Computer Networks

Assignment1

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Some points to be considered:

- All the codes are managed on GitHub and can also be found in this folder.
- We both have Macbook so any functionality that is only specific to Windows Command Shell or Power Shell couldn't be concluded by us.

Token Distribution:
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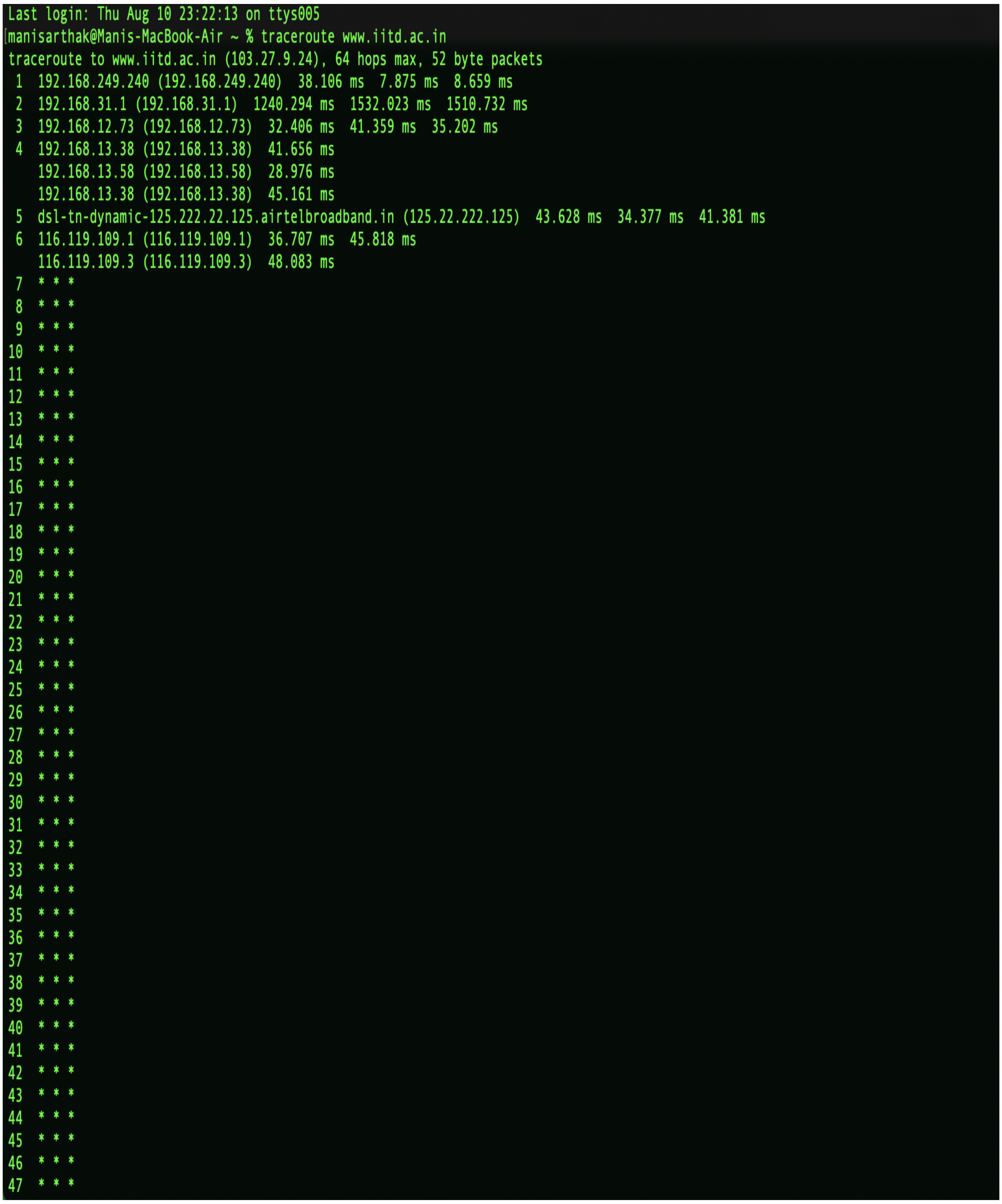
§1 Part1 : Network Analysis

§1.1 Traceroute to servers

Procedure: Connected personal laptop (Mani's Macbook) to 4G/5G cellular network of Jio using cellular hotspot. Then traceroute to different servers were called.

§1.1.1 Tracerouting to www.iitd.ac.in



```
Last login: Thu Aug 10 23:22:13 on ttys005
[manisarthak@Manis-MacBook-Air ~ % traceroute www.iitd.ac.in
traceroute to www.iitd.ac.in (103.27.9.24), 64 hops max, 52 byte packets
 1  192.168.249.240 (192.168.249.240)  38.106 ms  7.875 ms  8.659 ms
 2  192.168.31.1 (192.168.31.1)  1240.294 ms  1532.023 ms  1510.732 ms
 3  192.168.12.73 (192.168.12.73)  32.406 ms  41.359 ms  35.202 ms
 4  192.168.13.38 (192.168.13.38)  41.656 ms
    192.168.13.58 (192.168.13.58)  28.976 ms
    192.168.13.38 (192.168.13.38)  45.161 ms
 5  dsl-tn-dynamic-125.222.22.125.airtelbroadband.in (125.22.222.125)  43.628 ms  34.377 ms  41.381 ms
 6  116.119.109.1 (116.119.109.1)  36.707 ms  45.818 ms
    116.119.109.3 (116.119.109.3)  48.083 ms
 7  * * *
 8  * * *
 9  * * *
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47  * * *
```
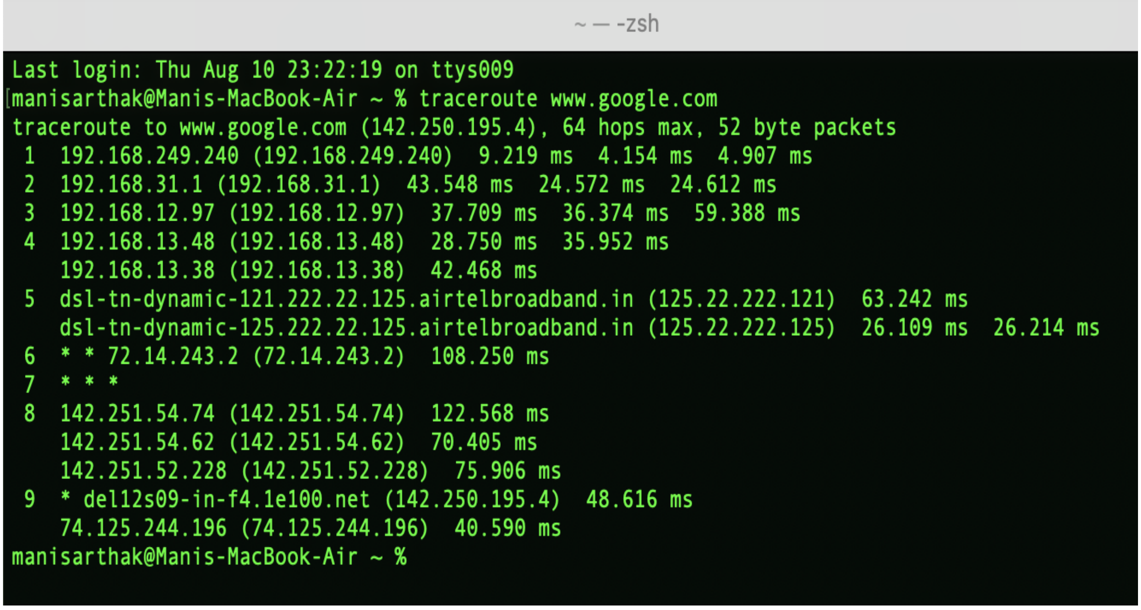

It seems as the ISP is blocking packets to the path to www.iitd.ac.in, so we now try to traceroute to www.google.com.

§1.1.2 Tracerouting to www.google.com



```
Last login: Thu Aug 10 23:22:19 on ttys009
[manisarthak@Manis-MacBook-Air ~ % traceroute www.google.com
traceroute to www.google.com (142.250.195.4), 64 hops max, 52 byte packets
 1  192.168.249.240 (192.168.249.240)  9.219 ms  4.154 ms  4.907 ms
 2  192.168.31.1 (192.168.31.1)  43.548 ms  24.572 ms  24.612 ms
 3  192.168.12.97 (192.168.12.97)  37.709 ms  36.374 ms  59.388 ms
 4  192.168.13.48 (192.168.13.48)  28.750 ms  35.952 ms
    192.168.13.38 (192.168.13.38)  42.468 ms
 5  dsl-tn-dynamic-121.222.22.125.airtelbroadband.in (125.22.222.121)  63.242 ms
    dsl-tn-dynamic-125.222.22.125.airtelbroadband.in (125.22.222.125)  26.109 ms  26.214 ms
 6  * * 72.14.243.2 (72.14.243.2)  108.250 ms
 7  * * *
 8  142.251.54.74 (142.251.54.74)  122.568 ms
    142.251.54.62 (142.251.54.62)  70.405 ms
    142.251.52.228 (142.251.52.228)  75.906 ms
 9  * del12s09-in-f4.1e100.net (142.250.195.4)  48.616 ms
    74.125.244.196 (74.125.244.196)  40.590 ms
manisarthak@Manis-MacBook-Air ~ %
```

The traceroute to www.google.com was successful and it took 9 hops to reach the destination address.

§1.2 Observations

- After calling traceroute to multiple destinations, i didn't find any case in which paths default to IPv6, so i conclude that if that occurs then it must be rare.

- By default in Mac's unix running traceroute returns IP addresses in paths in IPv4 only, however if one wants to get the IP's in IPv6 then one should use the command traceroute6.

- We can also observe private IP addresses in the paths like 192.168.249.240, 192.168.31.1, 198.162.13.38 and so on and these are common in the path of both. This shows that they both use the initial routers of Jio Network which is private before transferring the packets to the global networks.

- There are also routers that do not reply to traceroute requests. Example: see router number 7 in google.com traceroute call.

§1.3 Ping

- Ping command is used to send packets to check wether an IP address is live or not.

- The -s flag allows us to send ping requests with different packet sizes with the default value being 56 Bytes (excluding 8 Bytes ICMP header). The real packet which is sent and received is 8 Bytes more than the data pinged, this is because of the 8 Byte ICMP header which is added to the original data.

- The maximum size of ping packets that we are able to send from MacBook M1 by using IITD WiFi for websites is mentioned below. We have used Binary Search to get to the conclusion.

Destination	Size
www.facebook.com	1472
www.nytimes.com	1472
www.indianexpress.com	8184
www.iitd.ac.in	8184

Table 1 Table showing the maximum size of ping packets without ICMP header (in Bytes) that can be sent to the destination servers.

Observations:

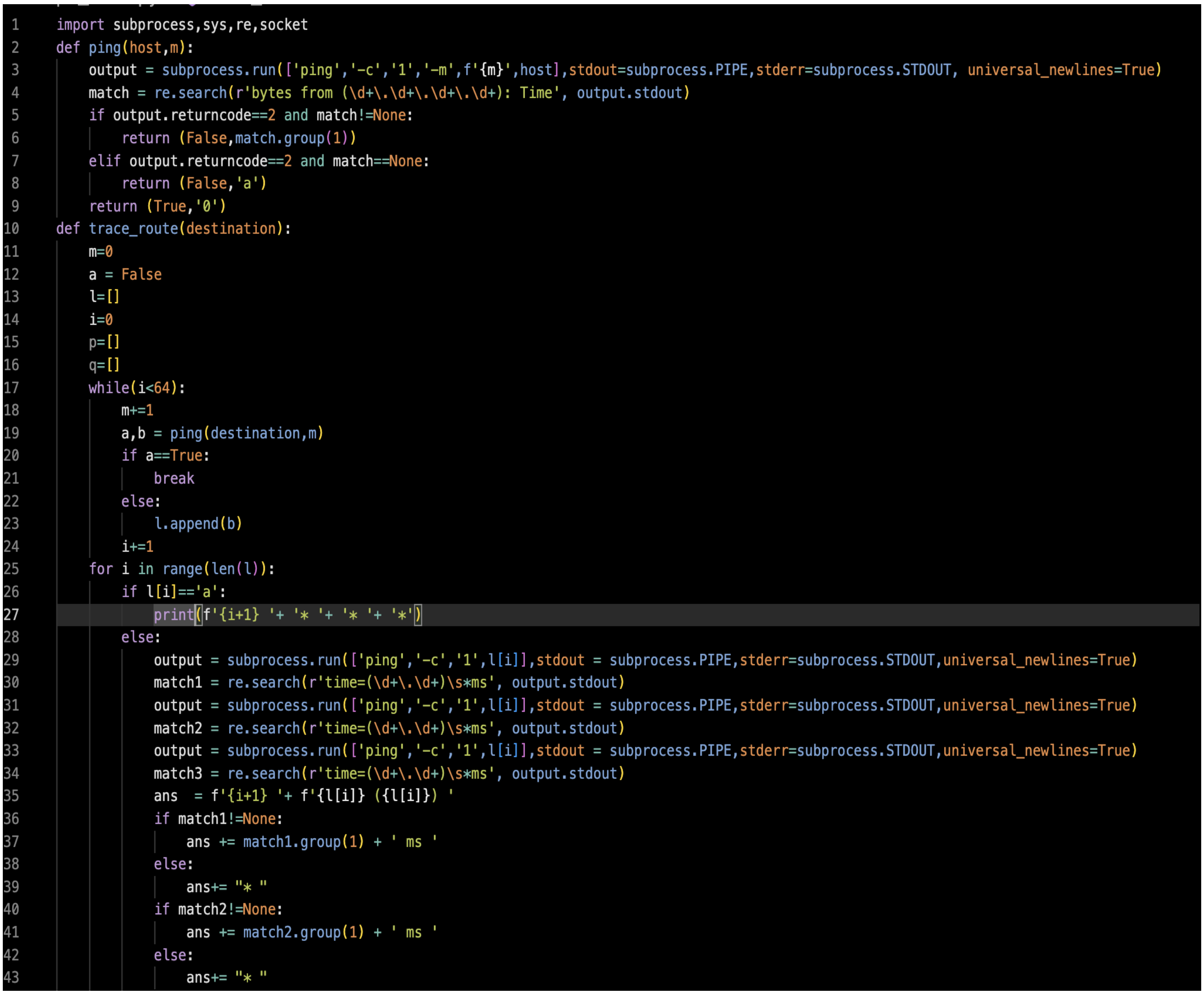
- As servers like www.iitd.ac.in and www.indianexpress.com have very higher sizes. Also because www.facebook.com have multiple servers and the one we are sending ping is also in proximity to us but still we are getting lesser size, can be because packet size for ping also depends on servers.
- So we conclude that the maximum size depends on the servers that we are sending and also that whether they are in our proximity or not.

§2 Part2

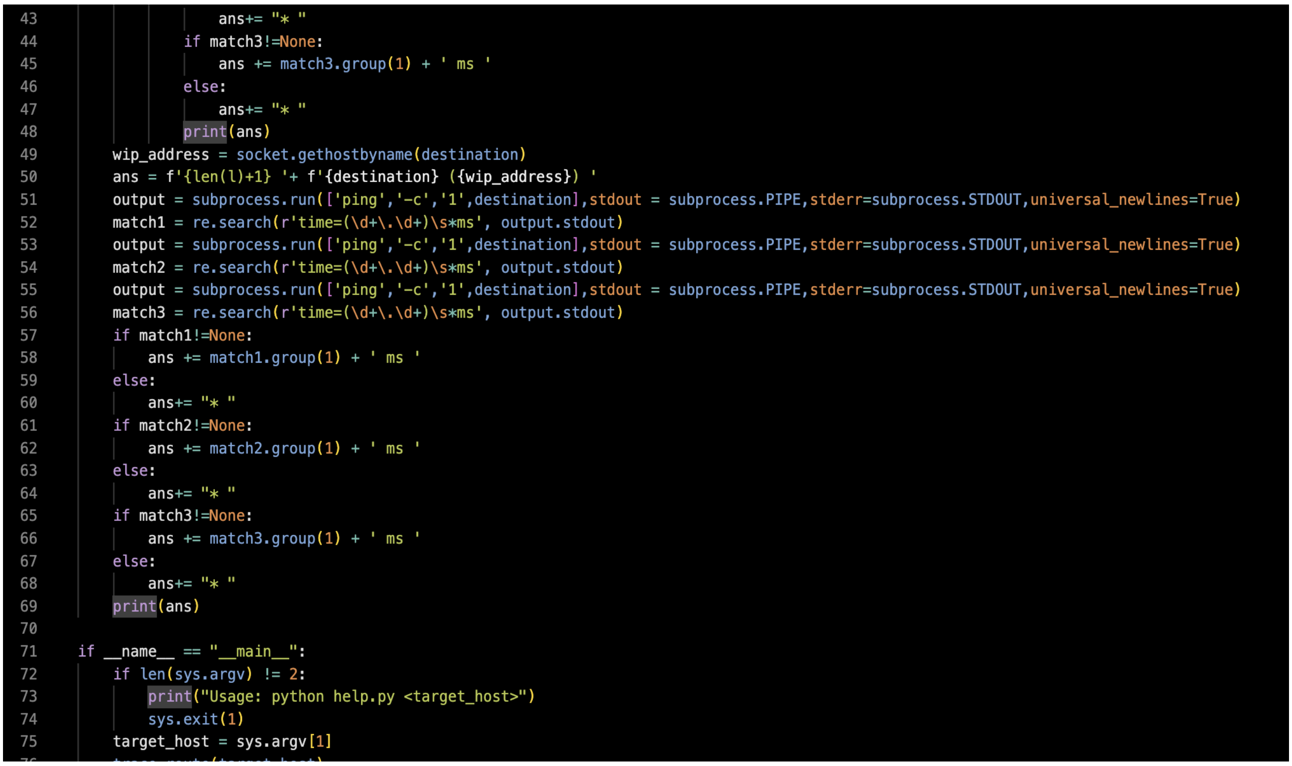
§2.1 Methodology

Logic : What we did here was very simple. we used linux ping command here. we observed that when we limit the TTL (max no. of hopes) such that it can't reach the destination IP, the router sends a ICMP response upon dropping the packet which contain the IP address at which packet is dropped. so by using this observation , we iterate and increased the TTL at each iteration so that we get all intermediate IP address as no. of hops is increased by 1 each time until the packet is reached to the destination and we stop there. after that we ping at each intermediate IP to get **Round Trip Time** and we report it. so traceroute functionality is replictaed.

§2.2 View of code



```python
import subprocess,sys,re,socket
def ping(host,m):
    output = subprocess.run(['ping','-c','1','-m',f'{m}',host],stdout=subprocess.PIPE,stderr=subprocess.STDOUT, universal_newlines=True)
    match = re.search(r'bytes from (\d+\.\d+\.\d+\.\d+): Time', output.stdout)
    if output.returncode==2 and match!=None:
        return (False,match.group(1))
    elif output.returncode==2 and match==None:
        return (False,'a')
    return (True,'0')
def trace_route(destination):
    m=0
    a = False
    l=[]
    i=0
    p=[]
    q=[]
    while(i<64):
        m+=1
        a,b = ping(destination,m)
        if a==True:
            break
        else:
            l.append(b)
        i+=1
    for i in range(len(l)):
        if l[i]=='a':
            print(f'{i+1} '+ '* '+ '* '+ '*')
        else:
            output = subprocess.run(['ping','-c','1',l[i]],stdout = subprocess.PIPE,stderr=subprocess.STDOUT,universal_newlines=True)
            match1 = re.search(r'time=(\d+\.\d+)\s*ms', output.stdout)
            output = subprocess.run(['ping','-c','1',l[i]],stdout = subprocess.PIPE,stderr=subprocess.STDOUT,universal_newlines=True)
            match2 = re.search(r'time=(\d+\.\d+)\s*ms', output.stdout)
            output = subprocess.run(['ping','-c','1',l[i]],stdout = subprocess.PIPE,stderr=subprocess.STDOUT,universal_newlines=True)
            match3 = re.search(r'time=(\d+\.\d+)\s*ms', output.stdout)
            ans  = f'{i+1} '+ f'{l[i]} ({l[i]}) '
            if match1!=None:
                ans += match1.group(1) + ' ms '
            else:
                ans+= "* "
            if match2!=None:
                ans += match2.group(1) + ' ms '
            else:
                ans+= "* "
```



```
                ans+= "* "
            if match3!=None:
                ans += match3.group(1) + ' ms '
            else:
                ans+= "* "
            print(ans)
    wip_address = socket.gethostbyname(destination)
    ans = f'{len(l)+1} '+ f'{destination} ({wip_address}) '
    output = subprocess.run(['ping','-c','1',destination],stdout = subprocess.PIPE,stderr=subprocess.STDOUT,universal_newlines=True)
    match1 = re.search(r'time=(\d+\.\d+)\s*ms', output.stdout)
    output = subprocess.run(['ping','-c','1',destination],stdout = subprocess.PIPE,stderr=subprocess.STDOUT,universal_newlines=True)
    match2 = re.search(r'time=(\d+\.\d+)\s*ms', output.stdout)
    output = subprocess.run(['ping','-c','1',destination],stdout = subprocess.PIPE,stderr=subprocess.STDOUT,universal_newlines=True)
    match3 = re.search(r'time=(\d+\.\d+)\s*ms', output.stdout)
    if match1!=None:
        ans += match1.group(1) + ' ms '
    else:
        ans+= "* "
    if match2!=None:
        ans += match2.group(1) + ' ms '
    else:
        ans+= "* "
    if match3!=None:
        ans += match3.group(1) + ' ms '
    else:
        ans+= "* "
    print(ans)

if __name__ == "__main__":
    if len(sys.argv) != 2:
        print("Usage: python help.py <target_host>")
        sys.exit(1)
    target_host = sys.argv[1]
    trace_route(target_host)
```

§2.3 Commands and Modules used

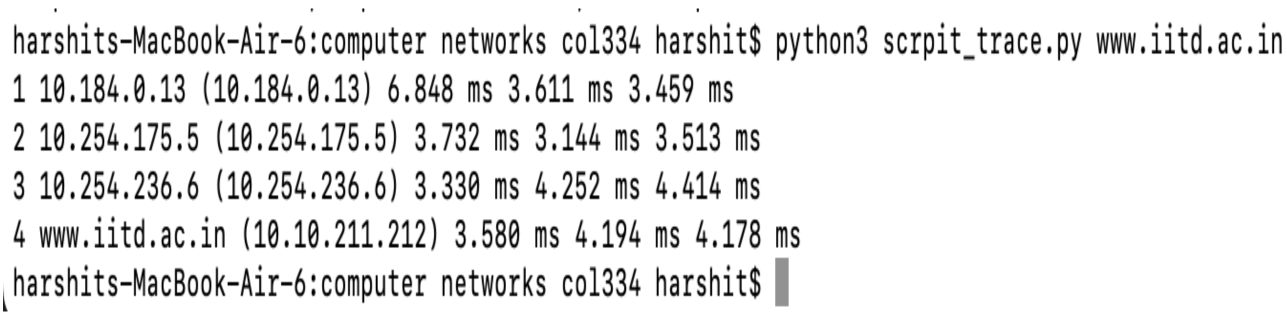
- ping -c 1 -m *TTL Destination_IP* here -c is for sending only 1 packet and -m is for defining TTL (here macos terminal is used)
- ping -c 1 *destination_ip* for getting the time for each intermediate IP
- **subprocess** module is used for running commands at console
- **re** module is used for extracting IP from text output
- **sys** module for taking input from command line
- **socket** module for getting ip address for destination website

§2.4 Input

Use the code and put input in console as:-

python/python3 script_trace.py *destination_ip*

§2.5 Output for www.iitd.ac.in



```
harshits-MacBook-Air-6:computer networks col334 harshit$ python3 scrpit_trace.py www.iitd.ac.in
1 10.184.0.13 (10.184.0.13) 6.848 ms 3.611 ms 3.459 ms
2 10.254.175.5 (10.254.175.5) 3.732 ms 3.144 ms 3.513 ms
3 10.254.236.6 (10.254.236.6) 3.330 ms 4.252 ms 4.414 ms
4 www.iitd.ac.in (10.10.211.212) 3.580 ms 4.194 ms 4.178 ms
harshits-MacBook-Air-6:computer networks col334 harshit$ 
```

§2.6 design decisions

- If in a particular IP we can't get a response or we can't get a intermediate IP during hops we leave a it blank with a * mark
- We are sending 3 packet here so Round Trip Time here is for 3 packets only and we can't change no. of packets as it is by default 3 in tarceroute as sending more than 1 packet will make many edge cases

§3 Part3

§3.1 Hops analysis

For India IITD WiFi is used, for South Africa the traceroute server of Capetown city was used and for USA traceroute server of Seattle was used.

Source & Destination	utah.edu	uct.ac.za	iitd.ac.in	google.com	facebook.com
India	64+	64+	4	11	13
South Africa	19	4	20	13	19
USA	11	NA	16	10	9

Table 2 Table showing the number of hops to the destination from different traceroute servers.

Observations:

- If the traceroute source and destination are close to each other geographically then they have roughly fewer hops between them. For example see (India, iitd.ac.in) , (South Africa, uct.ac.za), (USA, utah.ac.in).
- Google and Facebook have very few number of hops as compared to others. This is because they have distributed servers across the globe and the traceroute takes their closest server as destination.

§3.2 Latency Analysis

For India IITD WiFi is used, for South Africa the traceroute server of Capetown city was used and for USA traceroute server of Seattle was used.

Source & Destination	utah.edu	uct.ac.za	iitd.ac.in	google.com	facebook.com
India	NA	NA	5.066	8.023	31.093
South Africa	231.681	4.013	320.114	248.818	228.993
USA	22.038	NA	270.981	74.357	86.714

Table 3 Table showing the latency between destinations and different traceroute servers (in ms).

Observations:

- Latency seems to be related to the number of hops. Latency depends on a number of factors like traffic between the routers, processing time at the routers etc. Also higher number of hops means a higher chance of getting stuck in traffic and more time consumed at routers. Hence increase in number of hops increases the latency as well.

§3.3 Distributed servers

We find that servers like www.iitd.ac.in, www.utah.edu and www.uct.ac.za are resolved to same IP address irrespective of from where they are getting the traceroute request, whereas servers like www.google.com and www.facebook.com have different destination IP's for different parts of world.
The reason for this is because big MNC's like google and Facebook need to provide their

users with as low latency as possible and also that is economically optimal for them so they create their databases across the globe each acting as a server with unique IP. However educational institutes like utha.edu, iitd.ac.in have a single server for them.

§3.4 Distributed Servers of Google and Facebook

The IPv4 addresses of Google and Facebook are obtained by sending traceroute requests to them through different locations namely:

- IITD WiFi.
- Princeton traceroute server www.net.princeton.edu.
- HanNet Germany server.

The IPv4 addresses of the destination is summarised in the table below.

Source & Destination	www.google.com	www.facebook.com
IITD Wifi	142.250.206.142	157.240.16.35
Princeton	142.250.65.238	31.13.71.36
HanNet	172.217.18.14	157.240.210.35

Table 4 Table showing the IPv4 address of various Google and Facebook servers.

The number of hops and latency for the traceroute requests between the source and destinations can be summarised in the tables below (for latency average of the latency by three packets sent is taken).

Source & Destination	www.google.com	www.facebook.com
IITD Wifi	11	13
Princeton	20	20
HanNet	23	24

Table 5 Table showing #hops to various Google and Facebook servers from IITD WiFi.

Source & Destination	www.google.com	www.facebook.com
IITD Wifi	8.373	38.891
Princeton	334.253	314.255
HanNet	404.218	201.761

Table 6 Table showing the latency of various Google and Facebook servers from IITD WiFi.

Observation:

- Here also we see that traceroute requests to same server but with different IP address have different paths and latencies.
- Also the latencies and #hops are related to each other as increase in #hops roughly increases the latency too.
- Last but not the least, IP addresses for the server nearer to the source have very low latency as compared to other IP addresses.
- Some IP adresses are optimised for my location and hence they have very few hops and latencies but other IP's that are way too far off and hence are longer.

§3.5 Tracerouting to Google and Facebook from different sources

Source & Destination	www.google.com	www.facebook.com
Los Angeles, USA	8	9
Berlin, Germany	14	12
London, UK	12	12
Melbourne, Australia	7	1
Johannesburg, South Africa	-	10
Mombasa, Kenya	17	15

Table 7 Table showing the number of hops to destinations from different traceroute servers.

Source & Destination	www.google.com	www.facebook.com
Los Angeles, USA	7.861	10.717
Berlin, Germany	150.234	157.013
London, UK	131.682	128.631
Melbourne, Australia	11.528	11.823
Johannesburg, South Africa	-	226.6
Mombasa, Kenya	340.216	310.067

Table 8 Table showing the average latency to destinations from different traceroute servers (in ms)

Observations:

- We notice that the #hops and latency for South African cities are significantly more than that of cities like Los Angeles, Melbourne etc.
- We also find that the location of the intermediate IP's in the traceroute from Mombasa and Johannesberg lie in different countrues. So we can say that they are not peered directly with Google and Facebook.

§4 Part4

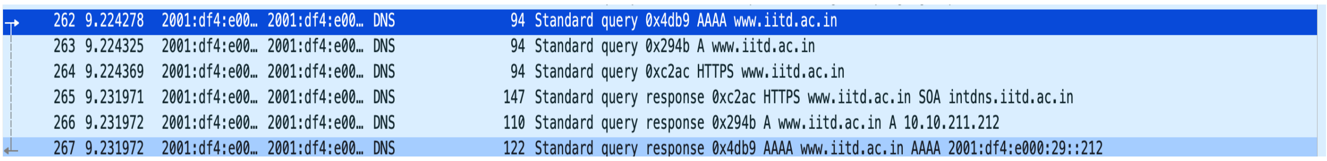
§4.1 Part a

In this part we started wireshark and captured the packets for 2 sites www.iitd.ac.in and http://act4d.iitd.ac.in.

Now we apply the DNS filter and got all the dns requests and responses and after subtracting the response time with request time we get the time for dns request-response, for www.iitd.ac.in it is:

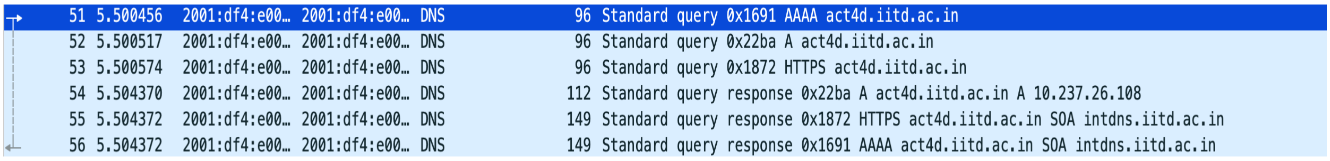
Response time & type of request	www.iitd.ac.in	http://act4d.iitd.ac.in
AAAA	7.694 ms	3.916 ms
A	7.647 ms	3.853 ms
HTTP	7.602 ms	3.798 ms

Table 9 Table showing the response time with different request for 2 sites (in ms)



```
262 9.224278  2001:df4:e00… 2001:df4:e00… DNS    94 Standard query 0x4db9 AAAA www.iitd.ac.in
263 9.224325  2001:df4:e00… 2001:df4:e00… DNS    94 Standard query 0x294b A www.iitd.ac.in
264 9.224369  2001:df4:e00… 2001:df4:e00… DNS    94 Standard query 0xc2ac HTTPS www.iitd.ac.in
265 9.231971  2001:df4:e00… 2001:df4:e00… DNS   147 Standard query response 0xc2ac HTTPS www.iitd.ac.in SOA intdns.iitd.ac.in
266 9.231972  2001:df4:e00… 2001:df4:e00… DNS   110 Standard query response 0x294b A www.iitd.ac.in A 10.10.211.212
267 9.231972  2001:df4:e00… 2001:df4:e00… DNS   122 Standard query response 0x4db9 AAAA www.iitd.ac.in AAAA 2001:df4:e000:29::212
```

pic for www.iitd.ac.in



```
51 5.500456  2001:df4:e00… 2001:df4:e00… DNS    96 Standard query 0x1691 AAAA act4d.iitd.ac.in
52 5.500517  2001:df4:e00… 2001:df4:e00… DNS    96 Standard query 0x22ba A act4d.iitd.ac.in
53 5.500574  2001:df4:e00… 2001:df4:e00… DNS    96 Standard query 0x1872 HTTPS act4d.iitd.ac.in
54 5.504370  2001:df4:e00… 2001:df4:e00… DNS   112 Standard query response 0x22ba A act4d.iitd.ac.in A 10.237.26.108
55 5.504372  2001:df4:e00… 2001:df4:e00… DNS   149 Standard query response 0x1872 HTTPS act4d.iitd.ac.in SOA intdns.iitd.ac.in
56 5.504372  2001:df4:e00… 2001:df4:e00… DNS   149 Standard query response 0x1691 AAAA act4d.iitd.ac.in SOA intdns.iitd.ac.in
```

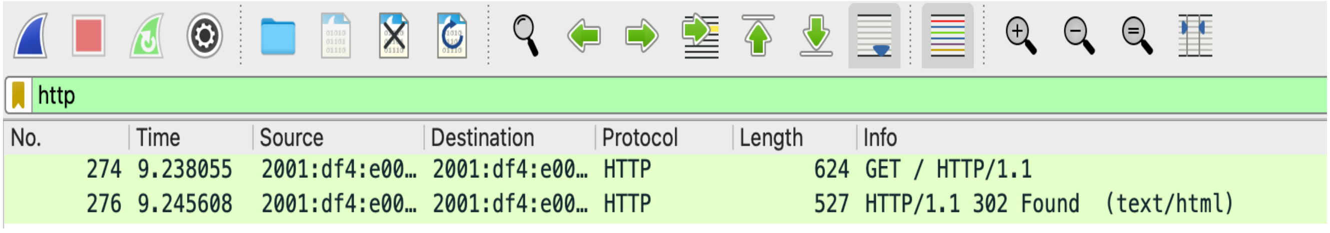
pic for http://act4d.iitd.ac.in

§4.2 Part b

Now applying the http filter and get those packets

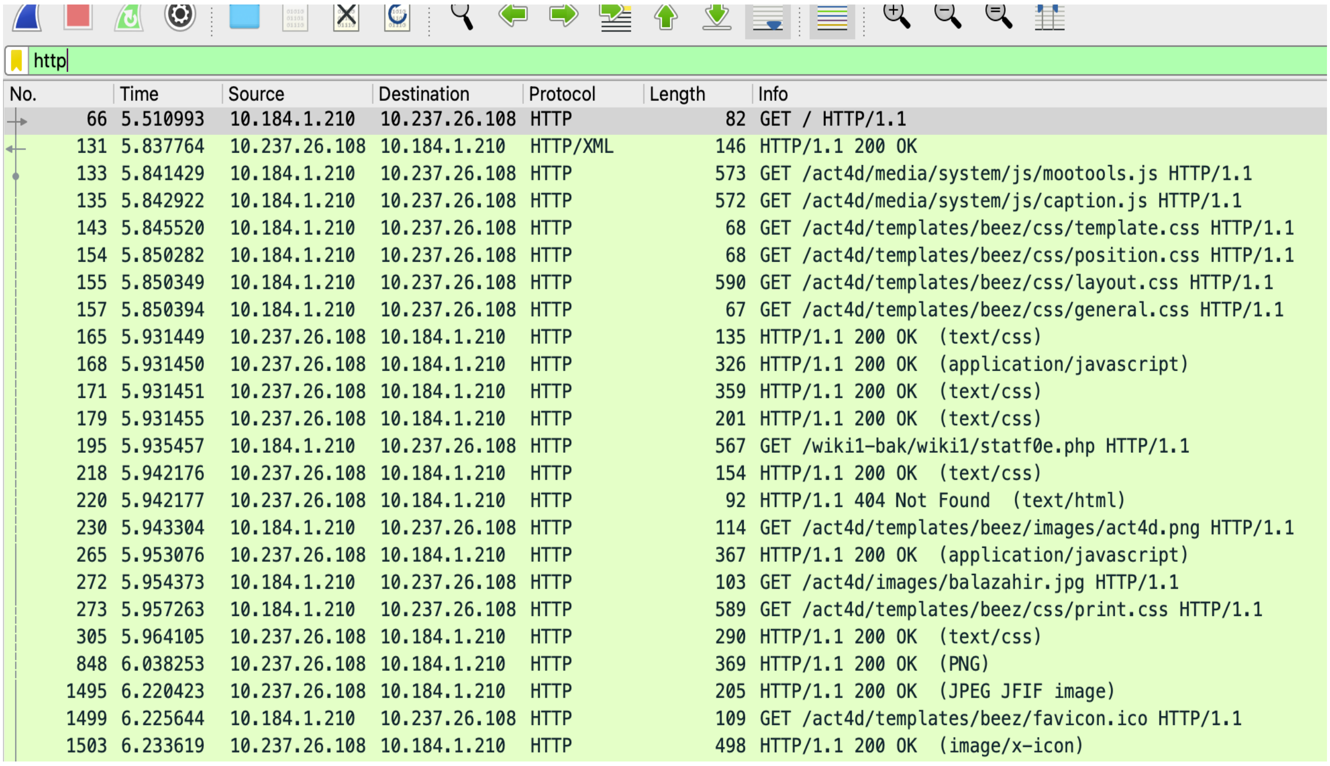
- no. of http request generated for www.iitd.ac.in is :- **1** beacuse this site has secured http so 1 request is visible not css ,js etc.
- no. of http request generated for http://act4d.iitd.ac.in is :- **12** beacuse this website is not secured so we can see how many request these pages have

with seeing the http request for act4d website we can see how webpages are structured and how browser render complex images and files. we can see. so we can see that first application javascript is requested and then templates pages such as html , css , text etc. are requested and then rendered. after they are completed media pages such as images, video , favicon etc. are requested and then rendered.



```
http
No.     Time      Source         Destination    Protocol   Length  Info
   274  9.238055  2001:df4:e00…  2001:df4:e00…  HTTP         624  GET / HTTP/1.1
   276  9.245608  2001:df4:e00…  2001:df4:e00…  HTTP         527  HTTP/1.1 302 Found  (text/html)
```

pic for www.iitd.ac.in



```
http
No.     Time      Source        Destination   Protocol   Length  Info
   66 5.510993 10.184.1.210  10.237.26.108 HTTP           82 GET / HTTP/1.1
  131 5.837764 10.237.26.108 10.184.1.210  HTTP/XML      146 HTTP/1.1 200 OK
  133 5.841429 10.184.1.210  10.237.26.108 HTTP          573 GET /act4d/media/system/js/mootools.js HTTP/1.1
  135 5.842922 10.184.1.210  10.237.26.108 HTTP          572 GET /act4d/media/system/js/caption.js HTTP/1.1
  143 5.845520 10.184.1.210  10.237.26.108 HTTP           68 GET /act4d/templates/beez/css/template.css HTTP/1.1
  154 5.850282 10.184.1.210  10.237.26.108 HTTP           68 GET /act4d/templates/beez/css/position.css HTTP/1.1
  155 5.850349 10.184.1.210  10.237.26.108 HTTP          590 GET /act4d/templates/beez/css/layout.css HTTP/1.1
  157 5.850394 10.184.1.210  10.237.26.108 HTTP           67 GET /act4d/templates/beez/css/general.css HTTP/1.1
  165 5.931449 10.237.26.108 10.184.1.210  HTTP          135 HTTP/1.1 200 OK  (text/css)
  168 5.931450 10.237.26.108 10.184.1.210  HTTP          326 HTTP/1.1 200 OK  (application/javascript)
  171 5.931451 10.237.26.108 10.184.1.210  HTTP          359 HTTP/1.1 200 OK  (text/css)
  179 5.931455 10.237.26.108 10.184.1.210  HTTP          201 HTTP/1.1 200 OK  (text/css)
  195 5.935457 10.184.1.210  10.237.26.108 HTTP          567 GET /wiki1-bak/wiki1/statf0e.php HTTP/1.1
  218 5.942176 10.237.26.108 10.184.1.210  HTTP          154 HTTP/1.1 200 OK  (text/css)
  220 5.942177 10.237.26.108 10.184.1.210  HTTP           92 HTTP/1.1 404 Not Found  (text/html)
  230 5.943304 10.184.1.210  10.237.26.108 HTTP          114 GET /act4d/templates/beez/images/act4d.png HTTP/1.1
  265 5.953076 10.237.26.108 10.184.1.210  HTTP          367 HTTP/1.1 200 OK  (application/javascript)
  272 5.954373 10.184.1.210  10.237.26.108 HTTP          103 GET /act4d/images/balazahir.jpg HTTP/1.1
  273 5.957263 10.184.1.210  10.237.26.108 HTTP          589 GET /act4d/templates/beez/css/print.css HTTP/1.1
  305 5.964105 10.237.26.108 10.184.1.210  HTTP          290 HTTP/1.1 200 OK  (text/css)
  848 6.038253 10.237.26.108 10.184.1.210  HTTP          369 HTTP/1.1 200 OK  (PNG)
 1495 6.220423 10.237.26.108 10.184.1.210  HTTP          205 HTTP/1.1 200 OK  (JPEG JFIF image)
 1499 6.225644 10.184.1.210  10.237.26.108 HTTP          109 GET /act4d/templates/beez/favicon.ico HTTP/1.1
 1503 6.233619 10.237.26.108 10.184.1.210  HTTP          498 HTTP/1.1 200 OK  (image/x-icon)
```

pic for http://act4d.iitd.ac.in

§4.3 Part c

Now we apply the ((ip.src==192.168.1.3 && ip.dst==10.7.174.111) or (ip.src==10.7.174.111 && ip.dst==192.168.1.3)) && TCP filter and answer of 3 questions are given below:

- Now we need to find the no. of tcp connections opened between my browser and web-server. as stated a tcp connection is 3-way handshake, our browser,client, sends SYN message to server , server replies with SYN-ACK message and then client sends an ACK. now to find no. of connecteions opened we just need to count no. of SYN request and we get that count as **6**

- Now we find that this is not same and less than number of HTTP requests for content objects in prevoius part due to the fact that multiple http objects get transferred over same tcp connection due to HTTP/1.1 protocol being alive to reduce latency

- Yes, as stated above multiple HTTP content being fetched over same TCP connection due to the fact the HTTP/1.1 protocol is present and its ability to reuse existing connections for multiple requests to reduce latency and we can identify by checking the source port for different HTTP request as each tcp connection is distinguished by their source and destination port so we found that multiple HTTP request get transfered over same TCP connection.

§4.4 Part d

Now applying trace for **http://www.indianexpress.com** and we apply the http filter. suprisingly we found that there is no HTTP traffic visible over the network as we only found 1 http request for indianexpress.com visible of HTTP/1.1 protocol visible now bowsing through the entire trace without any filters but we cannot see any contents of html and javascript files being transfered. so the reason for that is that this website and many other uses **HTTP secure** which encrypts the traffic, making it difficult to directly see the contents of the transferred files in plaintext.

Therefore we are not able to view the HTTP traffic like the act4d.iitd.ac.in