.215.200: icmp_seq=49 ttl=242 time=345.287 ms

--- stanford.edu ping statistics ---
50 packets transmitted, 50 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 287.868/310.598/390.744/31.275 ms
stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

Avg latency: 310.598ms

- g) 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`). [1]

```
--- stanford.edu ping statistics ---
50 packets transmitted, 50 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 287.868/310.598/390.744/31.275 ms
[stanzingyalpo@STANZINs-MacBook-Pro ~ % traceroute stanford.edu
traceroute to stanford.edu (171.67.215.200), 64 hops max, 40 byte packets
 1  192.168.32.254 (192.168.32.254)  49.998 ms  26.154 ms  16.389 ms
 2  vpn.iiitd.edu.in (192.168.1.99)  4.627 ms  4.185 ms  3.961 ms
 3  103.25.231.1 (103.25.231.1)  4.090 ms  15.437 ms  4.524 ms
 4  10.1.209.201 (10.1.209.201)  29.878 ms  32.765 ms  31.506 ms
 5  10.1.200.137 (10.1.200.137)  33.873 ms  35.630 ms  35.303 ms
 6  10.255.238.254 (10.255.238.254)  28.240 ms
    10.255.238.122 (10.255.238.122)  35.383 ms  33.011 ms
 7  180.149.48.18 (180.149.48.18)  29.212 ms  32.202 ms  28.947 ms
 8  * * *
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * campus-ial-nets-a-vl1020.sunet (171.64.255.232)  284.303 ms *
24  campus-ial-nets-b-vl1120.sunet (171.66.255.232)  298.663 ms * *
25  web.stanford.edu (171.67.215.200)  289.412 ms  335.727 ms *
stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

`google.in` : 9 hops

`stanford.edu` : 25 hops

- h) Can you explain the reason for the latency difference between `google.in` and `stanford.edu` (see (b) & (f))? [1]

Latency differences between `google.in` and `stanford.edu` are due to:

1. Distance: Longer travel distance to `stanford.edu` increases latency.
2. Routing Complexity: More intermediate hosts in the route to `stanford.edu` add to the latency.

Q.6.. [2+1] 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.

```
[stanzingyalpo@STANZINS-MacBook-Pro ~ % ifconfig lo0
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
    options=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
    inet6 ::1 prefixlen 128
    inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
    inet 127.0.0.1 netmask 0xff000000
        nd6 options=201<PERFORMNUD,DAD>
[stanzingyalpo@STANZINS-MacBook-Pro ~ % ping -c 5 127.0.0.1
PING 127.0.0.1 (127.0.0.1): 56 data bytes
64 bytes from 127.0.0.1: icmp_seq=0 ttl=64 time=0.090 ms
64 bytes from 127.0.0.1: icmp_seq=1 ttl=64 time=0.230 ms
64 bytes from 127.0.0.1: icmp_seq=2 ttl=64 time=0.172 ms
64 bytes from 127.0.0.1: icmp_seq=3 ttl=64 time=0.176 ms
64 bytes from 127.0.0.1: icmp_seq=4 ttl=64 time=0.154 ms

--- 127.0.0.1 ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.090/0.164/0.230/0.045 ms
[stanzingyalpo@STANZINS-MacBook-Pro ~ % sudo ifconfig lo0 12.34.56.78
[stanzingyalpo@STANZINS-MacBook-Pro ~ % ping -c 5 127.0.0.1
PING 127.0.0.1 (127.0.0.1): 56 data bytes
Request timeout for icmp_seq 0
Request timeout for icmp_seq 1
Request timeout for icmp_seq 2
Request timeout for icmp_seq 3

--- 127.0.0.1 ping statistics ---
5 packets transmitted, 0 packets received, 100.0% packet loss
[stanzingyalpo@STANZINS-MacBook-Pro ~ % ifconfig lo0
lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
    options=1203<RXCSUM,TXCSUM,TXSTATUS,SW_TIMESTAMP>
    inet6 ::1 prefixlen 128
    inet6 fe80::1%lo0 prefixlen 64 scopeid 0x1
    inet 12.34.56.78 netmask 0xff000000
        nd6 options=201<PERFORMNUD,DAD>
[stanzingyalpo@STANZINS-MacBook-Pro ~ % sudo ifconfig lo0 127.0.0.1
[stanzingyalpo@STANZINS-MacBook-Pro ~ % ping -c 5 127.0.0.1
PING 127.0.0.1 (127.0.0.1): 56 data bytes
64 bytes from 127.0.0.1: icmp_seq=0 ttl=64 time=0.164 ms
64 bytes from 127.0.0.1: icmp_seq=1 ttl=64 time=0.296 ms
64 bytes from 127.0.0.1: icmp_seq=2 ttl=64 time=0.307 ms
64 bytes from 127.0.0.1: icmp_seq=3 ttl=64 time=0.098 ms
64 bytes from 127.0.0.1: icmp_seq=4 ttl=64 time=0.207 ms

--- 127.0.0.1 ping statistics ---
```

```
--- 127.0.0.1 ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 0.098/0.214/0.307/0.079 ms
stanzingyalpo@STANZINs-MacBook-Pro ~ %
```

127.0.0.1 is the IP address assigned to the loopback interface (lo0) on your device. It is used to test the network stack of the device and is commonly referred to as localhost. We changed the ip address of lo0 by using the sudo ifconfig lo0 <random ip> command and tried pinging, and it failed. Then we reverted lo0 to the original ip address and pinged again and it worked.