

# Computer Networks Assignment 1

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This report aims to demonstrate the theoretical concepts involved in the process of sending data through a router network like Network Congestion, TCP Protocols, Maximum Transmissible Packet size, Packet Drop using tools like traceroute, wireshark, ping, nslookup, nmap and ifconfig. ’

## §1 Network Analysis

### §1.1 Running Traceroute on iitd.ac.in from extrenal(non-IITD) network

- Using Traceroute6 (ipv6) :

- After 15th hop, no router responded. It might be the case that packets have been blocked in the path by the ISP.
- At some times no route was found to the host by traceroute6. The possible reasons for this could be that the end system would not be able to find the DNS server, or if it found the server then the server might not be able to find the required IP addresses or route to path could not be found, knowing the ip address.
- In traceroute6 some routers did not respond in between at some hops.

- Using Traceroute (ipv4) :

- IP Addresses on the path - 192.168.114.11, 192.168.59.1, 192.168.27.45, (192.168.27.111/192.168.27.109/ 192.168.27.105), (nsg-corporate-5.39.185.122.airtel.in (122.185.39.5)/nsg-corporate-1.39.185.122.airtel.in (122.185.39.1)), (116.119.109.78/ 116.119.109.72/116.119.109.74).
- Private IP Addresses - 192.168.114.11, 192.168.59.1, 192.168.27.45, (192.168.27.111/192.168.27.109/192.168.27.105). Here 192.168.114.11 is the ip address of my hotspot device. These addresses are reserved for private use and are not available for public internet.
- After the 6th hop, no routers responded for further any hops and the packets were lost. This might be because of disabled traceroute or security measures on any of these routers.

```
[sanya@Sanya-MacBook-Air-2 ~ % traceroute iitd.ac.in
traceroute to iitd.ac.in (103.27.9.24), 64 hops max, 52 byte packets
 1  192.168.114.11 (192.168.114.11)  5.095 ms  2.922 ms  2.799 ms
 2  192.168.59.1 (192.168.59.1)  22.605 ms  39.491 ms  17.317 ms
 3  192.168.27.45 (192.168.27.45)  26.219 ms  21.041 ms  15.935 ms
 4  192.168.27.111 (192.168.27.111)  21.288 ms
 192.168.27.109 (192.168.27.109)  22.108 ms
 192.168.27.105 (192.168.27.105)  23.709 ms
 5  nsg-corporate-5.39.185.122.airtel.in (122.185.39.5)  27.028 ms  20.145 ms
  nsg-corporate-1.39.185.122.airtel.in (122.185.39.1)  25.811 ms
 6  116.119.109.78 (116.119.109.78)  19.524 ms
 116.119.109.72 (116.119.109.72)  21.655 ms
 116.119.109.74 (116.119.109.74)  24.276 ms
 7  * * *
 8  * * *
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  *^C
```

Figure 1: traceroute iitd

```
sanya@Sanyas-MacBook-Air-2 ~ % traceroute6 iitd.ac.in
traceroute6 to iitd.ac.in (2001:df4:e000:29::212) from 2401:4900:47f5:cccd:b441:69bb:459a:9b7b, 64 hops max, 12 byte packets
1 2401:4900:47f5:cccd::3e 2.886 ms 33.747 ms 2.757 ms
2 2401:4900:47f5:cccd::45:e2e6:7240 18.069 ms 36.382 ms 52.113 ms
3 2401:4900:0:c003::6491 16.713 ms 18.966 ms 127.051 ms
4 2401:4900:0:c003::660d 24.384 ms 17.518 ms
2401:4900:0:c003::6601 31.168 ms
5 2401:4900:0:c003::6664 18.194 ms 25.858 ms 25.152 ms
6 2404:a800:1a00:801::e9 25.307 ms
2404:a800:1a00:801::e5 39.783 ms 28.405 ms
7 2404:a800::93 65.628 ms
2404:a800::98 33.139 ms 27.349 ms
8 2405:200:1654:600:49:44:187:a4 46.128 ms 56.878 ms 22.596 ms
9 2405:203:89a::141e 83.251 ms 82.631 ms
2405:203:882::cd2 24.897 ms
10 2405:8a00:a:3::2 89.672 ms
2405:8a00:a:10::1 34.840 ms
2405:8a00:a:3::2 74.474 ms
11 2405:8a00:a:2::c5 36.137 ms 41.584 ms 40.014 ms
12 2405:8a00:a:2::c6 23.771 ms 27.326 ms *
13 2001:4408:a::1 75.257 ms *
2001:4408:520a:18::10:128:128:1 79.915 ms
14 2405:8a00:a:2::c5 75.779 ms * 103.209 ms
15 2405:8a00:a:2::c6 114.982 ms * *
16 * * *
17 * * *
18 * * *
19 * * *
20 * * *
21 * * *
22 * * *
23 * * *
24 * * *
25 * * *
26 * * *
```

Figure 2: traceroute6 iitd

```
sanya@Sanyas-MacBook-Air-2 ~ % traceroute6 iitd.ac.in
connect: No route to host
```

Figure 3: traceroute6 iitd

## §1.2 Running Traceroute functionality on google.com using external(non-IITD network)

- Using Traceroute6 (ipv6) :

- The required number of hops were less for traceroute6 in this case. This could be due to less congestion, optimized routing, or other network-specific factors that favor ipv6 traffic.
- At some times no route was found to the host by traceroute6. The possible reasons for this could be that the end system would not be able to find the DNS server, or if it found the server then the server might not be able to find the required IP addresses or route to path could not be found, knowing the ip address.
- In traceroute some routers did not respond in between at some hops.

- Using Traceroute (ipv4) :

- IP Addresses on the path - 192.168.114.11, 192.168.59.1, (192.168.27.33/ 192.168.27.45), (192.168.27.107/ 192.168.27.105/ 192.168.27.111), nsg-corporate-5.39.185.122.airtel.in (122.185.39.5), 72.14.217.194, (142.251.76.200/ 64.233.174.70), (216.239.54.92/ 64.233.174.0), (108.170.248.193/ 142.251.64.11), 142.250.183.206.
- Private IP Addresses - 192.168.114.11, 192.168.59.1, (192.168.27.33/ 192.168.27.45), (192.168.27.107/ 192.168.27.105/ 192.168.27.111). Here 192.168.114.11 is the ip address of my hotspot device.
- Here we observe that at hops 7, 9, and 10 no response was received from the routers.

```
[sanya@Sanyas-MacBook-Air-2 ~ % traceroute google.com
traceroute to google.com (142.250.183.206), 64 hops max, 52 byte packets
 1  192.168.114.11 (192.168.114.11)  7.622 ms  2.160 ms  1.818 ms
 2  192.168.59.1 (192.168.59.1)  27.280 ms  27.772 ms  25.112 ms
 3  192.168.27.33 (192.168.27.33)  21.188 ms  17.382 ms
 192.168.27.45 (192.168.27.45)  30.115 ms
 4  192.168.27.187 (192.168.27.187)  19.062 ms
 192.168.27.185 (192.168.27.185)  20.223 ms
 192.168.27.111 (192.168.27.111)  22.658 ms
 5  nsg-corporate-5.39.185.122.airtel.in (122.185.39.5)  17.370 ms *  292.926 ms
 6  * * 72.14.217.194 (72.14.217.194)  23.590 ms
 7  * * *
 8  142.251.76.200 (142.251.76.200)  20.253 ms
 64.233.174.70 (64.233.174.70)  19.524 ms *
 9  * * *
10  * * *
11  * 216.239.54.92 (216.239.54.92)  141.875 ms
 64.233.174.0 (64.233.174.0)  44.005 ms
12  108.170.248.193 (108.170.248.193)  42.586 ms *
 142.251.64.11 (142.251.64.11)  80.196 ms
13  bom07s33-in-f14.1e100.net (142.250.183.206)  51.922 ms  54.675 ms  51.369 ms
```

Figure 4: traceroute google

```
[sanya@Sanyas-MacBook-Air-2 ~ % traceroute6 google.com
traceroute6 to google.com (2404:6800:4002:80ff:200e) from 2401:4900:47f6:cccd:b441:69bb:459a:9b7b, 64 hops max, 12 byte packets
 1  2401:4900:47f5:cccd:0:45:e2e6:7240  27.717 ms  20.165 ms  42.896 ms
 2  2401:4900:0:c003::6401  26.078 ms  18.843 ms  29.874 ms
 4  2401:4900:0:c003::6601  26.048 ms  21.374 ms  29.078 ms
 5  2401:4900:0:c003::6602  29.797 ms  40.172 ms
 2401:4900:0:c003::6600  26.086 ms
 6  2404:6800:1a00:801::e5  44.732 ms  24.521 ms  29.380 ms
 7  2001:4860:1:1::10c4  28.578 ms  43.682 ms  37.600 ms
 8  2404:6800:806e::1  40.033 ms
 2404:6800:810d::1  25.610 ms
 2404:6800:811d::1  37.747 ms
 9  2001:4860:0:1::5664  28.259 ms
 2001:4860:0:1::43b8  22.477 ms
 2001:4860:0:1::306a  29.053 ms
10  2001:4860:0:1::3061  39.134 ms
 2001:4860:0:1::11dd::b  22.044 ms
 2001:4860:0:1::305f  33.720 ms
11  dell1s04-in-x0e.1e100.net  19.547 ms
 2001:4860:0:9e::1  35.720 ms
 2001:4860:0:1a::1  25.129 ms
sanya@Sanyas-MacBook-Air-2 ~ % traceroute6 indianexpress.com
traceroute6: nodename nor servname provided, or not known
```

Figure 5: traceroute6 google

```
[sanya@Sanyas-MacBook-Air-2 ~ % traceroute6 google.com
connect: No route to host
```

Figure 6: traceroute6 google

### §1.3 Paths Defaulting to ipv6 and forced to ipv4

- When we try to find the traceroute of google.com, it is observed that the path gets defaulted to ipv6 routers. This might be because of the larger address spaces offered by ipv6, which can accommodate the growing number of devices connected to the internet. Ipv6 also provides improved network efficiency and performance, making it a practical choice for modern networks.
- To force the traceroute to use a path containing ipv4 routers, -4 flag is used. As we can observe, the address changed from the hexadecimal representation used in ipv6 to decimal representation in ipv4.
- Here the ip addresses lying in the range 10.0.0.0 to 10.255.255.255 belong to the IIT Delhi Network.

```
PS C:\Users\adity> tracert google.com
Tracing route to google.com [2404:6800:4002:82c::200e]
over a maximum of 30 hops:
1  1 ms    1 ms    1 ms  2001:df4:e000:3fd1::2
2  7 ms    1 ms    1 ms  2001:df4:e000:108::2
3  2 ms    2 ms    2 ms  2405:8a00:a2::c6
4  1 ms    1 ms    1 ms  2405:8a00:a2::c5
5  7 ms    3 ms    3 ms  2405:8a00::16
6  4 ms    3 ms    2 ms  2405:8a00:a10::2
7  9 ms    3 ms    3 ms  2001:4860:1:1:0:269d::
8  4 ms    3 ms    3 ms  2001:4860:0:1a::1
9  3 ms    3 ms    3 ms  2001:4860:0:1::5e5f
10 12 ms    3 ms    4 ms  dell11s21-in-x0e.1e100.net [2404:6800:4002:82c::200e]

Trace complete.
```

Figure 7: Defaults to ipv6

```
PS C:\Users\adity> tracert -4 google.com
Tracing route to google.com [142.250.206.142]
over a maximum of 30 hops:
1  1 ms    1 ms    1 ms  10.184.0.13
2  2 ms    1 ms    1 ms  10.254.175.5
3  1 ms    1 ms    2 ms  10.255.1.34
4  2 ms    2 ms    1 ms  10.119.233.65
5  *        *        *        Request timed out.
6  *        *        *        Request timed out.
7  2 ms    3 ms    3 ms  10.119.234.162
8  4 ms    6 ms    5 ms  72.14.194.160
9  3 ms    3 ms    3 ms  74.125.244.193
10 9 ms    3 ms    4 ms  142.251.76.197
11 13 ms   20 ms   21 ms  dell11s21-in-f14.1e100.net [142.250.206.142]

Trace complete.
```

Figure 8: Forced to ipv4

Note:

- The previous reporting of running traceroute on google.com was on MACOS where traceroute gives the path containing ipv4 routers and traceroute6 gives that for ipv6. Here we have run traceroute on a Windows machine to show defaulting of the path.
- 1.1,1.2,1.3 comprise Q1(a) and (b) of the assignment and 1.4 is the answer of Q1(c).

#### §1.4 Maximum transmissible packet size through routers via ping command

```
sanya@Sanya-MacBook-Air-2 ~ % ping iitd.ac.in -s 8184 -c 7
PING iitd.ac.in (10.10.211.212): 8184 data bytes
8192 bytes from 10.10.211.212: icmp_seq=0 ttl=61 time=4.101 ms
8192 bytes from 10.10.211.212: icmp_seq=1 ttl=61 time=3.712 ms
8192 bytes from 10.10.211.212: icmp_seq=2 ttl=61 time=8.638 ms
8192 bytes from 10.10.211.212: icmp_seq=3 ttl=61 time=103.490 ms
8192 bytes from 10.10.211.212: icmp_seq=4 ttl=61 time=122.226 ms
8192 bytes from 10.10.211.212: icmp_seq=5 ttl=61 time=9.796 ms
8192 bytes from 10.10.211.212: icmp_seq=6 ttl=61 time=71.586 ms

--- iitd.ac.in ping statistics ---
7 packets transmitted, 7 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 3.712/46.221/122.226/47.839 ms
```

Figure 9: Size 8192

- For ping to iitd.ac.in the maximum transmissible packet size is 8192 bytes. On ping command size specification we cannot specify beyond 8184 bytes and 8 bytes(overhead) are added, which might be because of the different layer headers including bytes for error correction, ip source and destination, source and destination ports. Timeout occurs on larger sizes.

```
[sanya@Sanyas-MacBook-Air-2 ~ % ping iitd.ac.in -s 8185 -c 7
PING iitd.ac.in (10.10.211.212): 8185 data bytes
ping: sendto: Message too long
ping: sendto: Message too long
Request timeout for icmp_seq 0
^C
--- iitd.ac.in ping statistics ---
2 packets transmitted, 0 packets received, 100.0% packet loss
```

Figure 10: Size 8193

- For ping to google.com the maximum transmissible packet size that can be specified by -s flag is 1472 bytes. After which request timeout occurs. Google has set limits on data size and can send a maximum of 76 byte packets only. For data size less than or equal to 68(76-8) bytes it behaves similar to the previous case and adds 8 bytes before transmission.

```
[sanya@Sanyas-MacBook-Air-2 ~ % ping google.com -s 1472
PING google.com (142.250.196.78): 1472 data bytes
76 bytes from 142.250.196.78: icmp_seq=0 ttl=115 time=120.990 ms
wrong total length 96 instead of 1500
76 bytes from 142.250.196.78: icmp_seq=1 ttl=115 time=100.053 ms
wrong total length 96 instead of 1500
76 bytes from 142.250.196.78: icmp_seq=2 ttl=115 time=95.469 ms
wrong total length 96 instead of 1500
76 bytes from 142.250.196.78: icmp_seq=3 ttl=115 time=93.235 ms
wrong total length 96 instead of 1500
76 bytes from 142.250.196.78: icmp_seq=4 ttl=115 time=106.795 ms
wrong total length 96 instead of 1500
^C
--- google.com ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 93.235/103.308/120.990/9.983 ms
[sanya@Sanyas-MacBook-Air-2 ~ % ping google.com -s 1473
PING google.com (142.250.196.78): 1473 data bytes
Request timeout for icmp_seq 0
Request timeout for icmp_seq 1
^C
--- google.com ping statistics ---
3 packets transmitted, 0 packets received, 100.0% packet loss
```

Figure 11: maximum transmissible data size to ping google

```
[sanya@Sanyas-MacBook-Air-2 ~ % ping google.com -s 67
PING google.com (142.250.206.142): 67 data bytes
75 bytes from 142.250.206.142: icmp_seq=0 ttl=116 time=7.618 ms
75 bytes from 142.250.206.142: icmp_seq=1 ttl=116 time=8.239 ms
75 bytes from 142.250.206.142: icmp_seq=2 ttl=116 time=9.412 ms
75 bytes from 142.250.206.142: icmp_seq=3 ttl=116 time=4.827 ms
75 bytes from 142.250.206.142: icmp_seq=4 ttl=116 time=4.733 ms
75 bytes from 142.250.206.142: icmp_seq=5 ttl=116 time=11.761 ms
^C
--- google.com ping statistics ---
6 packets transmitted, 6 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 4.733/7.765/11.761/2.475 ms
```

Figure 12: ping google below 76 bytes transmission

- For ping to facebook.com the same behaviour is observed as that with iitd.ac.in but with a data limit of 1480 bytes. 8 bytes are added so the specified maximum size by -s flag is 1472.

```
[sanya@Sanyas-MacBook-Air-2 ~ % ping facebook.com -s 1473
PING facebook.com (157.240.16.35): 1473 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
^C
--- facebook.com ping statistics ---
5 packets transmitted, 0 packets received, 100.0% packet loss
[sanya@Sanyas-MacBook-Air-2 ~ % ping facebook.com -s 1472
PING facebook.com (157.240.16.35): 1472 data bytes
1480 bytes from 157.240.16.35: icmp_seq=0 ttl=51 time=31.881 ms
1480 bytes from 157.240.16.35: icmp_seq=1 ttl=51 time=34.971 ms
1480 bytes from 157.240.16.35: icmp_seq=2 ttl=51 time=33.557 ms
1480 bytes from 157.240.16.35: icmp_seq=3 ttl=51 time=33.591 ms
1480 bytes from 157.240.16.35: icmp_seq=4 ttl=51 time=32.273 ms
^C
--- facebook.com ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 31.881/33.255/34.971/1.096 ms
```

Figure 13: ping facebook

## §2 Traceroute functionality using Ping

```
1 import subprocess
2 import sys
3 max_hops=1
4 hop_limit=30
5 ip_address=sys.argv[1]
6 destination=""
7 prev=""
8 while(True):
9     command=f"ping -m {max_hops} {ip_address} -t 1"
10    print(f"{max_hops}:",end=" ")
11    for i in range(3):
12        out=subprocess.run(command, shell=True, capture_output=True)
13        output=out.stdout.decode().split("\n")
14        try:
```

```

15         if(output[1].split(" ")[0]=="Request"):
16             raise Exception("Request Timed Out")
17         destination=output[0].split(" ")[2][1:-2]
18         current=output[1].split(" ")[3][:-1]
19         if(current!=prev and prev==""):
20             print(f"{current}",end=" ")
21         elif(current!=prev):
22             print()
23             print(f"{current}",end=" ")
24         prev=current
25         command2=f"ping -t 1 -m {max_hops} {current}"
26         out2=subprocess.run(command2,shell=True,capture_output=True)
27         output2=out2.stdout.decode().split("\n")
28         time= output2[-2].split("/")[-1]
29
30         print(f"{time}",end=" ")
31     except:
32         print("*",end=" ")
33     print()
34     prev=""
35     if(current==destination):
36         break
37     max_hops+=1
38     if(max_hops>hop_limit):
39         break

```

The above code takes either the domain name or the IP address as input in the form (`python3 {filename} {destination}`) and returns the path from your system to the specified destination in a similar manner as **traceroute**. It calculates the IP address of intermediate routers and their respective latencies by first sending a packet with a specified time-to-live(ttl) to get the IP of the router at each hop and then pings it to get the latency. For each hop, it sends three packets and if any router does not respond then the function prints \* in place of its IP address.

## §3 Internet Architecture

### §3.1 Location-Hops Relation Analysis

Destination: Google([www.google.com](http://www.google.com)), Facebook([www.facebook.com](http://www.facebook.com)), IITD([www.iitd.ac.in](http://www.iitd.ac.in)), University of Utah([www.utah.edu](http://www.utah.edu)), University of Cape Town([www.uct.ac.za](http://www.uct.ac.za)).

Sources: Self(IITD private wifi), AS13911 (in Edmonton, Alberta, Canada) , 10.92.36.120(HansNet, Germany).

	IITD	Canada	Germany
IITD	4	15+	14+
University of Utah	34+	26	27+
University of Cape Town	17+	20+	16+
Google	11	8	11
Facebook	13	8	11

Table 1 Number of Hops using traceroute

- If the (traceroute source, destination) pair are geographically close to each other, roughly it would translate into fewer hops. This is because routing is more likely

	IITD	Canada	Germany
IITD	4	NA	18
University of Utah	NA	NA	NA
University of Cape Town	NA	NA	NA
Google	10	NA	11
Facebook	12	NA	11

Table 2 Number of Hops using traceroute6

to be more efficient and direct when the endpoints are physically closer as there is a high probability that the path would involve fewer intermediate routers.

- However, it's also important to note that while geographical closeness can affect the number of hops, factors like routing algorithms and network congestion can still overpower and the number of hops in a traceroute could be large, even for geographically close end systems.
- Significantly less number of hops are required to reach Google and Facebook in all traceroute sources except for the case when both the source and destination are in iitd network. This is because Google and Facebook have extensive and optimized global networks with distributed servers and often partnerships with telcom service providers which gives them a better reach. These networks optimize routing and caching, leading to more direct and efficient paths, resulting in fewer hops.

### §3.2 Latency-Hops Relation Analysis

	IITD	Canada	Germany
IITD	4(3.9 ms)	15+(296.8+ ms)	14+(161.5 ms)
University of Utah	34+(370.4 ms)	26(46.9 ms)	27+(155.5+ ms)
University of Cape Town	17+(435.2+ ms)	20+(244.5+ ms)	16+(210+ ms)
Google	11(6.5 ms)	8(19.5 ms)	11(3.2 ms)
Facebook	13(25.8 ms)	8(18.3 ms)	11(8.2 ms)

Table 3 Number of Hops and Latency using traceroute

- In this table 'x+' denotes that after x hops no router path was obtained continuously at each hop and after waiting for a sufficient amount of time the traceroute run had to be ended. So the number of hops could be anything greater than x.
- Generally, latency tends to increase with the number of hops as each hop introduces queuing delay, processing delay and propagation delays. This might accumulate along the path and result in higher overall latency.
- But in the data as we can observe the latency for data to reach the University of Cape Town and IITD is much higher than that to reach the University of Utah, despite the significantly less number of hops. One of the possible reasons for this could be a stronger and low latency network connectivity with the United States as compared to India and South Africa. Reasons for this might include the fact that US is a developed country while the other two are developing countries.

- Google and Facebook have drastically lower latencies than the other destinations due to their stronger network connectivity as mentioned in the previous part. Data reaching IITD from IITD intranet has much lower latency because of relatively extremely low distance, number of hops, and latencies. They need to maintain this because data gets requested from their web servers every second and low latency could also lead to a bad consumer experience.
- We used nslookup to change DNS server and run traceroute again which led to change in destination and route for google and facebook.

### §3.3 Destination IP Address

	IITD	Canada	Germany
IITD	10.10.211.212	103.27.9.24	103.27.9.24
University of Utah	155.98.186.21	155.98.186.21	155.98.186.21
University of Cape Town	137.158.159.192	137.158.159.192	137.158.159.192
Google	142.250.207.196	142.250.69.196	142.250.74.196
Facebook	157.240.16.35	157.240.3.35	157.240.223.35

Table 4 Destination IP Address

- IITD, University of Utah and University of Cape Town are resolved to the same IP address irrespective of the source in the traceroute, except for IITD intranet. Whereas Google and Facebook have different ip addresses for different source ips. This is because of the limited servers in the networks of a university compared to the huge and widely spread network of Google and Facebook.
- To maintain lower latencies Google and Facebook have widely distributed servers spread all over the world thus the source communicates with the lowest latency server possible. This also explains the lower number of hops required for data to reach Google and Facebook.

### §3.4 Path difference for same web-server using different destination IP

	IITD	Canada	Germany
Google(142.250.207.196)	11(6.6 ms)	16(246.1 ms)	24(371.5 ms)
Google(142.250.69.196)	18(316 ms)	8(19.5 ms)	20(145.4 ms)
Google(142.250.74.196)	23(380 ms)	17(143.8 ms)	9(4.1 ms)
Facebook(157.240.16.35)	13(34 ms)	17(223.5)	17(170 ms)
Facebook(157.240.3.35)	22(275 ms)	8(18.2 ms)	16(149 ms)
Facebook(157.240.223.35)	24(200 ms)	21(158 ms)	11(8.3 ms)

Table 5 Number of Hops and latencies for different IP addresses to same web-server

We can observe that the IP addresses for the same server are distributed geographically and thus each location has shorter routes to one of them.

### §3.5 Peering of ISP with Google and Facebook for different countries

If we use the traceroute command with the destination as www.google.com and www.facebook.com from servers in countries like India, and Argentina, the packets are directed to GOOGLE

and FACEBOOK servers directly through the local ISP as the servers are peered directly. On the other hand, for countries like S. Korea(Seoul) and Brazil(Rio de Janerio) the packets have to travel through intermediate AS to reach the servers. This can be due to reasons like Peering Agreements, Geographical Location, Internet Exchange Points (IXPs), Global Network Infrastructure, etc.

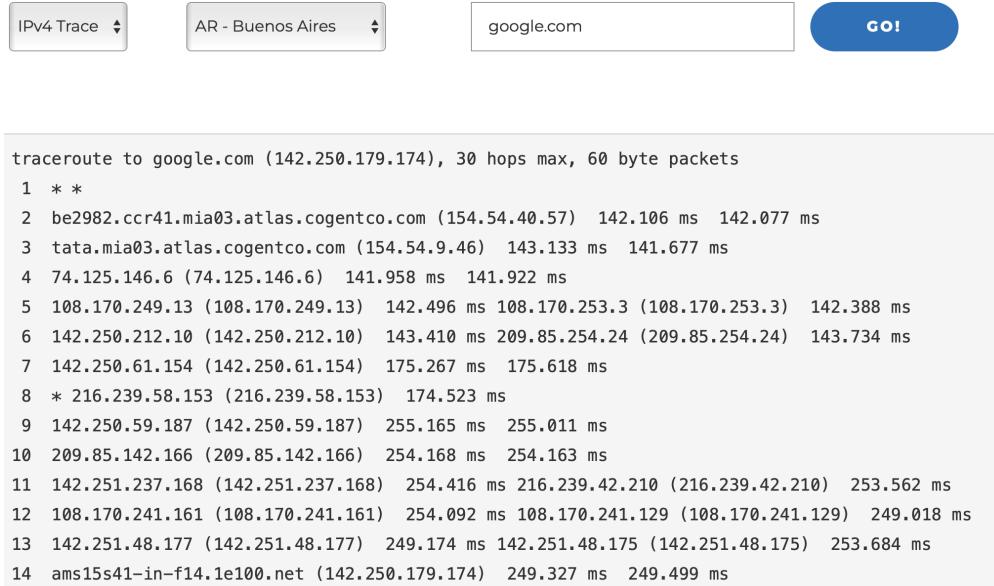


Figure 14: traceroute from Argentina

	IP Address	AS #	AS Name	AS Range
□	154.54.40.57	174	COGENT-174	154.48.0.0/12
□	154.54.9.46	174	COGENT-174	154.48.0.0/12
□	74.125.146.6	15169	GOOGLE	74.125.0.0/16
□	108.170.249.13	15169	GOOGLE	108.170.192.0/18
□	142.250.212.10	15169	GOOGLE	142.250.0.0/15
□	142.250.61.154	15169	GOOGLE	142.250.0.0/15
□	216.239.58.153	15169	GOOGLE	216.239.32.0/19
□	142.250.59.187	15169	GOOGLE	142.250.0.0/15
□	209.85.142.166	15169	GOOGLE	209.85.128.0/17
□	142.251.237.168	15169	GOOGLE	142.250.0.0/15
□	108.170.241.161	15169	GOOGLE	108.170.192.0/18
□	142.251.48.177	15169	GOOGLE	142.251.48.0/24
□	142.250.179.174	15169	GOOGLE	142.250.0.0/15

Figure 15: Directly peered ISP

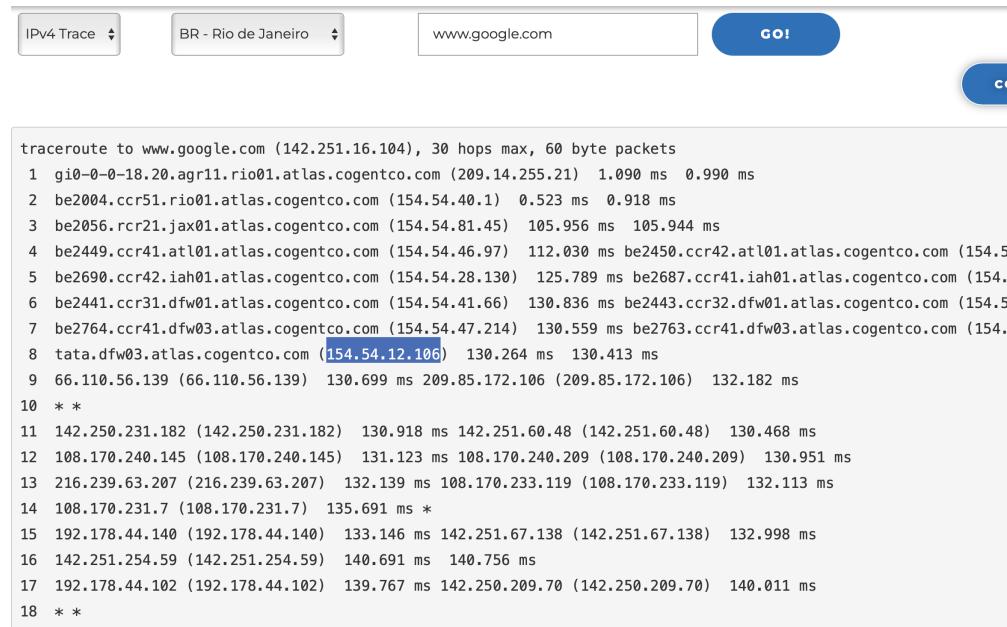


Figure 16: traceroute from Brazil

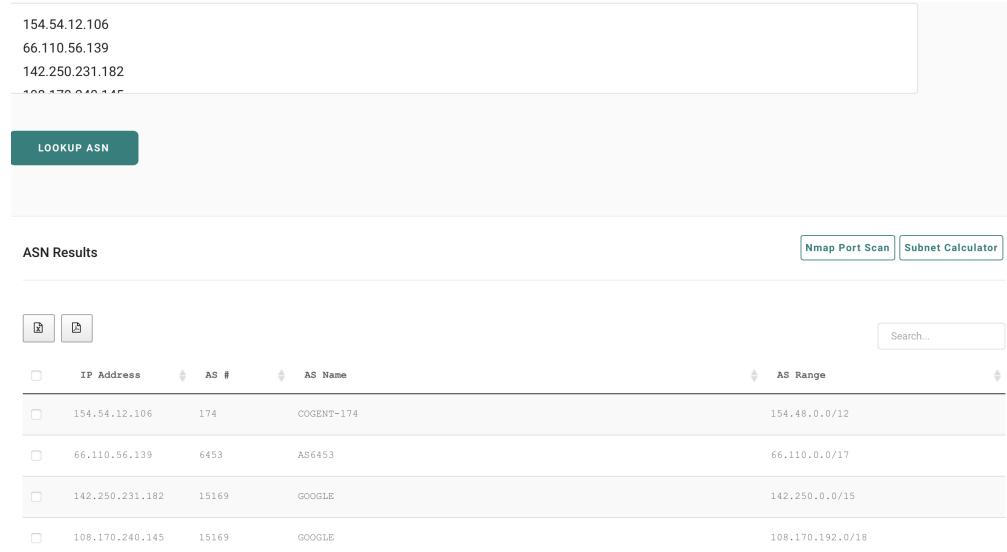


Figure 17: Not directly peered ISP

## §4 Packet Analysis

### §4.1 Dns Filter

- The selections in the image represent dns queries and responses to act4.iitd.ac.in. First three queries were sent from browser(10.184.31.235) to dns server(10.10.1.4). The DNS request-response completes in
  - For AAAA request, representing ipv6 address, the time taken is 0.001926, 0.002529 seconds(9.664174-9.662248),(9.680447-9.677918)
  - For A request, representing ipv4 address, the time taken is 0.002029, 0.002482 seconds(9.664340-9.662311),(9.680448-9.677966)

- For Http request, the time taken is 0.002232, 0.002778 seconds(9.664686-9.662454), (9.680772-9.677994)
- This duration includes the round-trip time for the DNS query to reach the DNS server, and the subsequent response to return to requesting end system. The actual time might vary depending on the network congestion.

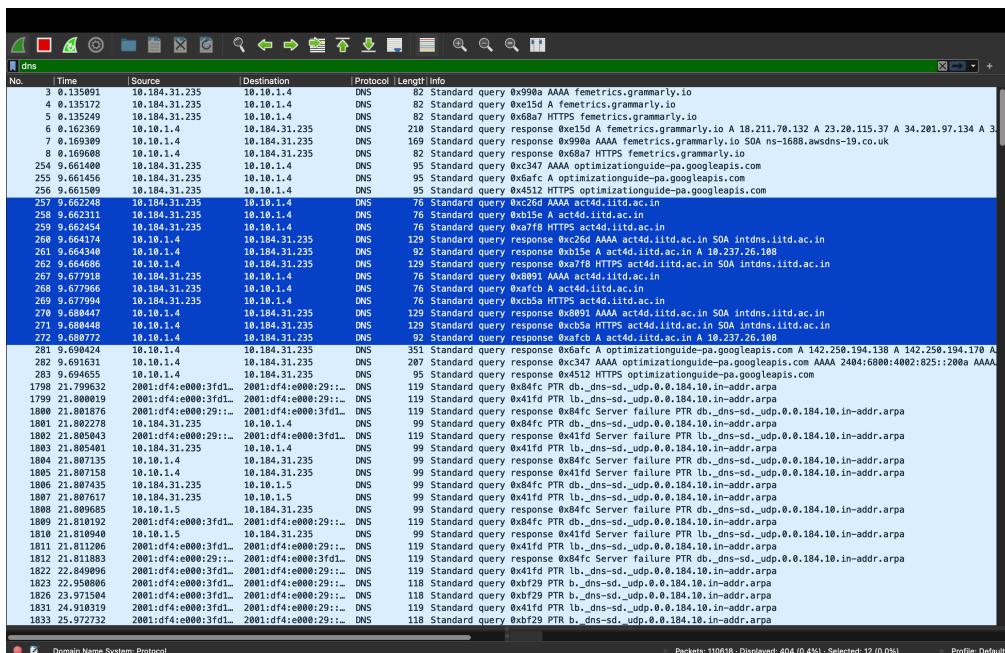


Figure 18: dns filter

## §4.2 HTTP Filter

- A reasonable approximation to estimate the number of HTTP requests is to report the number of GET requests made by the browser(10.184.31.235) to the HTTP server(10.237.26.108), which is 12 (including the first GET request).
- This shows that web pages are fragmented into pieces and the request is sent from different source ports of the web browser to the server. Then, when the server sends back data packets browser renders these fragments independently in different ports which significantly decreases the latency and waiting time. This decreases the total waiting time as objects don't have to wait for other objects to be rendered and enhances user experience as well as user does not have to wait for the entire data to reach and can access fragments as and when they are delivered.
- Since there are multiple images and files in the webpage, they are designed such that there are separate javascript, css and image files which can be sent to different ports. As we can see in the example below the browser sends request for mootools.js from port 60696 and for caption.js from port 60695 to the same destination port 80.

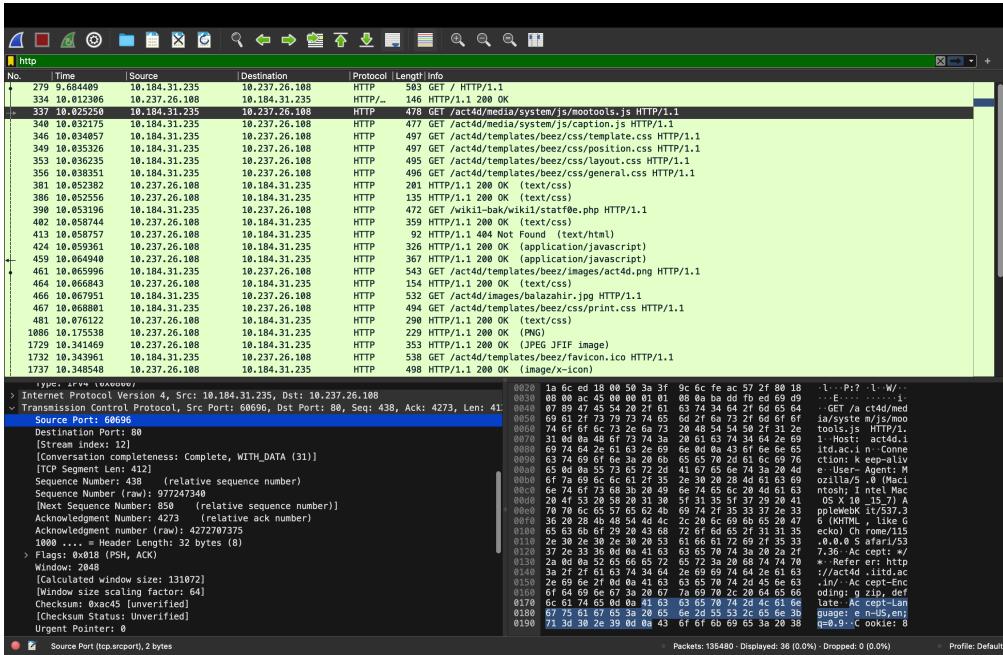


Figure 19: http filter

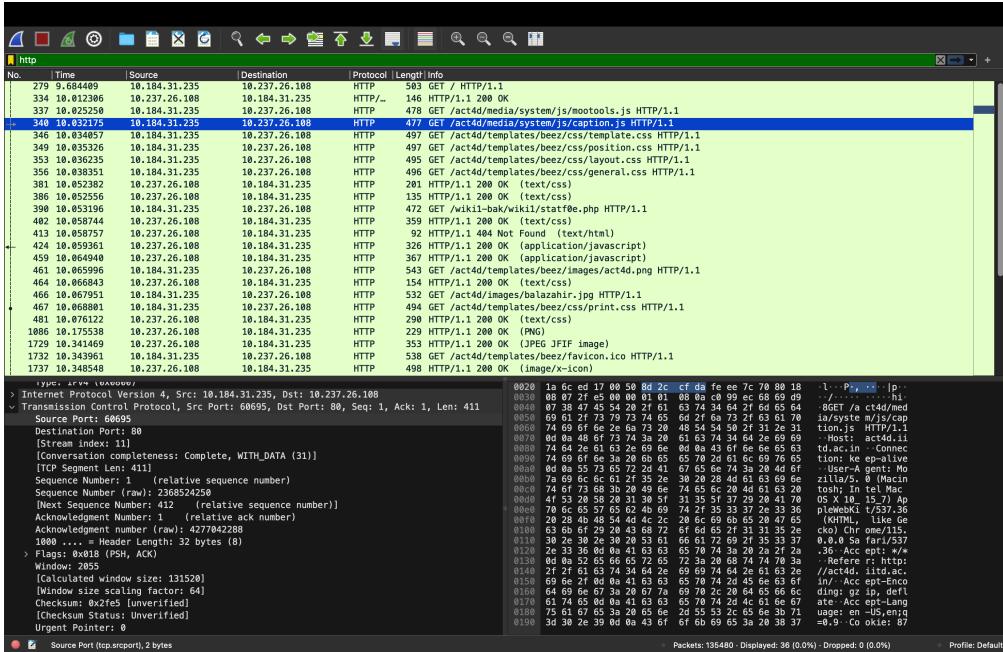


Figure 20: different ports

### §4.3 TCP Packets between browser and web server

- Number of TCP connections opened between browser and server in this case is 8 as 8 3-way handshakes are established. The number of HTTP requests for content objects in the previous part were 11 and 8 TCP connections have been established. This shows that some objects have been sent through the same connection. Upon observing the ports used for HTTP requests we found that the unique source ports used by the browser were 60695, 60696, 60699, 60700, 60701 and 60702 which is 6

ports.

- Opening of a new TCP connection requires 2 Round Trip Times extra which is much more than the time to receive data which is (Size of Packet)/Transmission Rate. Thus there is a tradeoff as dividing into fragments decreases the wait time for an individual packet but opening new TCP connections also increases the time for the packet to actually be delivered. Thus reusing of TCP connections to send objects is also important.

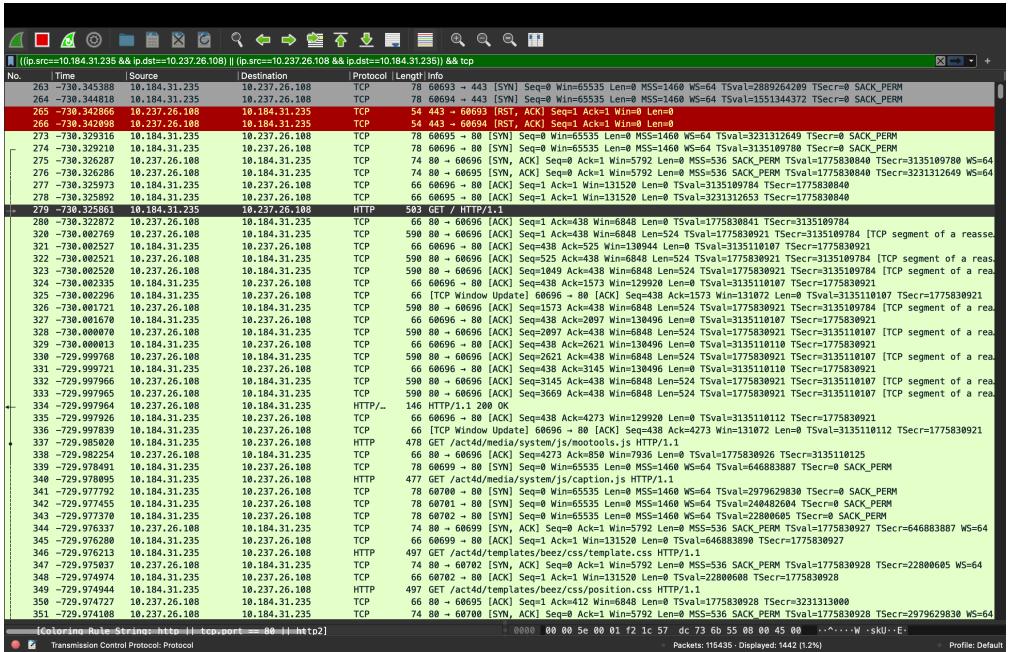


Figure 21: SYN-SYN ACK-ACK

#### §4.4 Secure Transmission

- No HTTP traffic is observed as Indian Express has security constraints as it is a https website. And the server prompts "Moved Permanently".
- No data transfer - html or javascript files can be observed even without any filter as data transfer for an https website is securely encrypted and thus cannot be captured by wireshark.

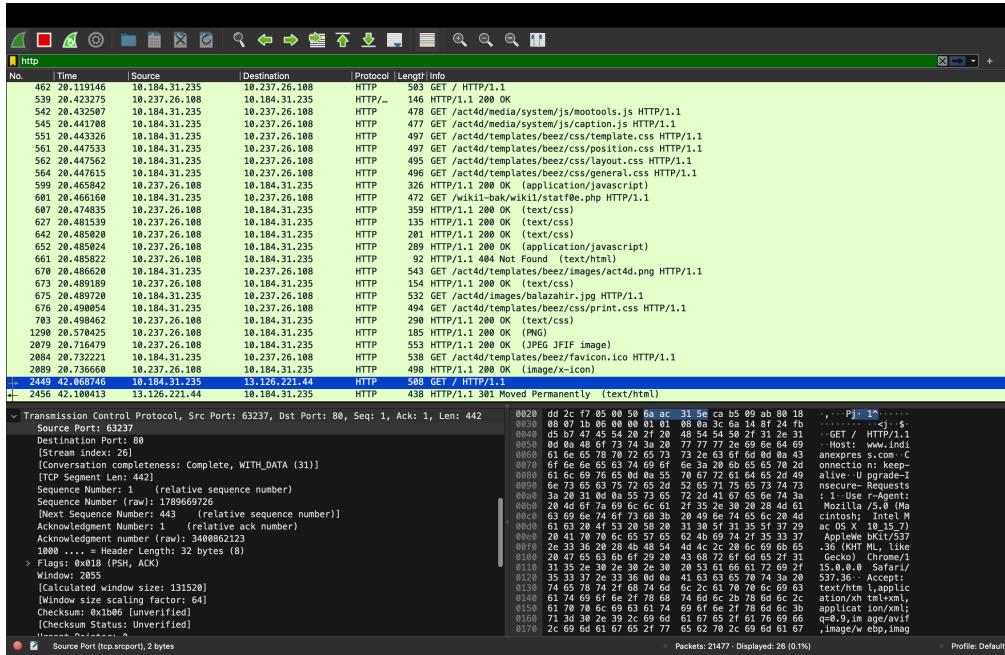


Figure 22: Server sends back a response - Moved Permanently

## §5 Part 3 screenshots

### FROM [www.tera-byte.com](http://www.tera-byte.com) TO [www.facebook.com](http://www.facebook.com)

```
traceroute to star-mini.c10r.facebook.com (157.240.3.35) from 216.234.191.172, 30 hops max, 40 byte packets
1 cat6807-vlan2.edm.tera-byte.com (216.234.161.1) 0.243 ms
2 *
3 154.11.2.81 (154.11.2.81) 18.260 ms
4 ae19.pr03.seal.tfbnw.net (157.240.71.102) 20.423 ms
5 po201.asw02.seal.tfbnw.net (157.240.105.124) 18.277 ms
6 psw04.seal.tfbnw.net (173.252.66.179) 19.253 ms
7 173.252.67.177 (173.252.67.177) 19.262 ms
8 edge-star-mini-shv-01-seal.facebook.com (157.240.3.35) 18.212 ms
```

### FROM [www.tera-byte.com](http://www.tera-byte.com) TO [www.google.com](http://www.google.com)

```
traceroute to www.google.com (142.250.69.196) from 216.234.191.172, 30 hops max, 40 byte packets
1 cat6807-vlan2.edm.tera-byte.com (216.234.161.1) 0.254 ms
2 *
3 154.11.12.217 (154.11.12.217) 18.280 ms
4 74.125.50.110 (74.125.50.110) 20.721 ms
5 *
6 108.170.245.97 (108.170.245.97) 20.485 ms
7 142.251.48.211 (142.251.48.211) 18.602 ms
8 sea30s08-in-f4.1e100.net (142.250.69.196) 19.471 ms
```

### FROM [www.tera-byte.com](http://www.tera-byte.com) TO [www.iitd.ac.in](http://www.iitd.ac.in)

```
traceroute to www.iitd.ac.in (103.27.9.24) from 216.234.191.172, 30 hops max, 40 byte packets
1 cat6807-vlan2.edm.tera-byte.com (216.234.161.1) 19.379 ms
2 *
3 rc2ar-be18-100.ed.shawcable.net (66.163.70.86) 1.248 ms
4 rc2we-be7.ed.shawcable.net (66.163.70.129) 1.643 ms
5 rc3no-be6.cg.shawcable.net (66.163.64.69) 5.246 ms
6 rc2wt-be100.wa.shawcable.net (66.163.75.233) 20.543 ms
7 lag-111.ear3.Seattle1.Level3.net (4.71.152.133) 20.496 ms
8 *
9 4.7.26.62 (4.7.26.62) 47.006 ms
10 49.45.4.87 (49.45.4.87) 259.316 ms
11 49.45.4.102 (49.45.4.102) 248.848 ms
12 103.198.140.65 (103.198.140.65) 247.706 ms
13 *
14 *
15 136.232.148.178 (136.232.148.178) 296.834 ms
16 *
17 *
18 *
19 *
20 *
21 *
22 *
23 *
24 *
25 *
26 *
27 *
28 *
29 *
30 *
```

### FROM [www.tera-byte.com](http://www.tera-byte.com) TO [www.uct.ac.za](http://www.uct.ac.za)

```
traceroute to cms-vip-prd.uct.ac.za (137.158.159.192) from 216.234.191.172, 30 hops max, 40 byte packets
1 cat6807-vlan2.edm.tera-byte.com (216.234.161.1) 0.257 ms
2 *
3 rc2ar-be18-100.ed.shawcable.net (66.163.70.86) 1.284 ms
4 rc2we-be7.ed.shawcable.net (66.163.70.129) 1.312 ms
5 rc3no-be6.cg.shawcable.net (66.163.64.69) 5.303 ms
6 rc2wt-be100.wa.shawcable.net (66.163.75.233) 20.330 ms
7 lag-111.ear3.Seattle1.Level3.net (4.71.152.133) 20.311 ms
8 4.69.219.206 (4.69.219.206) 20.811 ms
9 ae-10.a03.sttlwa01.us.bb.gin.ntt.net (129.250.9.180) 56.547 ms
10 ae-3.r25.sttlwa01.us.bb.gin.ntt.net (129.250.2.206) 46.210 ms
11 ae-4.r22.chcgil09.us.bb.gin.ntt.net (129.250.3.43) 46.701 ms
12 ae-1.r23.chcgil09.us.bb.gin.ntt.net (129.250.2.27) 56.221 ms
13 ae-11.r24.asbnva02.us.bb.gin.ntt.net (129.250.2.138) 60.286 ms
14 ae-1.r23.miamfl02.us.bb.gin.ntt.net (129.250.2.87) 109.189 ms
15 ae-1.a02.miamfl02.us.bb.gin.ntt.net (129.250.2.108) 88.251 ms
16 ce-2-0-2.a02.miamfl02.us.ce.gin.ntt.net (129.250.200.114) 86.365 ms
17 30.8.39.170.ampath.net (170.39.8.30) 86.256 ms
18 187-185-103-190.ampath.net (190.103.185.187) 247.609 ms
19 et-0-0-1-0-cpt7-pe1.net.tenet.ac.za (155.232.64.70) 244.575 ms
20 154.114.124.1 (154.114.124.1) 244.526 ms
21 *
22 *
23 *
24 *
25 *
26 *
27 *
28 *
29 *
30 *
```

FROM [www.tera-byte.com](http://www.tera-byte.com) TO [www.utah.edu](http://www.utah.edu)

```

traceroute to www.utah.edu (155.98.186.21) from 216.234.191.172, 30 hops max, 40 byte packets
 1 cat6807-vlan2.edm.tera-byte.com (216.234.161.1)  0.276 ms
 2 *
 3 rc2ar-be18-100.ed.shawcable.net (66.163.70.86)  1.252 ms
 4 rc2we-be7.ed.shawcable.net (66.163.70.129)  1.641 ms
 5 rc3no-be6.cg.shawcable.net (66.163.64.69)  5.184 ms
 6 rc2wt-be100.wa.shawcable.net (66.163.75.233)  20.841 ms
 7 rclwt-be18-1.wa.shawcable.net (66.163.64.81)  20.760 ms
 8 six.tr-cps.internet2.edu (206.81.80.77)  22.505 ms
 9 fourhundredge-0-0-0-19.4079.core1.seat.net.internet2.edu (163.253.1.158)  46.408 ms
10 fourhundredge-0-0-0-0.4079.core1.salt.net.internet2.edu (163.253.1.156)  46.596 ms
11 fourhundredge-0-0-0-1.4079.core1.lasv.net.internet2.edu (163.253.1.152)  44.966 ms
12 198.71.47.69 (198.71.47.69)  46.465 ms
13 tdc-beibr-b-170-int.uen.net (140.197.249.81)  44.882 ms
14 ddc-pep-c-123-int.uen.net (140.197.251.32)  45.075 ms
15 ddc-pep-b-129-int.uen.net (140.197.253.97)  44.861 ms
16 ebc-pep-b-179-int.uen.net (140.197.252.76)  45.184 ms
17 ebc-pep-a-178-int.uen.net (140.197.252.84)  45.293 ms
18 *
19 199.104.93.22 (199.104.93.22)  45.307 ms
20 199.104.93.33 (199.104.93.33)  46.395 ms
21 155.99.130.65 (155.99.130.65)  45.928 ms
22 155.99.130.105 (155.99.130.105)  45.943 ms
23 *
24 *
25 *
26 www.utah.edu (155.98.186.21)  46.909 ms

```

```

traceroute www.facebook.com
traceroute to star-mini.c10r.facebook.com (157.240.16.35), 64 hops max, 52 byte packets
 1 10.184.0.13 (10.184.0.13)  4.307 ms  4.126 ms  3.227 ms
 2 10.254.175.5 (10.254.175.5)  3.636 ms
 3 10.254.175.1 (10.254.175.1)  5.159 ms  3.906 ms
 4 10.119.233.65 (10.119.233.65)  4.577 ms  3.856 ms  4.637 ms
 5 * *
 6 10.1.207.65 (10.1.207.65)  39.803 ms  31.628 ms  31.257 ms
 7 * *
 8 * 10.255.238.122 (10.255.238.122)  39.677 ms *
 9 10.152.7.214 (10.152.7.214)  33.969 ms
 10 10.152.7.38 (10.152.7.38)  30.564 ms  32.549 ms
11 ae1.pr01.bom1.tfbnw.net (157.240.68.238)  38.340 ms
12 ae2.pr02.bom1.tfbnw.net (157.240.66.204)  27.332 ms
  ae1.pr01.bom1.tfbnw.net (157.240.68.238)  26.827 ms
  ae2.pr02.bom1.tfbnw.net (157.240.66.204)  27.709 ms
13 157.240.38.77 (157.240.38.77)  29.217 ms
  157.240.38.117 (157.240.38.117)  25.410 ms
  157.240.38.149 (157.240.38.149)  59.267 ms
14 edge-star-mini-shv-01-bom1.facebook.com (157.240.16.35)  25.322 ms  25.188 ms  27.093 ms

```

```

traceroute6 www.facebook.com
traceroute6 to star-mini.c10r.facebook.com (2a03:2880:f12f:83:face:b00c:0:25de) from 2001:df4:e000:3fd1:e5e2:d069:fdc1:f99c, 64 hops max, 12 byte packets
 1 2001:df4:e000:3fd1::2  3.967 ms  3.810 ms  3.944 ms
 2 2001:df4:e000:108::2  4.952 ms
 2001:df4:e000:108::1  4.269 ms  4.670 ms
 3 2405:8a00:a2::c0  4.546 ms  4.188 ms  3.866 ms
 4 2405:8a00:a2::c0  5.389 ms  3.717 ms  3.666 ms
 5 2001:4408:a::1  24.471 ms  24.973 ms  24.459 ms
 6 *
 7 2405:8a00::2::3  35.857 ms  27.155 ms  25.564 ms
 8 2405:8a00::14::2  26.499 ms  28.959 ms  26.370 ms
 9 ae2.pr02.bom1.tfbnw.net 70.571 ms  52.359 ms  36.553 ms
10 p0102.psw04.bom1.tfbnw.net 38.545 ms  41.158 ms  36.024 ms
11 p01.msw1ah.01.bom1.tfbnw.net 24.987 ms
  p04.msw1am.01.bom1.tfbnw.net 56.319 ms
  p03.msw1ai.01.bom1.tfbnw.net 59.284 ms
12 edge-star-mini6-shv-01-bom1.facebook.com 33.266 ms  33.240 ms  30.657 ms

```

```

traceroute www.google.com
traceroute to www.google.com (142.250.207.196), 64 hops max, 52 byte packets
 1 10.184.0.13 (10.184.0.13)  3.677 ms  6.609 ms  6.322 ms
 2 10.254.175.1 (10.254.175.1)  11.692 ms
 10.254.175.5 (10.254.175.5)  5.115 ms  3.073 ms
 3 10.255.1.34 (10.255.1.34)  3.667 ms  4.005 ms  4.481 ms
 4 10.119.233.65 (10.119.233.65)  4.602 ms  5.127 ms  3.394 ms
 5 * *
 6 * *
 7 10.119.234.162 (10.119.234.162)  13.569 ms  5.196 ms  5.376 ms
 8 72.14.194.160 (72.14.194.160)  5.677 ms
 72.14.195.56 (72.14.195.56)  5.901 ms  7.405 ms
 9 108.170.251.97 (108.170.251.97)  6.879 ms
 108.170.251.113 (108.170.251.113)  7.715 ms  25.823 ms
10 142.251.76.169 (142.251.76.169)  6.967 ms  6.205 ms  6.290 ms
11 del12s10-in-f4.1e100.net (142.250.207.196)  6.884 ms  5.855 ms  6.814 ms

```

```

traceroute6 www.google.com
traceroute6 to www.google.com (2a04:6800:4002:82e::2004) from 2001:df4:e000:3fd1:e5e2:d069:fdc1:f99c, 64 hops max, 12 byte packets
 1 2001:df4:e000:3fd1::2  5.445 ms  4.923 ms  4.248 ms
 2 2001:df4:e000:108::2  4.334 ms
 2001:df4:e000:108::1  5.815 ms  4.854 ms
 3 2405:8a00:a2::c0  4.248 ms  4.688 ms  4.688 ms
 4 2405:8a00:a2::c0  3.946 ms  4.145 ms  3.666 ms
 5 2405:8a00::16  5.110 ms  5.607 ms  5.108 ms
 6 * *
 7 * *
 8 2001:4860:0:11de::1  15.624 ms
 2001:4860:0:11de::1  5.934 ms
 2001:4860:0:11de::1  8.103 ms
 9 2001:4860:0:1::5e45  6.324 ms  6.432 ms  5.913 ms
10 del12s10-in-x04.1e100.net 5.851 ms  6.091 ms  5.890 ms

```

```

traceroute www.uct.ac.za
traceroute to cms-vip-prd.uct.ac.za (137.158.159.192), 64 hops max, 52 byte packets
 1 10.184.0.13 (10.184.0.13) 5.593 ms 3.522 ms 3.374 ms
 2 10.254.175.5 (10.254.175.5) 3.616 ms
 10.254.175.1 (10.254.175.1) 3.804 ms 4.220 ms
 3 10.255.1.34 (10.255.1.34) 6.190 ms 3.781 ms 3.781 ms
 4 10.119.233.65 (10.119.233.65) 3.805 ms 3.803 ms 3.861 ms
 5 * * *
 6 10.1.207.65 (10.1.207.65) 37.311 ms 29.123 ms 29.248 ms
 7 10.1.200.137 (10.1.200.137) 27.480 ms 26.914 ms 27.491 ms
 8 10.255.238.122 (10.255.238.122) 29.491 ms 28.986 ms 29.324 ms
 9 180.149.48.18 (180.149.48.18) 32.764 ms 32.881 ms 30.516 ms
10 180.149.48.2 (180.149.48.2) 184.716 ms * *
11 180.149.48.20 (180.149.48.20) 207.644 ms
xe-0-0-2-0-600-ams1-ir1.net.tenet.ac.za (155.232.220.18) 169.945 ms
180.149.48.20 (180.149.48.20) 200.001 ms
12 xe-0-0-1-1-10-mtz1-ir1.net.tenet.ac.za (155.232.1.21) 424.632 ms 417.173 ms
xe-0-0-2-0-600-ams1-ir1.net.tenet.ac.za (155.232.220.18) 168.650 ms
13 et-1-1-0-0-0-0-0-ams1-pe1.net.tenet.ac.za (155.232.1.153) 350.887 ms 369.996 ms 417.235 ms
14 et-1-1-4-0-cpt3-pe1.net.tenet.ac.za (155.232.1.148) 417.764 ms
et-1-1-0-0-0-0-0-ams1-pe1.net.tenet.ac.za (155.232.1.153) 395.048 ms 416.727 ms
15 et-1-1-4-0-cpt3-pe1.net.tenet.ac.za (155.232.1.148) 417.721 ms 416.651 ms
et-0-0-1-0-cpt7-pe1.net.tenet.ac.za (155.232.64.70) 417.563 ms
16 et-0-0-1-0-cpt7-pe1.net.tenet.ac.za (155.232.64.70) 418.973 ms
154.114.124.1 (154.114.124.1) 414.596 ms
et-0-0-1-0-cpt7-pe1.net.tenet.ac.za (155.232.64.70) 483.956 ms
17 * * 154.114.124.1 (154.114.124.1) 435.270 ms
18 * * *
19 * * *
20 * * *

traceroute www.utah.edu
traceroute to www.utah.edu (155.98.186.21), 64 hops max, 52 byte packets
 1 10.184.0.13 (10.184.0.13) 4.528 ms 3.460 ms 3.674 ms
 2 10.254.175.5 (10.254.175.5) 3.741 ms
 10.254.175.1 (10.254.175.1) 3.922 ms 3.744 ms
 3 10.255.1.34 (10.255.1.34) 3.873 ms 4.583 ms 3.455 ms
 4 10.119.233.65 (10.119.233.65) 4.030 ms 3.751 ms 3.821 ms
 5 * * *
 6 10.1.207.65 (10.1.207.65) 29.212 ms 29.127 ms 28.939 ms
 7 10.1.200.137 (10.1.200.137) 26.684 ms 27.634 ms 26.962 ms
 8 10.255.238.122 (10.255.238.122) 29.238 ms
 10.255.238.254 (10.255.238.254) 36.904 ms
 10.255.238.122 (10.255.238.122) 30.528 ms
 9 180.149.48.18 (180.149.48.18) 35.728 ms 32.445 ms 29.964 ms
10 * 180.149.48.2 (180.149.48.2) 187.182 ms *
11 180.149.48.20 (180.149.48.20) 204.749 ms 207.200 ms
180.149.48.13 (180.149.48.13) 266.160 ms
12 fourhundredreduge-0-0-0-2.4079.core1.ashb.net.internet2.edu (163.253.1.116) 405.759 ms 311.909 ms 309.214 ms
13 fourhundredreduge-0-0-0-2.4079.core1.ashb.net.internet2.edu (163.253.1.116) 311.220 ms 334.801 ms
fourhundredreduge-0-0-0-16.4079.core2.ashb.net.internet2.edu (163.253.1.139) 317.790 ms
14 fourhundredreduge-0-0-0-16.4079.core2.ashb.net.internet2.edu (163.253.1.139) 457.383 ms
fourhundredreduge-0-0-0-1.4079.core2.clev.net.internet2.edu (163.253.1.139) 415.177 ms 417.397 ms
15 fourhundredreduge-0-0-0-1.4079.core2.clev.net.internet2.edu (163.253.1.139) 313.306 ms
fourhundredreduge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.17) 417.048 ms
fourhundredreduge-0-0-0-1.4079.core2.eqch.net.internet2.edu (163.253.1.139) 377.799 ms
16 fourhundredreduge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.17) 521.982 ms 389.225 ms
fourhundredreduge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.18) 341.122 ms
17 fourhundredreduge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.18) 367.552 ms
fourhundredreduge-0-0-0-1.4079.core1.kans.net.internet2.edu (163.253.1.245) 415.170 ms 308.225 ms
18 fourhundredreduge-0-0-0-1.4079.core1.kans.net.internet2.edu (163.253.1.245) 319.206 ms
fourhundredreduge-0-0-0-1.4079.core1.denv.net.internet2.edu (163.253.1.242) 414.803 ms 312.979 ms
19 fourhundredreduge-0-0-0-1.4079.core1.denv.net.internet2.edu (163.253.1.242) 314.944 ms
fourhundredreduge-0-0-0-3.4079.core1.salt.net.internet2.edu (163.253.1.171) 414.637 ms
fourhundredreduge-0-0-0-1.4079.core1.salt.net.internet2.edu (163.253.1.242) 314.910 ms
20 fourhundredreduge-0-0-0-3.4079.core1.salt.net.internet2.edu (163.253.1.171) 320.539 ms
fourhundredreduge-0-0-0-1.4079.core1.lasv.net.internet2.edu (163.253.1.152) 376.295 ms
fourhundredreduge-0-0-0-3.4079.core1.salt.net.internet2.edu (163.253.1.171) 420.648 ms
21 163.253.5.7 (163.253.5.7) 310.981 ms
fourhundredreduge-0-0-0-1.4079.core1.lasv.net.internet2.edu (163.253.1.152) 317.276 ms
163.253.5.7 (163.253.5.7) 375.302 ms
22 163.253.5.7 (163.253.5.7) 416.278 ms
tdc-beibr-b-170-int.uen.net (140.197.249.81) 314.128 ms 310.525 ms
23 tdc-beibr-b-170-int.uen.net (140.197.249.81) 387.885 ms
ddc-pep-c-123-int.uen.net (140.197.251.32) 376.159 ms
tdc-beibr-b-170-int.uen.net (140.197.249.81) 384.061 ms
24 ddc-pep-b-129-int.uen.net (140.197.253.97) 415.435 ms 371.382 ms
ddc-pep-c-123-int.uen.net (140.197.251.32) 426.684 ms
25 ebc-pep-b-179-int.uen.net (140.197.252.76) 413.562 ms
ddc-pep-b-129-int.uen.net (140.197.253.97) 430.858 ms 313.816 ms
26 ebc-pep-a-178-int.uen.net (140.197.252.84) 312.228 ms
ebc-pep-b-179-int.uen.net (140.197.252.76) 368.759 ms 321.851 ms
27 ebc-pep-a-178-int.uen.net (140.197.252.84) 310.411 ms * 348.228 ms
28 199.104.93.22 (199.104.93.22) 320.656 ms 417.176 ms *
29 199.104.93.29 (199.104.93.29) 321.621 ms
199.104.93.22 (199.104.93.22) 416.980 ms 416.596 ms
30 155.99.130.59 (155.99.130.59) 417.779 ms
199.104.93.29 (199.104.93.29) 309.326 ms
155.99.130.57 (155.99.130.57) 310.691 ms
31 155.99.130.103 (155.99.130.103) 311.955 ms
155.99.130.59 (155.99.130.59) 315.416 ms
155.99.130.105 (155.99.130.105) 323.499 ms
32 172.31.241.253 (172.31.241.253) 310.625 ms 347.438 ms
155.99.130.107 (155.99.130.107) 311.872 ms
33 172.31.241.18 (172.31.241.18) 333.304 ms
172.31.241.253 (172.31.241.253) 386.378 ms
172.31.241.249 (172.31.241.249) 315.402 ms
34 172.31.241.229 (172.31.241.229) 345.444 ms * *
35 * * *
36 * * *

```

```
traceroute6 www.iitd.ac.in
traceroute6 to www.iitd.ac.in (2001:df4:e000:29::212) from 2001:df4:e000:3fd1:188e:7bff:62b0:6082, 64 hops max, 12 byte packets
1 2001:df4:e000:3fd1::2 3.090 ms 4.435 ms 4.960 ms
2 6.989 ms
3 4.349 ms 4.521 ms
4 4.135 ms 4.051 ms 3.746 ms
5 3.386 ms 3.560 ms 3.501 ms
```

```
traceroute www.iitd.ac.in
traceroute to www.iitd.ac.in (10.10.211.212), 64 hops max, 52 byte packets
1 10.184.0.13 (10.184.0.13) 4.212 ms 3.377 ms 3.385 ms
2 10.254.175.1 (10.254.175.1) 3.781 ms
10.254.175.5 (10.254.175.5) 3.781 ms 3.744 ms
3 10.254.236.22 (10.254.236.22) 3.600 ms
10.254.236.2 (10.254.236.2) 3.580 ms
10.254.236.26 (10.254.236.26) 3.542 ms
4 www.iitd.ac.in (10.10.211.212) 3.336 ms 3.329 ms 3.267 ms
```

### traceroute to www.facebook.com

```
traceroute to www.facebook.com (157.240.223.35), 30 hops max, 60 byte packets
1 vsm0057.vr.mass.systems (10.92.36.120) 0.031 ms 0.018 ms 0.012 ms
2 ae3-u100.sxbl-cr-nunki.bb.gdinf.net (87.230.112.2) 0.380 ms 0.351 ms 0.370 ms
3 ael.sxbl-ibr-altair.bb.gdinf.net (2001:488:bb00:105::2) 1.479 ms 0.711 ms
4 ae0.sxbl-ibr-tarazed.bb.gdinf.net (87.230.112.19) 0.641 ms 0.623 ms 0.601 ms
5 ae7.fral0-cr-antares.bb.gdinf.net (87.230.115.2) 3.330 ms 3.368 ms 3.340 ms
6 ae2.fral1-cr-polaris.bb.gdinf.net (87.230.115.0) 4.191 ms 3.836 ms 3.799 ms
7 ae1.pr02.muc2.tfbnw.net (185.103.103.1) 5.000 ms 4.778 ms 4.740 ms
8 po202.asew04.muc2.tfbnw.net (129.134.75.90) 8.165 ms po202.asw03.muc2.tfbnw.net (129.134.75.88) 8.490 ms po202.asw02.muc2.tfbnw.net (129.134.75.54) 8.335 ms
9 po241.psw02.muc2.tfbnw.net (129.134.100.135) 8.510 ms po241.psw04.muc2.tfbnw.net (129.134.75.79) 8.431 ms po223.psw01.muc2.tfbnw.net (129.134.74.199) 8.500 ms
10 157.240.38.129 (157.240.38.129) 8.317 ms 173.252.67.117 (173.252.67.117) 8.158 ms 173.252.67.13 (173.252.67.13) 8.133 ms
11 edge-star-mini-hw-01-muc2.facebook.com (157.240.223.35) 8.379 ms 8.253 ms 8.257 ms
```

### traceroute6 to www.facebook.com

```
traceroute to star-mini.c10r.facebook.com (2a03:2880:f157:83:face:b00c:0:25de) from 2a01:488:66:1000:5c33:9112:0:1, 30 hops max, 24 byte packets
1 2a01:488:66:a5c:2478 (2a01:488:66:a5c:2478) 0.229 ms 0.155 ms 0.085 ms
2 ae3-u100.cr-nunki.sxbl.bb.godaddy.com (2a01:488:bb::42) 0.371 ms 0.285 ms 0.27 ms
3 ael.sxbl-ibr-altair.bb.gdinf.net (2a01:488:bb00:105::2) 14.702 ms 7.4 ms 0.71 ms
4 ae0.sxbl-ibr-tarazed.bb.gdinf.net (2a01:488:bb00:107::3) 0.749 ms 0.729 ms 0.786 ms
5 ae7.fral0-cr-antares.bb.gdinf.net (2a01:488:bb03:101::2) 3.501 ms 3.49 ms 3.375 ms
6 ae2.fral1-cr-polaris.bb.gdinf.net (2a01:488:bb03:100::2) 3.288 ms 3.585 ms 3.449 ms
7 ae1.pr02.muc2.tfbnw.net (2001:78:44:80a6::2) 30.78 ms 28.703 ms 33.716 ms
8 po202.asew04.muc2.tfbnw.net (2620:0:1:cfcc:dead:beef::4:1ea) 8.333 ms 8.335 ms 8.352 ms
9 po243.psw03.muc2.tfbnw.net (2620:0:1:cfcc:dead:beef::4:10d) 9.667 ms 8.422 ms 8.383 ms
10 po3.mswlac.01.muc2.tfbnw.net (2a03:2880:f057:ffff::d) 8.386 ms 8.4 ms 8.412 ms
11 edge-star-mini-hw-01-muc2.facebook.com (2a03:2880:f157:83:face:b00c:0:25de) 8.226 ms 8.239 ms 8.264 ms
```

### traceroute to www.google.com

```
traceroute to www.google.com (142.250.74.196), 30 hops max, 60 byte packets
1 vsm0057.vr.mass.systems (10.92.36.120) 0.028 ms 0.014 ms 0.010 ms
2 ae3-u100.sxbl-cr-nunki.bb.gdinf.net (87.230.112.2) 0.234 ms 0.357 ms 0.333 ms
3 ael.sxbl-ibr-altair.bb.gdinf.net (87.230.112.14) 0.479 ms 0.453 ms 0.483 ms
4 ffbm-b11-link.ip.twelve99.net (62.115.144.6) 2.938 ms 2.927 ms 2.934 ms
5 *
6 ffbm-b11-link.ip.twelve99.net (62.115.124.117) 3.214 ms ffbm-b11-link.ip.twelve99.net (62.115.124.119) 3.287 ms ffbm-b11-link.ip.twelve99.net (62.115.124.117) 3.283 ms
7 google-ic-ic-319727.ip.twelve99-cust.net (62.115.151.27) 3.716 ms google-ic-ic-319726.ip.twelve99-cust.net (62.115.151.25) 3.333 ms google-ic-ic-324085.ip.twelve99-cust.net (62.115.153.2)
8 *
9 108.170.252.65 (108.170.252.65) 4.812 ms 142.250.210.196 (142.250.210.196) 3.490 ms 142.251.64.186 (142.251.64.186) 5.520 ms
10 108.170.252.82 (108.170.252.82) 3.565 ms 108.170.251.209 (108.170.251.209) 4.123 ms 108.170.251.209 (108.170.251.208) 3.368 ms
11 fra24s02-in-f4.le100.net (142.250.74.196) 3.248 ms 3.228 ms 209.85.255.205 (209.85.255.205) 7.060 ms
```

### traceroute6 to www.google.com

```
traceroute to www.google.com (2a00:1450:4001:827::2004) from 2a01:488:66:1000:5c33:9112:0:1, 30 hops max, 24 byte packets
1 2a01:488:66:a5c:2478 (2a01:488:66:a5c:2478) 0.143 ms 0.146 ms 0.079 ms
2 ae3-u100.cr-nunki.sxbl.bb.godaddy.com (2a01:488:bb::42) 0.286 ms 0.266 ms 0.242 ms
3 ael.sxbl-ibr-altair.bb.gdinf.net (2a01:488:bb00:105::2) 4.296 ms 0.614 ms 0.387 ms
4 ffbm-b11-link.ip.twelve99.net (2001:2000:3080:3e3::1) 3.096 ms 3.109 ms 3.112 ms
5 ffbm-b2-v6.ip.twelve99.net (2001:2034:1:6c::1) 3.467 ms *
6 *
7 google-ic319727-ffm-b11.ip.twelve99-cust.net (2001:2000:3080:107c::2) 3.442 ms 3.465 ms 3.39 ms
8 2a00:1450:8152::1 (2a00:1450:8152::1) 3.262 ms 3.244 ms 3.259 ms
9 2001:4860:0:1::5004 (2001:4860:0:1::5004) 3.345 ms 3.391 ms 3.575 ms
10 2001:4860:0:1::509d (2001:4860:0:1::509d) 14.094 ms 14.055 ms 14.04 ms
11 fra24s04-in-x04.le100.net (2a00:1450:4001:827::2004) 3.27 ms 3.248 ms 3.258 ms
```

### traceroute6 to www.iitd.ac.in

```
traceroute to www.iitd.ac.in (2001:df4:e000:29::212) from 2a01:488:66:1000:5c33:9112:0:1, 30 hops max, 24 byte packets
1 2a01:488:66:a5c:2478 (2a01:488:66:a5c:2478) 0.121 ms 0.146 ms 0.065 ms
2 ae3-u100.cr-nunki.sxbl.bb.godaddy.com (2a01:488:bb::42) 0.386 ms 0.283 ms 0.248 ms
3 ael.sxbl-ibr-altair.bb.gdinf.net (2a01:488:bb00:105::2) 14.717 ms 2.73 ms 1.038 ms
4 ae0.sxbl-ibr-tarazed.bb.gdinf.net (2a01:488:bb00:107::3) 0.809 ms 0.707 ms 0.757 ms
5 ae7.fral0-cr-antares.bb.gdinf.net (2a01:488:bb03:101::2) 3.513 ms 3.709 ms 3.953 ms
6 ae2.fral1-cr-polaris.bb.gdinf.net (2a01:488:bb03:100::2) 3.55 ms 3.685 ms 3.484 ms
7 jio.com (2001:7f8::fa31:0:1) 4.161 ms 4.134 ms 4.283 ms
8 *
9 2405:203:89a::141e (2405:203:89a::141e) 147.304 ms 147.38 ms 147.493 ms
10 2405:8a00:a::3::2 (2405:8a00:a::3::2) 146.36 ms 146.22 ms 146.055 ms
11 2405:8a00:a::a::3 (2405:8a00:a::a::3) 154.767 ms 155.536 ms 162.446 ms
12 *
13 2001:4408:a::1 (2001:4408:a::1) 182.437 ms 160.298 ms 160.364 ms
14 2405:8a00:a::2::c5 (2405:8a00:a::2::c5) 162.785 ms 163.726 ms 162.758 ms
15 2405:8a00:a::2::c6 (2405:8a00:a::2::c6) 165.487 ms 165.533 ms 165.567 ms
16 2001:df4:e000:108::2 (2001:df4:e000:108::2) 161.182 ms 159.835 ms 159.938 ms
17 2001:df4:e000:26::24 (2001:df4:e000:26::24) 163.63 ms 163.516 ms 163.652 ms
18 2001:df4:e000:29::212 (2001:df4:e000:29::212) 161.498 ms 161.652 ms 161.548 ms
```

## traceroute to www.iitd.ac.in

---

```
traceroute to www.iitd.ac.in (103.27.9.24), 30 hops max, 60 byte packets
 1 vsn0057.vs.mass.systems (10.92.36.120)  0.036 ms  0.015 ms  0.010 ms
 2 ae3-u100.sxbl1-cr-nunki.bb.gdinf.net (87.230.112.2)  4.436 ms  2.068 ms  4.373 ms
 3 ael.sxbl1-ibr-altair.bb.gdinf.net (87.230.112.14)  1.262 ms  1.240 ms  1.214 ms
 4 ae0.sxbl1-ibr-tarazed.bb.gdinf.net (87.230.112.19)  1.915 ms  1.895 ms  1.871 ms
 5 ae7.fral0-cr-antares.bb.gdinf.net (87.230.115.2)  3.422 ms  3.269 ms  3.367 ms
 6 ae2.fral1-cr-polaris.bb.gdinf.net (87.230.115.0)  3.506 ms  3.566 ms  3.515 ms
 7 jio.com (80.81.195.32)  4.049 ms  3.852 ms  3.783 ms
 8 103.198.140.26 (103.198.140.26)  119.950 ms 103.198.140.84 (103.198.140.84)  118.400 ms  118.471 ms
 9 103.198.140.84 (103.198.140.84)  116.929 ms 116.991 ms  116.895 ms
10 * 103.198.140.26 (103.198.140.26)  119.965 ms *
11 103.198.140.175 (103.198.140.175)  115.507 ms * *
12 * *
13 136.232.148.178 (136.232.148.178)  151.898 ms 143.777 ms  140.611 ms
14 136.232.148.178 (136.232.148.178)  142.682 ms 145.010 ms  143.717 ms
15 * *
16 * *
17 * *
18 * *
19 * *
20 * *
21 * *
22 * *
23 * *
24 * *
25 * *
26 * *
27 * *
28 * *
29 * *
30 * *
```

## traceroute to www.uct.ac.za

---

```
traceroute to www.uct.ac.za (137.158.159.192), 30 hops max, 60 byte packets
 1 vsn0057.vs.mass.systems (10.92.36.120)  0.037 ms  0.025 ms  0.014 ms
 2 ae3-u100.sxbl1-cr-nunki.bb.gdinf.net (87.230.112.2)  0.409 ms  0.382 ms  0.414 ms
 3 ae0.sxbl1-ibr-altair.bb.gdinf.net (87.230.112.14)  29.879 ms  29.851 ms  29.818 ms
 4 ffb-b11-link.ip.twelve99.net (62.115.144.8)  2,878 ms  2,918 ms  2,985 ms
 5 * ffb-b11-link.ip.twelve99.net (62.115.143.226)  3,356 ms  3,394 ms
 6 ffb-b11-link.ip.twelve99.net (62.115.124.119)  3,409 ms  3,203 ms  3,177 ms
 7 *
 8 be2846.ccr42.fra03.atlas.cogentco.com (154.54.37.29)  3,754 ms be2845.ccr41.fra03.atlas.cogentco.com (154.54.56.189)  6,803 ms  6,740 ms
 9 be2813.ccr41.ams03.atlas.cogentco.com (130.117.0.121)  10,253 ms be2814.ccr42.ams03.atlas.cogentco.com (130.117.0.141)  10,531 ms be2813.ccr41.ams03.atlas.cogentco.com (130.117.0.121)  10,531 ms
10 be3458.ccr21.ams04.atlas.cogentco.com (154.54.39.186)  10,761 ms be3457.ccr21.ams04.atlas.cogentco.com (130.117.1.10)  10,976 ms  10,813 ms
11 *
12 ae0-306-mtz1-ir1.net.tenet.ac.za (155.232.1.86)  185.460 ms 185.323 ms  185.137 ms
13 et-1-1-0-isd1-pel.net.tenet.ac.za (155.232.1.153)  194.414 ms 194.037 ms 193.982 ms
14 et-1-1-0-cpt3-pel.net.tenet.ac.za (155.232.1.148)  209.854 ms 209.801 ms 209.806 ms
15 et-1-1-0-cpt7-pel.net.tenet.ac.za (155.232.64.70)  209.480 ms 209.745 ms 209.711 ms
16 154.114.124.1 (154.114.124.1)  209.984 ms 209.919 ms 209.050 ms
17 *
18 *
19 *
20 *
21 *
22 *
23 *
24 *
25 *
26 *
27 *
28 *
29 *
30 *
```

## traceroute to www.utah.edu

---

```
traceroute to www.utah.edu (155.98.186.21), 30 hops max, 60 byte packets
 1 vsn0057.vs.mass.systems (10.92.36.120)  0.040 ms  0.014 ms  0.011 ms
 2 ae3-u100.sxbl1-cr-nunki.bb.gdinf.net (87.230.112.2)  0.352 ms  0.325 ms  0.224 ms
 3 ae1.sxbl1-ibr-altair.bb.gdinf.net (87.230.112.14)  0.408 ms  0.400 ms  0.404 ms
 4 217.243.179.244 (217.243.179.244)  4,138 ms  4,288 ms  4,405 ms
 5 f-ed13-i.F.DE.NET.DTAG.DE (217.5.70.42)  4,632 ms f-ed13-i.F.DE.NET.DTAG.DE (217.0.203.10)  4,708 ms f-ed13-i.F.DE.NET.DTAG.DE (217.0.201.102)  4,379 ms
 6 80.150.170.214 (80.150.170.214)  13.425 ms 13.483 ms 13.449 ms
 7 ae0.cs1.fra6.de.eth.zayo.com (64.125.26.172)  134.318 ms 134.355 ms *
 8 ae2.cs1.ams17.nl.eth.zayo.com (64.125.29.59)  133.589 ms *
 9 *
10 *
11 *
12 * ae5.cs1.iga5.us.eth.zayo.com (44.125.29.126)  133.605 ms 133.660 ms
13 *
14 *
15 *
16 ae4.mpr1.las5.us.zip.zayo.com (64.125.26.241)  133.744 ms 133.903 ms 133.865 ms
17 ae7.mcs1.las2.us.zip.zayo.com (64.125.21.202)  134.579 ms 133.717 ms 134.050 ms
18 209.66.120.14.IDIA-249109-ZY0.zip.zayo.com (209.66.120.14)  137.618 ms 137.646 ms 137.582 ms
19 ddc-pep-c-123-int.uen.net (140.197.251.32)  144.900 ms 145.016 ms 144.802 ms
20 ddc-pep-b-129-int.uen.net (140.197.253.97)  144.784 ms 144.779 ms 144.845 ms
21 ebc-pep-b-179-int.uen.net (140.197.252.76)  144.631 ms 144.731 ms 144.687 ms
22 ebc-pep-a-178-int.uen.net (140.197.252.84)  144.832 ms 144.803 ms 144.865 ms
23 *
24 199.104.93.22 (199.104.93.22)  144.582 ms 145.316 ms 145.148 ms
25 199.104.93.33 (199.104.93.33)  145.944 ms 145.933 ms 145.507 ms
26 155.99.130.65 (155.99.130.65)  145.410 ms 155.99.130.67 (155.99.130.67)  146.375 ms 145.647 ms
27 155.99.130.105 (155.99.130.105)  145.937 ms 155.99.130.103 (155.99.130.103)  146.073 ms 155.99.130.107 (155.99.130.107)  146.523 ms
28 *
29 *
30 *
```