COL334 Assignment1

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August 12, 2023

§1. Network Analysis

a. We ran `tracert` on `iitd.ac.in` outside IITD network and got the following output:

```
PS C:\Users\Anish> tracert iitd.ac.in

Tracing route to iitd.ac.in [103.27.9.24]
over a maximum of 30 hops:

  1     4 ms     3 ms     9 ms  dsldevice.lan [192.168.1.1]
  2    87 ms    73 ms    26 ms  abts-north-dynamic-255.187.69.182.airtelbroadband.in [182.69.187.255]
  3    34 ms    28 ms    48 ms  125.18.240.153
  4    38 ms    45 ms    38 ms  116.119.106.136
  5    47 ms    53 ms    49 ms  49.44.220.188
  6     *        *        *     Request timed out.
  7     *        *        *     Request timed out.
  8    47 ms    43 ms    47 ms  136.232.148.178
  9     *        *        *     Request timed out.
 10     *        *        *     Request timed out.
 11     *        *        *     Request timed out.
 12    45 ms    59 ms    52 ms  103.27.9.24
 13   187 ms    46 ms    61 ms  103.27.9.24
 14    47 ms    48 ms    49 ms  103.27.9.24

Trace complete.
```

b. TODO

c. We observe that the maximum packet size that can be sent is 68 (to `google.com`)

```
root@IdeapadAB:/mnt/c/Users/Anish# ping -s 68 -c 5 google.com
PING google.com (142.250.194.238) 68(96) bytes of data.
76 bytes from del12s08-in-f14.1e100.net (142.250.194.238): icmp_seq=1 ttl=116 time=7.00 ms
76 bytes from del12s08-in-f14.1e100.net (142.250.194.238): icmp_seq=2 ttl=116 time=6.73 ms
76 bytes from del12s08-in-f14.1e100.net (142.250.194.238): icmp_seq=3 ttl=116 time=7.11 ms
76 bytes from del12s08-in-f14.1e100.net (142.250.194.238): icmp_seq=4 ttl=116 time=6.05 ms
76 bytes from del12s08-in-f14.1e100.net (142.250.194.238): icmp_seq=5 ttl=116 time=7.98 ms

--- google.com ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4007ms
rtt min/avg/max/mdev = 6.052/6.973/7.975/0.621 ms
root@IdeapadAB:/mnt/c/Users/Anish# ping -s 69 -c 5 google.com
PING google.com (142.250.194.238) 69(97) bytes of data.

--- google.com ping statistics ---
5 packets transmitted, 0 received, 100% packet loss, time 4009ms
```

However, we also observe that the max ping size depends on the site requested for. For example, we saw that for `iitd.ac.in`, it is 1472 bytes. We can run the following python code to find the maximum packet size for a given site:

```
#!/usr/bin/python3

import os
site=input("Enter the site: ")
l=1
r=65007
while l<r:
    mid=(l+r)//2
    if os.system("ping -c 1 -s "+str(mid)+" "+site)==0:
        l=mid+1
    else:
        r=mid
print("\n\nMax ping size is: "+str(l-1))
```

§2. `traceroute` using python

The code for `traceroute` can be found in `traceroute.py`.

§3. Internet Architecture

First we run a traceroute from our own IP address to the 5 different servers.

a. Here is the route to `www.google.com`

```
Ankits-MacBook-Air-6:~ ankitmondal$ traceroute google.com
traceroute to google.com (142.250.194.238), 64 hops max, 52 byte packets
 1  10.184.0.13 (10.184.0.13)  3.999 ms  3.570 ms  3.506 ms
 2  10.254.175.1 (10.254.175.1)  4.146 ms
    10.254.175.5 (10.254.175.5)  3.675 ms  3.223 ms
 3  10.255.1.34 (10.255.1.34)  3.562 ms  3.512 ms  3.357 ms
 4  10.119.233.65 (10.119.233.65)  3.463 ms  3.959 ms  3.930 ms
 5  * * *
 6  10.119.234.162 (10.119.234.162)  12.045 ms  5.639 ms  5.675 ms
 7  72.14.194.160 (72.14.194.160)  5.484 ms  5.647 ms  6.487 ms
 8  108.170.251.113 (108.170.251.113)  7.106 ms
    108.170.251.97 (108.170.251.97)  6.339 ms  6.480 ms
 9  142.251.52.217 (142.251.52.217)  6.274 ms  6.749 ms  6.689 ms
10  del12s08-in-f14.1e100.net (142.250.194.238)  6.588 ms  6.423 ms  6.608 ms
```

b. Here is the route to `www.iitd.ac.in`

```
Ankits-MacBook-Air-6:~ ankitmondal$ 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)  4.675 ms  4.242 ms  3.512 ms
 2  10.254.175.5 (10.254.175.5)  4.012 ms
    10.254.175.1 (10.254.175.1)  4.016 ms  4.356 ms
 3  10.254.236.6 (10.254.236.6)  3.285 ms
    10.254.236.26 (10.254.236.26)  3.920 ms
    10.254.236.2 (10.254.236.2)  5.730 ms
 4  www.iitd.ac.in (10.10.211.212)  3.830 ms  4.643 ms  5.628 ms
```

c. Here is the route to `www.utah.edu`

```
Ankits-MacBook-Air-6:~ ankitmondal$ 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)  5.480 ms  3.898 ms  3.338 ms
 2  10.254.175.1 (10.254.175.1)  3.602 ms
    10.254.175.5 (10.254.175.5)  3.922 ms  3.769 ms
 3  10.255.1.34 (10.255.1.34)  5.116 ms  5.269 ms  5.756 ms
 4  10.119.233.65 (10.119.233.65)  64.339 ms  67.830 ms  65.010 ms
 5  10.1.207.69 (10.1.207.69)  80.742 ms  86.632 ms  93.759 ms
 6  10.1.200.137 (10.1.200.137)  84.119 ms  85.695 ms  70.847 ms
 7  10.255.238.254 (10.255.238.254)  80.166 ms
    10.255.238.122 (10.255.238.122)  78.281 ms
    10.255.238.254 (10.255.238.254)  86.918 ms
 8  180.149.48.18 (180.149.48.18)  71.995 ms  60.372 ms  58.199 ms
 9  180.149.48.6 (180.149.48.6)  244.512 ms  207.941 ms  197.721 ms
10  180.149.48.20 (180.149.48.20)  182.712 ms
    180.149.48.13 (180.149.48.13)  337.379 ms
    180.149.48.20 (180.149.48.20)  173.159 ms
11  fourhundredge-0-0-0-2.4079.core1.ashb.net.internet2.edu (163.253.1.116)  340.584 ms
    180.149.48.13 (180.149.48.13)  270.570 ms
    fourhundredge-0-0-0-2.4079.core1.ashb.net.internet2.edu (163.253.1.116)  314.143 ms
12  fourhundredge-0-0-0-16.4079.core2.ashb.net.internet2.edu (163.253.1.3)  312.121 ms
    fourhundredge-0-0-0-2.4079.core1.ashb.net.internet2.edu (163.253.1.116)  417.111 ms
    fourhundredge-0-0-0-16.4079.core2.ashb.net.internet2.edu (163.253.1.3)  416.768 ms
13  fourhundredge-0-0-0-16.4079.core2.ashb.net.internet2.edu (163.253.1.3)  313.367 ms
    fourhundredge-0-0-0-1.4079.core2.clev.net.internet2.edu (163.253.1.139)  319.440 ms
418.102 ms
14  fourhundredge-0-0-0-1.4079.core2.clev.net.internet2.edu (163.253.1.139)  417.208 ms
    fourhundredge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.17)  416.394 ms
    fourhundredge-0-0-0-1.4079.core2.clev.net.internet2.edu (163.253.1.139)  319.361 ms
15  fourhundredge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.17)  410.326 ms
    fourhundredge-0-0-0-2.4079.core2.chic.net.internet2.edu (163.253.2.18)  416.659 ms
    fourhundredge-0-0-0-2.4079.core2.eqch.net.internet2.edu (163.253.2.17)  417.562 ms
16  fourhundredge-0-0-0-2.4079.core2.chic.net.internet2.edu (163.253.2.18)  415.580 ms
417.440 ms
    fourhundredge-0-0-0-1.4079.core1.kans.net.internet2.edu (163.253.1.245)  418.242 ms
17  fourhundredge-0-0-0-1.4079.core1.kans.net.internet2.edu (163.253.1.245)  418.728 ms
    fourhundredge-0-0-0-1.4079.core1.denv.net.internet2.edu (163.253.1.242)  416.527 ms
417.077 ms
18  fourhundredge-0-0-0-1.4079.core1.denv.net.internet2.edu (163.253.1.242)  416.455 ms
    fourhundredge-0-0-0-3.4079.core1.salt.net.internet2.edu (163.253.1.171)  418.388 ms
    fourhundredge-0-0-0-1.4079.core1.denv.net.internet2.edu (163.253.1.242)  314.445 ms
19  fourhundredge-0-0-0-3.4079.core1.salt.net.internet2.edu (163.253.1.171)  315.540 ms
    fourhundredge-0-0-0-1.4079.core1.lasv.net.internet2.edu (163.253.1.152)  411.072 ms
    fourhundredge-0-0-0-3.4079.core1.salt.net.internet2.edu (163.253.1.171)  417.062 ms
20  163.253.5.7 (163.253.5.7)  319.476 ms  319.171 ms
    fourhundredge-0-0-0-1.4079.core1.lasv.net.internet2.edu (163.253.1.152)  410.432 ms
21  tdc-beibr-b-170-int.uen.net (140.197.249.81)  415.347 ms  322.845 ms  404.272 ms
22  tdc-beibr-b-170-int.uen.net (140.197.249.81)  363.062 ms
    ddc-pep-c-123-int.uen.net (140.197.251.32)  318.119 ms
    tdc-beibr-b-170-int.uen.net (140.197.249.81)  322.820 ms
23  ddc-pep-c-123-int.uen.net (140.197.251.32)  346.374 ms
    ddc-pep-b-129-int.uen.net (140.197.253.97)  416.809 ms
    ddc-pep-c-123-int.uen.net (140.197.251.32)  411.102 ms
24  ddc-pep-b-129-int.uen.net (140.197.253.97)  416.736 ms
    ebc-pep-b-179-int.uen.net (140.197.252.76)  416.798 ms
    ddc-pep-b-129-int.uen.net (140.197.253.97)  412.609 ms
25  ebc-pep-a-178-int.uen.net (140.197.252.84)  416.708 ms  411.943 ms
    ebc-pep-b-179-int.uen.net (140.197.252.76)  419.376 ms
26  * ebc-pep-a-178-int.uen.net (140.197.252.84)  319.891 ms *
27  * 199.104.93.22 (199.104.93.22)  337.648 ms *
28  199.104.93.22 (199.104.93.22)  321.654 ms
    199.104.93.29 (199.104.93.29)  343.305 ms
    199.104.93.22 (199.104.93.22)  345.169 ms
```

```
29  155.99.130.57 (155.99.130.57)  416.730 ms
    199.104.93.29 (199.104.93.29)  416.822 ms  416.541 ms
30  155.99.130.103 (155.99.130.103)  414.959 ms
    155.99.130.57 (155.99.130.57)  313.681 ms
    155.99.130.107 (155.99.130.107)  416.673 ms
31  172.31.241.255 (172.31.241.255)  416.605 ms
    155.99.130.101 (155.99.130.101)  412.722 ms
    172.31.241.255 (172.31.241.255)  416.726 ms
32  172.31.241.255 (172.31.241.255)  416.528 ms *
    172.31.241.251 (172.31.241.251)  423.757 ms
33  172.31.241.25 (172.31.241.25)  413.229 ms  404.049 ms
    172.31.241.22 (172.31.241.22)  425.597 ms
34  www.utah.edu (155.98.186.21)  412.101 ms * *
```

d. Here is the route to `www.facebook.com`

```
Ankits-MacBook-Air-6:~ ankitmondal$ traceroute facebook.com
traceroute to facebook.com (157.240.16.35), 64 hops max, 52 byte packets
 1  10.184.0.13 (10.184.0.13)  4.151 ms  3.441 ms  3.988 ms
 2  10.254.175.5 (10.254.175.5)  3.479 ms
    10.254.175.1 (10.254.175.1)  3.745 ms  3.525 ms
 3  10.255.1.34 (10.255.1.34)  3.845 ms  3.429 ms  6.735 ms
 4  10.119.233.65 (10.119.233.65)  13.776 ms  5.528 ms  4.366 ms
 5  10.1.207.69 (10.1.207.69)  29.882 ms  30.418 ms  31.270 ms
 6  * * *
 7  10.255.238.122 (10.255.238.122)  39.404 ms
    10.255.238.254 (10.255.238.254)  34.321 ms
    10.255.238.122 (10.255.238.122)  32.331 ms
 8  10.152.7.214 (10.152.7.214)  35.129 ms  33.873 ms  35.280 ms
 9  10.152.7.233 (10.152.7.233)  29.310 ms
    ae1.pr01.bom1.tfbnw.net (157.240.68.238)  53.885 ms  35.890 ms
10  po101.psw01.bom1.tfbnw.net (31.13.29.205)  38.635 ms
    po101.psw02.bom1.tfbnw.net (157.240.33.239)  35.706 ms
    ae2.pr02.bom1.tfbnw.net (157.240.66.204)  30.943 ms
11  po101.psw04.bom1.tfbnw.net (157.240.44.31)  29.498 ms *
    po102.psw02.bom1.tfbnw.net (157.240.35.63)  39.553 ms
12  157.240.38.65 (157.240.38.65)  30.149 ms
    173.252.67.185 (173.252.67.185)  35.504 ms
    edge-star-mini-shv-01-bom1.facebook.com (157.240.16.35)  31.092 ms
```

We will now run traceroute from Buenos Aires, Argentina.

a. Here is the route to `www.utah.edu`

```
traceroute to www.utah.edu (155.98.186.21), 30 hops max, 60 byte packets
 1  * *
 2  be2982.ccr41.mia03.atlas.cogentco.com (154.54.40.57)  141.964 ms  141.989 ms
 3  be3087.ccr22.mia01.atlas.cogentco.com (154.54.88.233)  142.235 ms  142.303 ms
 4  be3569.ccr41.iah01.atlas.cogentco.com (154.54.82.241)  168.591 ms be3570.ccr42.iah01.atlas.coge
168.661 ms
 5  be2441.ccr31.dfw01.atlas.cogentco.com (154.54.41.66)  173.936 ms be2443.ccr32.dfw01.atlas.coger
173.817 ms
 6  be2432.ccr21.mci01.atlas.cogentco.com (154.54.3.134)  183.750 ms  183.779 ms
 7  be3036.ccr22.den01.atlas.cogentco.com (154.54.31.89)  195.119 ms be3035.ccr21.den01.atlas.coger
195.010 ms
 8  be3038.ccr32.slc01.atlas.cogentco.com (154.54.42.97)  205.222 ms be3037.ccr21.slc01.atlas.coger
205.428 ms
```

[redacted]

b. Here is the route to `www.uct.ac.za`

```
traceroute to www.uct.ac.za (137.158.159.192), 30 hops max, 60 byte packets
 1  * *
 2  be2982.ccr41.mia03.atlas.cogentco.com (154.54.40.57)  142.191 ms  142.206 ms
 3  ntt.mia03.atlas.cogentco.com (154.54.9.42)  141.607 ms  141.613 ms
 4  ae-3.r22.miamfl02.us.bb.gin.ntt.net (129.250.7.45)  141.808 ms  141.823 ms
 5  ae-0.a02.miamfl02.us.bb.gin.ntt.net (129.250.2.4)  141.600 ms ae-1.a02.miamfl02.us.bb.gin.ntt.
141.759 ms
 6  ce-2-0-2.a02.miamfl02.us.ce.gin.ntt.net (129.250.200.114)  141.791 ms  141.766 ms
 7  30.8.39.170.ampath.net (170.39.8.30)  141.655 ms  141.714 ms
 8  * *
 9  et-0-0-1-0-cpt7-pe1.net.tenet.ac.za (155.232.64.70)  373.454 ms  373.416 ms
10  154.114.124.1 (154.114.124.1)  373.478 ms  373.495 ms
11  * *
12  * *
13  * *
14  * *
15  * *
16  * *
17  * *
18  * *
19  * *
20  * *
21  * *
22  * *
23  * *
24  * *
25  * *
26  * *
27  * *
28  * *
29  * *
30  * *
```

c. Here is the route to `www.iitd.ac.in`

```
traceroute to iitd.ac.in (103.27.9.24), 30 hops max, 40 byte packets
 1  1.ip-176-103-190.ar.ipxon.net (190.103.176.1)  0.106 ms *  0.098 ms
 2  Internal (Internal)  0.264 ms  0.263 ms  0.260 ms
 3  ae30-75.edge2.BuenosAires1.Level3.net (67.73.142.21)  0.790 ms  0.896 ms  0.803 ms
 4  * * *
 5  4.7.26.62 (4.7.26.62)  245.013 ms  245.016 ms  245.030 ms
 6  49.45.4.87 (49.45.4.87)  358.610 ms  358.603 ms  358.587 ms
```

d. Here is the route to `www.google.com`

```
 traceroute to google.com (216.58.202.110), 30 hops max, 40 byte packets
 1  host1.75.78.170.h2dns.net (170.78.75.1)  1.207 ms *  1.224 ms
 2  Internal (Internal)  0.548 ms  0.541 ms  0.509 ms
 3  200.16.206.3 (200.16.206.3)  1.628 ms  1.525 ms  1.530 ms
 4  200.32.34.185 (200.32.34.185)  1.842 ms  1.707 ms  1.508 ms
 5  200.32.33.174 (200.32.33.174)  1.357 ms  1.554 ms  1.430 ms
 6  200-26-92-114.advance.com.ar (200.26.92.114)  1.298 ms  2.608 ms  2.605 ms
 7  72.14.220.19 (72.14.220.19)  6.745 ms  5.560 ms  5.501 ms
 8  72.14.220.18 (72.14.220.18)  2.203 ms  2.138 ms  2.148 ms
 9  142.250.57.193 (142.250.57.193)  2.121 ms  2.214 ms  2.268 ms
10  142.251.79.143 (142.251.79.143)  2.867 ms  2.876 ms  2.890 ms
11  eze06s10-in-f14.1e100.net (216.58.202.110)  1.899 ms  1.989 ms  2.157 ms
```

e. Here is the route to `www.facebook.com`

```
traceroute to www.facebook.com (157.240.12.35), 30 hops max, 60 byte packets
 1  * *
 2  be2982.ccr41.mia03.atlas.cogentco.com (154.54.40.57)  142.001 ms  142.015 ms
 3  38.104.95.122 (38.104.95.122)  162.438 ms  166.992 ms
 4  po204.asw01.mia1.tfbnw.net (129.134.64.164)  141.721 ms po204.asw04.mia1.tfbnw.net (129.134.64.
141.751 ms
 5  ae103.ar04.mia1.tfbnw.net (129.134.64.128)  142.080 ms ae101.ar01.mia1.tfbnw.net (129.134.64.1
142.139 ms
 6  * *
 7  * *
 8  * ae2.ar01.gru2.tfbnw.net (129.134.50.215)  246.723 ms
 9  * ae1.ar02.gru1.tfbnw.net (204.15.22.51)  259.994 ms
10  po285.psw03.gru2.tfbnw.net (147.75.214.177)  245.858 ms po236.psw04.gru2.tfbnw.net (129.134.33.
246.164 ms
11  157.240.39.21 (157.240.39.21)  245.816 ms po216.psw04.gru2.tfbnw.net (129.134.33.91)
246.168 ms
12  edge-star-mini-shv-02-gru2.facebook.com (157.240.12.35)  245.545 ms 157.240.39.123 (157.240.39.
245.936 ms
```

We will now run traceroute from Johannesburg, South Africa.

a. Here is the route to `www.utah.edu`

```
traceroute to www.utah.edu (155.98.186.21), 30 hops max, 60 byte packets
 1  gi0-0-0-17.20.agr11.jnb01.atlas.cogentco.com (206.185.255.1)  1.012 ms  0.935 ms
 2  be2355.ccr51.jnb01.atlas.cogentco.com (154.54.43.37)  0.843 ms  0.888 ms
 3  be2385.ccr21.lon01.atlas.cogentco.com (154.54.40.93)  195.961 ms  193.712 ms
 4  be2871.ccr42.lon13.atlas.cogentco.com (154.54.58.185)  193.760 ms be2868.ccr41.lon13.atlas.coge
193.616 ms
 5  be2101.ccr32.bos01.atlas.cogentco.com (154.54.82.38)  256.072 ms  256.079 ms
 6  be3600.ccr22.alb02.atlas.cogentco.com (154.54.0.221)  259.695 ms  259.620 ms
 7  be2878.ccr21.cle04.atlas.cogentco.com (154.54.26.129)  270.013 ms be2879.ccr22.cle04.atlas.coge
270.017 ms
 8  be2718.ccr42.ord01.atlas.cogentco.com (154.54.7.129)  278.858 ms be2717.ccr41.ord01.atlas.coger
277.041 ms
 9  be2832.ccr22.mci01.atlas.cogentco.com (154.54.44.169)  288.298 ms be2831.ccr21.mci01.atlas.coge
290.698 ms
10  be3035.ccr21.den01.atlas.cogentco.com (154.54.5.89)  299.620 ms be3036.ccr22.den01.atlas.cogent
303.746 ms
11  be3038.ccr32.slc01.atlas.cogentco.com (154.54.42.97)  309.901 ms be3037.ccr21.slc01.atlas.coger
311.669 ms
12  be2685.rcr01.b020767-1.slc01.atlas.cogentco.com (154.54.41.118)  312.768 ms  314.768 ms
13  * 38.142.233.58 (38.142.233.58)  316.241 ms
14  lv3-beibr-a-184-int.uen.net (140.197.249.117)  313.536 ms  313.491 ms
15  ebc-pep-a-178-int.uen.net (140.197.253.23)  315.952 ms  316.280 ms
16  * *
17  * 199.104.93.22 (199.104.93.22)  314.488 ms
18  * 199.104.93.33 (199.104.93.33)  316.100 ms
19  155.99.130.67 (155.99.130.67)  316.597 ms  315.285 ms
20  155.99.130.103 (155.99.130.103)  315.946 ms 155.99.130.107 (155.99.130.107)  315.888 ms
21  * 172.31.241.255 (172.31.241.255)  317.363 ms
22  172.31.241.22 (172.31.241.22)  312.997 ms 172.31.241.18 (172.31.241.18)  317.951 ms
23  172.31.241.29 (172.31.241.29)  321.137 ms  313.012 ms
24  * uhome.web.utah.edu (155.98.186.21)  317.384 ms
```

b. Here is the route to `www.uct.ac.za`

```
traceroute to www.uct.ac.za (137.158.159.192), 30 hops max, 60 byte packets
 1  gi0-0-0-17.20.agr11.jnb01.atlas.cogentco.com (206.185.255.1)  0.962 ms  0.918 ms
 2  be2355.ccr51.jnb01.atlas.cogentco.com (154.54.43.37)  0.749 ms  0.661 ms
 3  be2385.ccr21.lon01.atlas.cogentco.com (154.54.40.93)  193.635 ms  193.572 ms
 4  be2185.rcr21.b015534-1.lon01.atlas.cogentco.com (154.54.61.61)  196.002 ms  195.926 ms
 5  tenet.demarc.cogentco.com (149.14.146.194)  198.562 ms *
 6  et-1-1-0-0-ams1-ir1.net.tenet.ac.za (155.232.1.80)  203.336 ms  203.247 ms
 7  ae0-306-mtz1-ir1.net.tenet.ac.za (155.232.1.86)  394.840 ms  394.697 ms
 8  lt-0-0-0-1-mtz1-ir1.net.tenet.ac.za (155.232.152.20)  413.789 ms  413.737 ms
 9  lt-1-0-0-0-mtz1-ir1.net.tenet.ac.za (155.232.152.23)  375.295 ms  375.201 ms
10  et-1-1-1-0-isd1-pe1.net.tenet.ac.za (155.232.1.153)  385.503 ms  385.438 ms
11  et-1-1-4-0-cpt3-pe1.net.tenet.ac.za (155.232.1.148)  399.751 ms  399.994 ms
12  et-0-0-1-0-cpt7-pe1.net.tenet.ac.za (155.232.64.70)  398.918 ms  398.768 ms
13  154.114.124.1 (154.114.124.1)  399.026 ms  400.762 ms
14  * *
15  * *
16  * *
17  * *
18  * *
19  * *
20  * *
21  * *
22  * *
23  * *
24  * *
25  * *
26  * *
27  * *
```

c. Here is the route to `www.iitd.ac.in`

```
 traceroute to iitd.ac.in (103.27.9.24), 30 hops max, 40 byte packets
 1  1.110.static.rdns.co.za (41.76.110.1)  0.181 ms *  0.733 ms
 2  * * *
 3  41.193.230.5 (41.193.230.5)  1.115 ms  1.152 ms  1.157 ms
 4  41-193-118-45.vox.co.za (41.193.118.45)  1.173 ms  1.914 ms  1.943 ms
 5  196.41.24.122 (196.41.24.122)  178.515 ms  178.570 ms  178.577 ms
 6  ldn-b2-link.ip.twelve99.net (213.248.100.161)  178.650 ms  179.272 ms  179.278 ms
 7  * * *
 8  prs-bb2-link.ip.twelve99.net (62.115.133.239)  185.759 ms  185.104 ms  185.732 ms
 9  mei-b5-link.ip.twelve99.net (62.115.124.57)  240.590 ms  241.707 ms  241.730 ms
10  reliance-ic-361536.ip.twelve99-cust.net (62.115.155.139)  395.344 ms  395.343 ms  395.439 ms
11  103.198.140.214 (103.198.140.214)  392.176 ms  392.163 ms  391.846 ms
12  103.198.140.177 (103.198.140.177)  391.266 ms  391.231 ms  391.237 ms
13  * * *
14  136.232.148.178 (136.232.148.178)  424.906 ms  424.911 ms  424.974 ms
15  * * *
16  * * *
17  * * *
18  * * *
19  103.27.9.24 (103.27.9.24)  428.173 ms  428.191 ms  428.313 ms
20  103.27.9.24 (103.27.9.24)  428.229 ms  428.237 ms  428.239 ms
21  103.27.9.24 (103.27.9.24)  427.742 ms  427.770 ms  427.922 ms
```

d. Here is the route to `www.google.com`

```
traceroute to www.google.com (172.217.169.36), 30 hops max, 60 byte packets
 1  gi0-0-0-17.20.agr11.jnb01.atlas.cogentco.com (206.185.255.1)  0.915 ms  0.920 ms
 2  be2355.ccr51.jnb01.atlas.cogentco.com (154.54.43.37)  0.760 ms  0.775 ms
 3  be2389.ccr22.lon01.atlas.cogentco.com (154.54.80.201)  193.854 ms be2385.ccr21.lon01.atlas.coge
195.729 ms
 4  be2869.ccr42.lon13.atlas.cogentco.com (154.54.57.161)  193.933 ms be2870.ccr41.lon13.atlas.coge
214.296 ms
 5  be2348.rcr21.b023101-0.lon13.atlas.cogentco.com (130.117.51.74)  198.012 ms be2350.rcr21.b0231
194.056 ms
 6  ae39-xcr1.ltw.cw.net (195.2.26.25)  196.957 ms *
 7  ae8-xcr1.lnt.cw.net (195.2.24.130)  196.961 ms *
 8  google-gw1.lnt.cw.net (195.2.5.10)  196.939 ms  197.481 ms
 9  74.125.242.65 (74.125.242.65)  205.332 ms *
10  172.253.66.87 (172.253.66.87)  200.761 ms 172.253.66.89 (172.253.66.89)  207.074 ms
11  lhr48s08-in-f4.1e100.net (172.217.169.36)  198.192 ms  198.100 ms
```

e. Here is the route to `www.facebook.com`

```
traceroute to www.facebook.com (157.240.221.35), 30 hops max, 60 byte packets
 1  gi0-0-0-17.20.agr11.jnb01.atlas.cogentco.com (206.185.255.1)  0.848 ms  0.833 ms
 2  be2355.ccr51.jnb01.atlas.cogentco.com (154.54.43.37)  1.043 ms  1.147 ms
 3  be2389.ccr22.lon01.atlas.cogentco.com (154.54.80.201)  194.069 ms  193.812 ms
 4  be2185.rcr21.b015534-1.lon01.atlas.cogentco.com (154.54.61.61)  195.434 ms  193.532 ms
 5  149.14.251.186 (149.14.251.186)  193.681 ms  193.576 ms
```

[redacted]

Hops Analysis

	google.com	Facebook.com	Utah.edu	iitd.ac.in	uct.ac.za
Laptop	9	11	34	4	-
Buenos Aires	11	9	19	11	-
Johannesburg	11	9	23	14	-

A detailed analysis:-

1. Geographical distance vs number of Hops.
   Let's use utah.edu as the sample to study the trend. The distance between utah and the 3 traceruote sources vary as follows, Utah-Buenos Aires ¡ Utah-Delhi ¡ Utah-Johannesburg. While it does take more hops to go from delhi to utah,than from Buenos Aires, it takes less hops to go from Johannesburg to utah than from Delhi. This shows that there might be some exceptions to the trend that it takes more hops for larger distances.
   Similarly for iitd.ac.in, the number of hops needed by local device (laptop) is 4, but Buenos Aires which is farther away from Delhi than Johannesburg takes lesser number of hops than Johannesburg.

2. Number of hops to Google and Facebook.
   In general, Google and Facebook seem to take fewer hops than other sites. Also the number of hops needed is almost constant and varies around 9-13. The number of hops required for sites like iitd and utah vary a lot depending on traceroute server and depend on geographical distance as well. This might be because, google and facebook resolve to different IPs from different sources in order to ensure a smooth experience from any country. This results in low variability. On the other hand such a situation is not needed for universities like utah or iitd as there is only one server for these institutes and they don't need to cater to too many requests from around the world. So the need to optimise hops across the world is not high for these sites.

Latency Analysis

	google.com	Facebook.com	Utah.edu	iitd.ac.in	uct.ac.za
Laptop	14.515	42.32	423.244	16.971	timeout
Buenos Aires	249.360	245.648	208.10	398.504	timeout
Johannesburg	195.502	197.082	316.645	429.453	timeout

In general the latency increases with number of hops, but for similar hop size, there might be some exceptions to the rule, for example Latency for facebook in Buenos Aires and Johannesburg is more than that of Local device even though the number of hops is more for local device.

On the other hand,the latency seems to follow the trend of number of hops for universities like utah and iitd.

Different IP addresses for same site

The IP address of utah.edu and iitd.ac.in seems to remain the same irrespective of the location form where traceroute is requested. On the other hand, the IP address of google and facebook is different for every traceroute location that we chose. One possible reason to explain this can be that sites like google and facebook have to ensure very low latency and high capacity for almost every country. It becomes necessary for them to maintain servers or peering services in almost every country, so the request to google or facebook from every other country seems to be routed to a different IP address corresponding to a different server.

For educational institutions, the requests are mostly from within the country. It is not necessary for them to optimise tehir performance across nations by maintaining multiple servers across the world. So, they have the same IP for multiple traceroute locations.

d

The paths to different IP addresses for the same site gives longer path when request is made to an IP address obtained from a request to a different country.

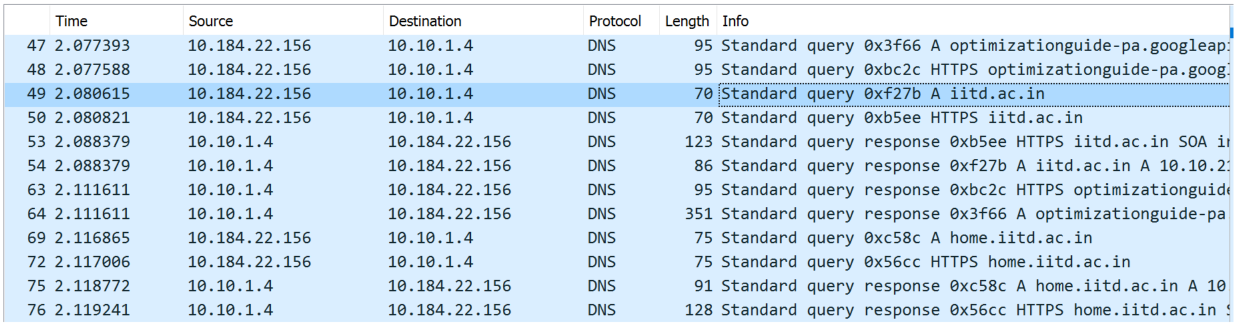
One possible reason for this can be that networks are optimised to ensure that people alwasy get access to the least latency path. So, the IP address to which the domain name corresponds to in our nation is the closest IP address (server) available to us.

e

For most countries, Google's network seems to be peered to the local ISP. However, on tracerouting for google and facebook from a server in Beijing, no response in received after 20 hops and it seems like the packet is dropped. It is possible that China's local ISPs are not peered with Google's network.

§4. Packet Analysis

a. We ran a DNS filter on the output to `iitd.ac.in` and got the following result(Fig. 1):



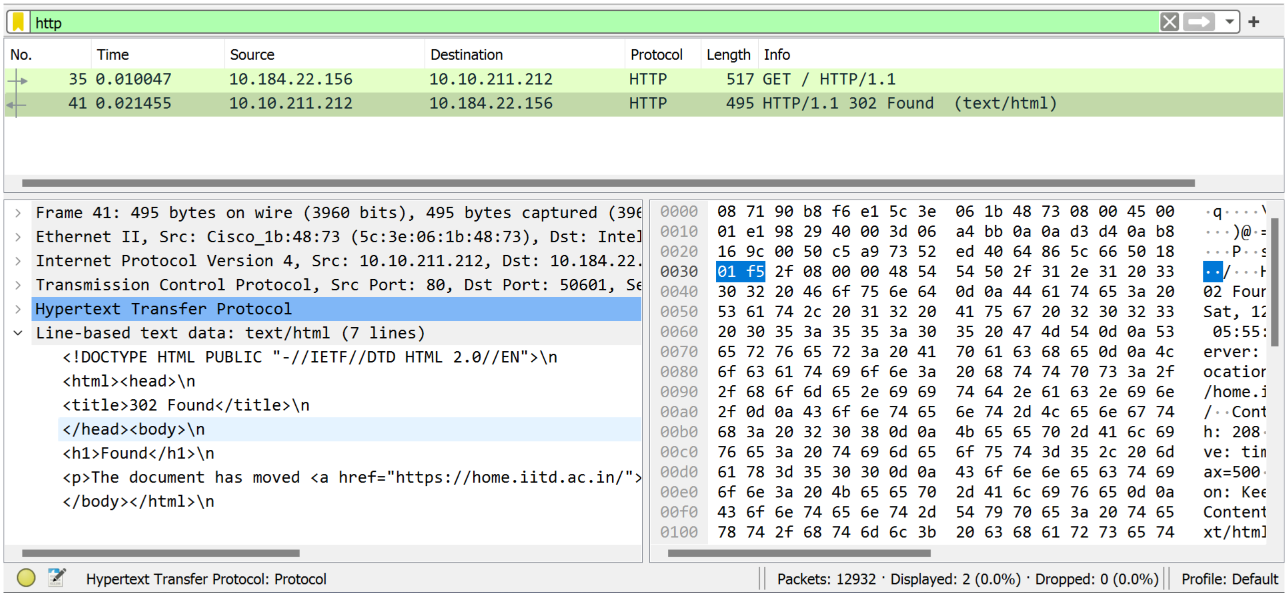
	Time	Source	Destination	Protocol	Length	Info
47	2.077393	10.184.22.156	10.10.1.4	DNS	95	Standard query 0x3f66 A optimizationguide-pa.googleap:
48	2.077588	10.184.22.156	10.10.1.4	DNS	95	Standard query 0xbc2c HTTPS optimizationguide-pa.googl
49	2.080615	10.184.22.156	10.10.1.4	DNS	70	Standard query 0xf27b A iitd.ac.in
50	2.080821	10.184.22.156	10.10.1.4	DNS	70	Standard query 0xb5ee HTTPS iitd.ac.in
53	2.088379	10.10.1.4	10.184.22.156	DNS	123	Standard query response 0xb5ee HTTPS iitd.ac.in SOA ir
54	2.088379	10.10.1.4	10.184.22.156	DNS	86	Standard query response 0xf27b A iitd.ac.in A 10.10.2:
63	2.111611	10.10.1.4	10.184.22.156	DNS	95	Standard query response 0xbc2c HTTPS optimizationguide
64	2.111611	10.10.1.4	10.184.22.156	DNS	351	Standard query response 0x3f66 A optimizationguide-pa
69	2.116865	10.184.22.156	10.10.1.4	DNS	75	Standard query 0xc58c A home.iitd.ac.in
72	2.117006	10.184.22.156	10.10.1.4	DNS	75	Standard query 0x56cc HTTPS home.iitd.ac.in
75	2.118772	10.10.1.4	10.184.22.156	DNS	91	Standard query response 0xc58c A home.iitd.ac.in A 10
76	2.119241	10.10.1.4	10.184.22.156	DNS	128	Standard query response 0x56cc HTTPS home.iitd.ac.in S

Figure 1: IITD DNS

Observations

There were DNS queries and responses for `iitd.ac.in`. The request-response began at 2.080615s and ended at 2.088379s lasting for a total of 7.764ms.

b. On applying a `http` filter, only one request is observed as shown in Fig. 2



http

No.	Time	Source	Destination	Protocol	Length	Info
35	0.010047	10.184.22.156	10.10.211.212	HTTP	517	GET / HTTP/1.1
41	0.021455	10.10.211.212	10.184.22.156	HTTP	495	HTTP/1.1 302 Found (text/html)

```
> Frame 41: 495 bytes on wire (3960 bits), 495 bytes captured (396
> Ethernet II, Src: Cisco_1b:48:73 (5c:3e:06:1b:48:73), Dst: Intel
> Internet Protocol Version 4, Src: 10.10.211.212, Dst: 10.184.22.
> Transmission Control Protocol, Src Port: 80, Dst Port: 50601, Se
> Hypertext Transfer Protocol
v Line-based text data: text/html (7 lines)
    <!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">\n
    <html><head>\n
    <title>302 Found</title>\n
    </head><body>\n
    <h1>Found</h1>\n
    <p>The document has moved <a href="https://home.iitd.ac.in/">
    </body></html>\n
```

```
0000  08 71 90 b8 f6 e1 5c 3e  06 1b 48 73 08 00 45 00   ·q····\
0010  01 e1 98 29 40 00 3d 06  a4 bb 0a 0a d3 d4 0a b8   ···)@·=
0020  16 9c 00 50 c5 a9 73 52  ed 40 64 86 5c 66 50 18   ···P··s
0030  01 f5 2f 08 00 00 48 54  54 50 2f 31 2e 31 20 33   ··/···H
0040  30 32 20 46 6f 75 6e 64  0d 0a 44 61 74 65 3a 20   02 Four
0050  53 61 74 2c 20 31 32 20  41 75 67 20 32 30 32 33   Sat, 12
0060  20 30 35 3a 35 35 3a 30  35 20 47 4d 54 0d 0a 53    05:55:
0070  65 72 76 65 72 3a 20 41  70 61 63 68 65 0d 0a 4c   erver:
0080  6f 63 61 74 69 6f 6e 3a  20 68 74 74 70 73 3a 2f   ocation
0090  2f 68 6f 6d 65 2e 69 69  74 64 2e 61 63 2e 69 6e   /home.i
00a0  2f 0d 0a 43 6f 6e 74 65  6e 74 2d 4c 65 6e 67 74   /··Cont
00b0  68 3a 20 32 30 38 0d 0a  4b 65 65 70 2d 41 6c 69   h: 208·
00c0  76 65 3a 20 74 69 6d 65  6f 75 74 3d 35 2c 20 6d   ve: tim
00d0  61 78 3d 35 30 30 0d 0a  43 6f 6e 6e 65 63 74 69   ax=500·
00e0  6f 6e 3a 20 4b 65 65 70  2d 41 6c 69 76 65 0d 0a   on: Kee
00f0  43 6f 6e 74 65 6e 74 2d  54 79 70 65 3a 20 74 65   Content
0100  78 74 2f 68 74 6d 6c 3b  20 63 68 61 72 73 65 74   xt/html
```

Hypertext Transfer Protocol: Protocol | Packets: 12932 · Displayed: 2 (0.0%) · Dropped: 0 (0.0%) | Profile: Default

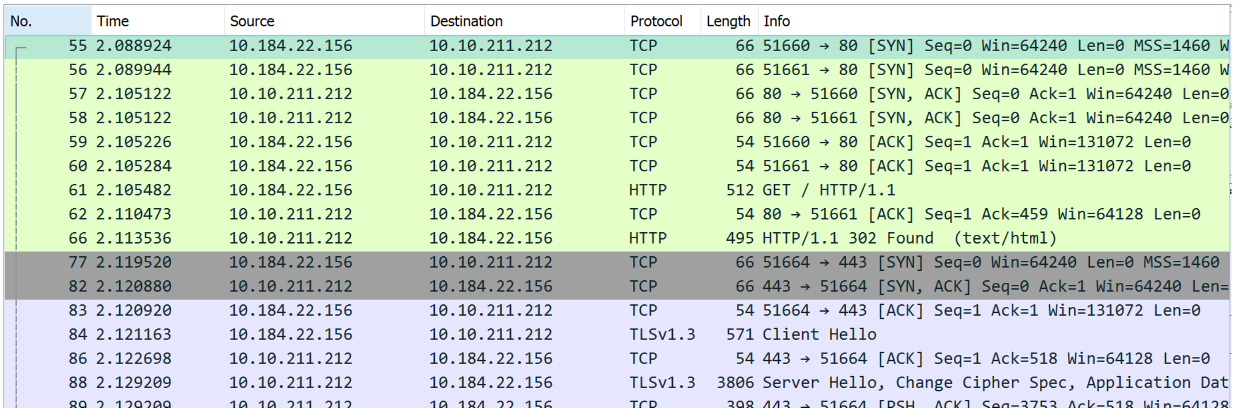
Figure 2: IITD HTTP

Observations

Only one request is observed. The request was for `http://www.iitd.ac.in/` and the response was `302 Found` indicating that the requested resource has been moved to a different URL. The text data tells us that ”The document has moved `https://home.iitd.ac.in/`”.

HTTPS traffic is encrypted using SSL/TLS, and the contents of the packets are scrambled and unreadable without the decryption keys. Hence, we are not able to find any html / css / js files for the webpage in the packets.

c. Next we applied the filter `((ip.src==10.184.22.156 && ip.dst==10.10.211.212) || (ip.src==10.10.211.212 && ip.dst==10.184.22.156)) && tcp` to get the TCP packets between the two hosts. The output is shown in Fig. 3



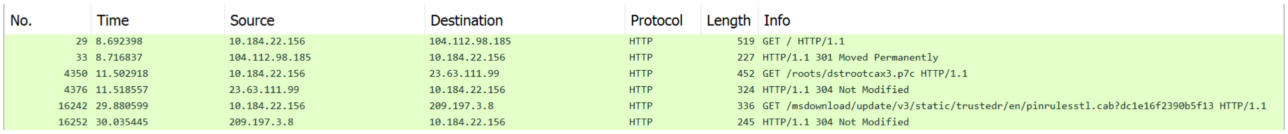
No.	Time	Source	Destination	Protocol	Length	Info
55	2.088924	10.184.22.156	10.10.211.212	TCP	66	51660 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 W
56	2.089944	10.184.22.156	10.10.211.212	TCP	66	51661 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 W
57	2.105122	10.10.211.212	10.184.22.156	TCP	66	80 → 51660 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0
58	2.105122	10.10.211.212	10.184.22.156	TCP	66	80 → 51661 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=0
59	2.105226	10.184.22.156	10.10.211.212	TCP	54	51660 → 80 [ACK] Seq=1 Ack=1 Win=131072 Len=0
60	2.105284	10.184.22.156	10.10.211.212	TCP	54	51661 → 80 [ACK] Seq=1 Ack=1 Win=131072 Len=0
61	2.105482	10.184.22.156	10.10.211.212	HTTP	512	GET / HTTP/1.1
62	2.110473	10.10.211.212	10.184.22.156	TCP	54	80 → 51661 [ACK] Seq=1 Ack=459 Win=64128 Len=0
66	2.113536	10.10.211.212	10.184.22.156	HTTP	495	HTTP/1.1 302 Found (text/html)
77	2.119520	10.184.22.156	10.10.211.212	TCP	66	51664 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460
82	2.120880	10.10.211.212	10.184.22.156	TCP	66	443 → 51664 [SYN, ACK] Seq=0 Ack=1 Win=64240 Len=
83	2.120920	10.184.22.156	10.10.211.212	TCP	54	51664 → 443 [ACK] Seq=1 Ack=1 Win=131072 Len=0
84	2.121163	10.184.22.156	10.10.211.212	TLSv1.3	571	Client Hello
86	2.122698	10.10.211.212	10.184.22.156	TCP	54	443 → 51664 [ACK] Seq=1 Ack=518 Win=64128 Len=0
88	2.129209	10.10.211.212	10.184.22.156	TLSv1.3	3806	Server Hello, Change Cipher Spec, Application Dat
89	2.129209	10.10.211.212	10.184.22.156	TCP	398	443 → 51664 [PSH, ACK] Seq=3753 Ack=518 Win=64128

Figure 3: IITD TCP

Observations

Total 9 connections were opened. Of these 2 were `http` and 7 were `https`, as identified by their port number (80 for `http` and 443 for `https`). Thus, for the `http` request in part (b), we have 2 corresponding tcp connections.

d. On running a `http` filter on `indianexpress.com`, we received the output Fig. 4



No.	Time	Source	Destination	Protocol	Length	Info
29	8.692398	10.184.22.156	104.112.98.185	HTTP	519	GET / HTTP/1.1
33	8.716837	104.112.98.185	10.184.22.156	HTTP	227	HTTP/1.1 301 Moved Permanently
4350	11.502918	10.184.22.156	23.63.111.99	HTTP	452	GET /roots/dstrootcax3.p7c HTTP/1.1
4376	11.518557	23.63.111.99	10.184.22.156	HTTP	324	HTTP/1.1 304 Not Modified
16242	29.880599	10.184.22.156	209.197.3.8	HTTP	336	GET /msdownload/update/v3/static/trustedr/en/pinrulesstl.cab?dc1e16f2390b5f13 HTTP/1.1
16252	30.035445	209.197.3.8	10.184.22.156	HTTP	245	HTTP/1.1 304 Not Modified

Figure 4: Indian Express

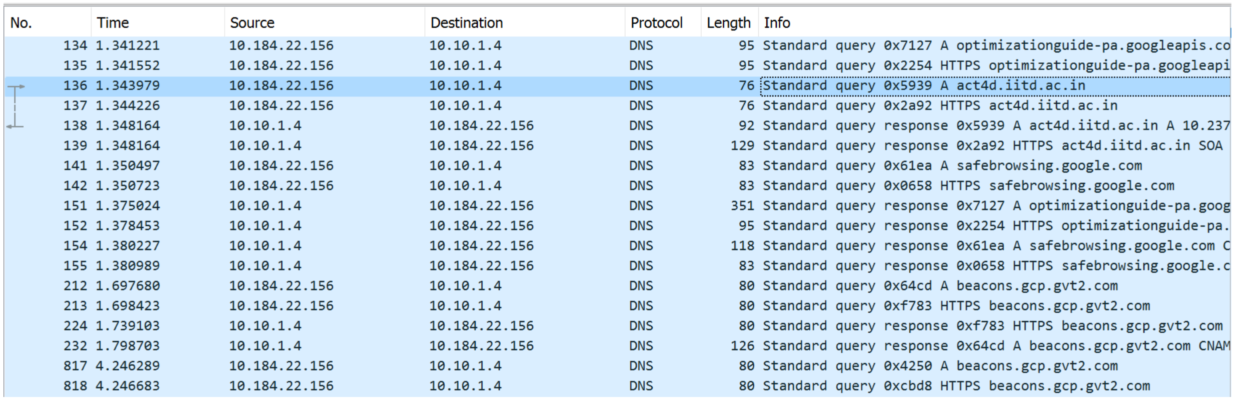
Observations

As mentioned above, HTTPS traffic is encrypted using SSL/TLS, and the contents of the packets are unreadable without the decryption keys. Hence, we see a very sparse http traffic and are not able to find any html/css/js files being transferred for the webpage in the packets. Wireshark can capture the encrypted packets, but the payload will appear as encrypted gibberish.

Similarly, we ran the filters for `act4d.iitd.ac.in` and got the outputs Fig. 5 Fig. 6 Fig. 7:

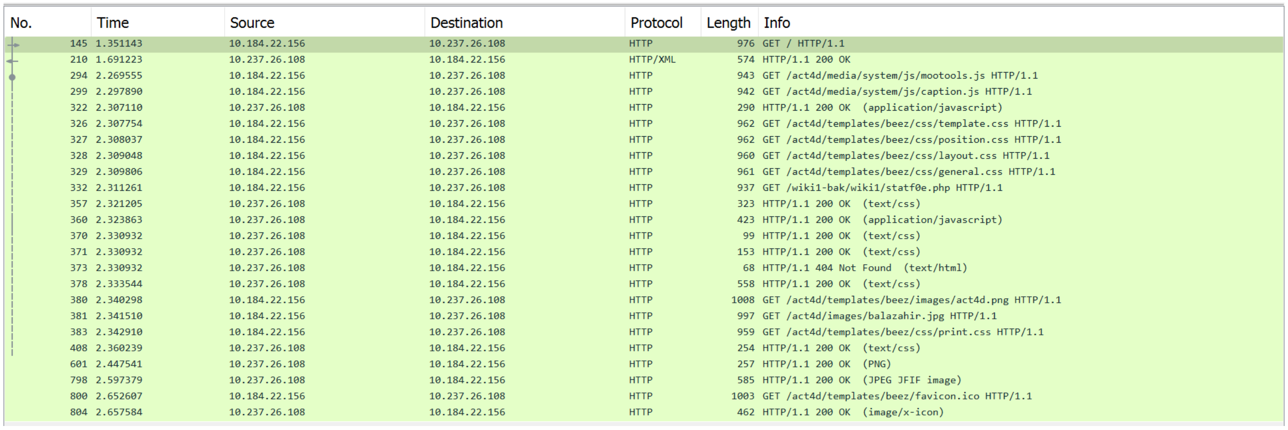
Observations

- On applying a `http` filter, only one request is observed as shown in Fig. 2. Similarly for the `indianexpress.com` website, very few `http` requests are observed.
-



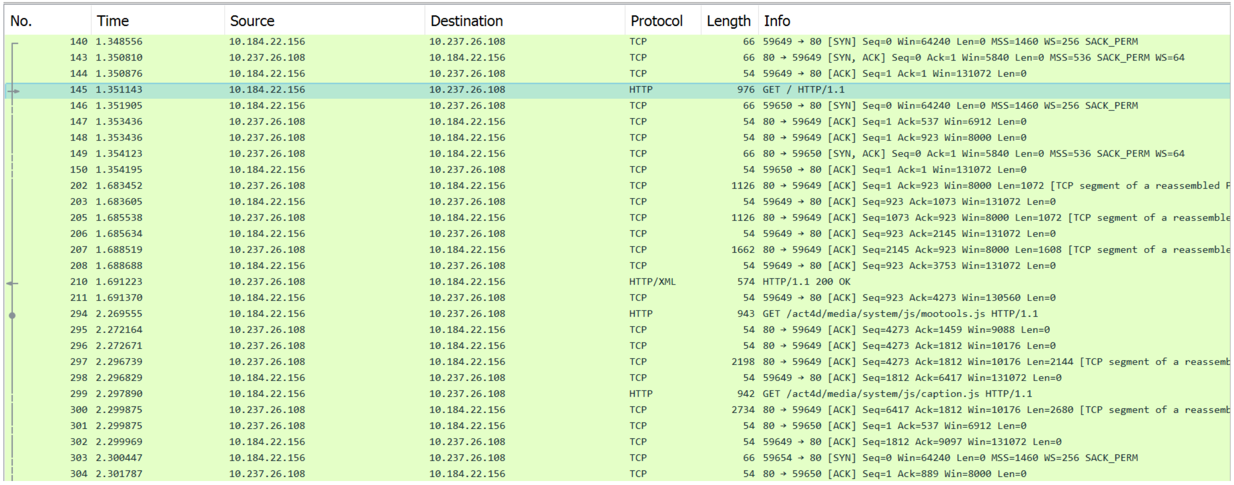
No.	Time	Source	Destination	Protocol	Length	Info
134	1.341221	10.184.22.156	10.10.1.4	DNS	95	Standard query 0x7127 A optimizationguide-pa.googleapis.co
135	1.341552	10.184.22.156	10.10.1.4	DNS	95	Standard query 0x2254 HTTPS optimizationguide-pa.googleapi
136	1.343979	10.184.22.156	10.10.1.4	DNS	76	Standard query 0x5939 A act4d.iitd.ac.in
137	1.344226	10.184.22.156	10.10.1.4	DNS	76	Standard query 0x2a92 HTTPS act4d.iitd.ac.in
138	1.348164	10.10.1.4	10.184.22.156	DNS	92	Standard query response 0x5939 A act4d.iitd.ac.in A 10.237
139	1.348164	10.10.1.4	10.184.22.156	DNS	129	Standard query response 0x2a92 HTTPS act4d.iitd.ac.in SOA
141	1.350497	10.184.22.156	10.10.1.4	DNS	83	Standard query 0x61ea A safebrowsing.google.com
142	1.350723	10.184.22.156	10.10.1.4	DNS	83	Standard query 0x0658 HTTPS safebrowsing.google.com
151	1.375024	10.10.1.4	10.184.22.156	DNS	351	Standard query response 0x7127 A optimizationguide-pa.goog
152	1.378453	10.10.1.4	10.184.22.156	DNS	95	Standard query response 0x2254 HTTPS optimizationguide-pa.
154	1.380227	10.10.1.4	10.184.22.156	DNS	118	Standard query response 0x61ea A safebrowsing.google.com C
155	1.380989	10.10.1.4	10.184.22.156	DNS	83	Standard query response 0x0658 HTTPS safebrowsing.google.c
212	1.697680	10.184.22.156	10.10.1.4	DNS	80	Standard query 0x64cd A beacons.gcp.gvt2.com
213	1.698423	10.184.22.156	10.10.1.4	DNS	80	Standard query 0xf783 HTTPS beacons.gcp.gvt2.com
224	1.739103	10.10.1.4	10.184.22.156	DNS	80	Standard query response 0xf783 HTTPS beacons.gcp.gvt2.com
232	1.798703	10.10.1.4	10.184.22.156	DNS	126	Standard query response 0x64cd A beacons.gcp.gvt2.com CNAM
817	4.246289	10.184.22.156	10.10.1.4	DNS	80	Standard query 0x4250 A beacons.gcp.gvt2.com
818	4.246683	10.184.22.156	10.10.1.4	DNS	80	Standard query 0xcbd8 HTTPS beacons.gcp.gvt2.com

Figure 5: ACT4D DNS



No.	Time	Source	Destination	Protocol	Length	Info
145	1.351143	10.184.22.156	10.237.26.108	HTTP	976	GET / HTTP/1.1
210	1.691223	10.237.26.108	10.184.22.156	HTTP/XML	574	HTTP/1.1 200 OK
294	2.269555	10.184.22.156	10.237.26.108	HTTP	943	GET /act4d/media/system/js/mootools.js HTTP/1.1
299	2.297890	10.184.22.156	10.237.26.108	HTTP	942	GET /act4d/media/system/js/caption.js HTTP/1.1
322	2.307110	10.237.26.108	10.184.22.156	HTTP	290	HTTP/1.1 200 OK (application/javascript)
326	2.307754	10.184.22.156	10.237.26.108	HTTP	962	GET /act4d/templates/beez/css/template.css HTTP/1.1
327	2.308037	10.184.22.156	10.237.26.108	HTTP	962	GET /act4d/templates/beez/css/position.css HTTP/1.1
328	2.309048	10.184.22.156	10.237.26.108	HTTP	960	GET /act4d/templates/beez/css/layout.css HTTP/1.1
329	2.309806	10.184.22.156	10.237.26.108	HTTP	961	GET /act4d/templates/beez/css/general.css HTTP/1.1
332	2.311261	10.184.22.156	10.237.26.108	HTTP	937	GET /wiki1-bak/wiki1/statf0e.php HTTP/1.1
357	2.321205	10.237.26.108	10.184.22.156	HTTP	323	HTTP/1.1 200 OK (text/css)
360	2.323863	10.237.26.108	10.184.22.156	HTTP	423	HTTP/1.1 200 OK (application/javascript)
370	2.330932	10.237.26.108	10.184.22.156	HTTP	99	HTTP/1.1 200 OK (text/css)
371	2.330932	10.237.26.108	10.184.22.156	HTTP	153	HTTP/1.1 200 OK (text/css)
373	2.330932	10.237.26.108	10.184.22.156	HTTP	68	HTTP/1.1 404 Not Found (text/html)
378	2.333544	10.237.26.108	10.184.22.156	HTTP	558	HTTP/1.1 200 OK (text/css)
380	2.340298	10.184.22.156	10.237.26.108	HTTP	1008	GET /act4d/templates/beez/images/act4d.png HTTP/1.1
381	2.341510	10.184.22.156	10.237.26.108	HTTP	997	GET /act4d/images/balazahir.jpg HTTP/1.1
383	2.342910	10.184.22.156	10.237.26.108	HTTP	959	GET /act4d/templates/beez/css/print.css HTTP/1.1
408	2.360239	10.237.26.108	10.184.22.156	HTTP	254	HTTP/1.1 200 OK (text/css)
601	2.447541	10.237.26.108	10.184.22.156	HTTP	257	HTTP/1.1 200 OK (PNG)
798	2.597379	10.237.26.108	10.184.22.156	HTTP	585	HTTP/1.1 200 OK (JPEG JFIF image)
800	2.652607	10.184.22.156	10.237.26.108	HTTP	1003	GET /act4d/templates/beez/favicon.ico HTTP/1.1
804	2.657584	10.237.26.108	10.184.22.156	HTTP	462	HTTP/1.1 200 OK (image/x-icon)

Figure 6: ACT4D http



No.	Time	Source	Destination	Protocol	Length	Info
140	1.348556	10.184.22.156	10.237.26.108	TCP	66	59649 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
143	1.350810	10.237.26.108	10.184.22.156	TCP	66	80 → 59649 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=536 SACK_PERM WS=64
144	1.350876	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=1 Ack=1 Win=131072 Len=0
145	1.351143	10.184.22.156	10.237.26.108	HTTP	976	GET / HTTP/1.1
146	1.351905	10.184.22.156	10.237.26.108	TCP	66	59650 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
147	1.353436	10.237.26.108	10.184.22.156	TCP	54	80 → 59649 [ACK] Seq=1 Ack=537 Win=6912 Len=0
148	1.353436	10.237.26.108	10.184.22.156	TCP	54	80 → 59649 [ACK] Seq=1 Ack=923 Win=8000 Len=0
149	1.354123	10.237.26.108	10.184.22.156	TCP	66	80 → 59650 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=536 SACK_PERM WS=64
150	1.354195	10.184.22.156	10.237.26.108	TCP	54	59650 → 80 [ACK] Seq=1 Ack=1 Win=131072 Len=0
202	1.683452	10.237.26.108	10.184.22.156	TCP	1126	80 → 59649 [ACK] Seq=1 Ack=923 Win=8000 Len=1072 [TCP segment of a reassembled F
203	1.683605	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=923 Ack=1073 Win=131072 Len=0
205	1.685538	10.237.26.108	10.184.22.156	TCP	1126	80 → 59649 [ACK] Seq=1073 Ack=923 Win=8000 Len=1072 [TCP segment of a reassemble
206	1.685634	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=923 Ack=2145 Win=131072 Len=0
207	1.688519	10.237.26.108	10.184.22.156	TCP	1662	80 → 59649 [ACK] Seq=2145 Ack=923 Win=8000 Len=1608 [TCP segment of a reassemble
208	1.688688	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=923 Ack=3753 Win=131072 Len=0
210	1.691223	10.237.26.108	10.184.22.156	HTTP/XML	574	HTTP/1.1 200 OK
211	1.691370	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=923 Ack=4273 Win=130560 Len=0
294	2.269555	10.184.22.156	10.237.26.108	HTTP	943	GET /act4d/media/system/js/mootools.js HTTP/1.1
295	2.272164	10.237.26.108	10.184.22.156	TCP	54	80 → 59649 [ACK] Seq=4273 Ack=1459 Win=9088 Len=0
296	2.272671	10.237.26.108	10.184.22.156	TCP	54	80 → 59649 [ACK] Seq=4273 Ack=1812 Win=10176 Len=0
297	2.296739	10.237.26.108	10.184.22.156	TCP	2198	80 → 59649 [ACK] Seq=4273 Ack=1812 Win=10176 Len=2144 [TCP segment of a reassemb
298	2.296829	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=1812 Ack=6417 Win=131072 Len=0
299	2.297890	10.184.22.156	10.237.26.108	HTTP	942	GET /act4d/media/system/js/caption.js HTTP/1.1
300	2.299875	10.237.26.108	10.184.22.156	TCP	2734	80 → 59649 [ACK] Seq=6417 Ack=1812 Win=10176 Len=2680 [TCP segment of a reassemb
301	2.299875	10.237.26.108	10.184.22.156	TCP	54	80 → 59650 [ACK] Seq=1 Ack=537 Win=6912 Len=0
302	2.299969	10.184.22.156	10.237.26.108	TCP	54	59649 → 80 [ACK] Seq=1812 Ack=9097 Win=131072 Len=0
303	2.300447	10.184.22.156	10.237.26.108	TCP	66	59654 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
304	2.301787	10.237.26.108	10.184.22.156	TCP	54	80 → 59650 [ACK] Seq=1 Ack=889 Win=8000 Len=0

Figure 7: ACT4D TCP (filter `((ip.src==10.184.22.156 && ip.dst==10.237.26.108) || (ip.src==10.237.26.108 && ip.dst==10.184.22.156)) && tcp`)

§5. Appendix: Preparatory Tasks

Here, we provide information about the various tools available for network analysis

5.1. ifconfig/ipconfig

This is used to find the following for the network interfaces on the computer:

IP address An IP (Internet Protocol) address is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication. It serves two main purposes: identifying the host or network interface and providing the location of the host in the network. IP addresses can be either IPv4 (32-bit) or IPv6 (128-bit) and are written in a dotted-decimal format (e.g., `172.31.225.222` for IPv4 or `fe80::215:5dff:feeb:19f7` for IPv6).

Gateway A gateway, often referred to as a default gateway, is a network device (usually a router) that serves as an access point to other networks. It acts as an intermediary between devices within a local network and devices on other networks, including the internet. When a device on a local network wants to communicate with a device on another network, it sends the data to the gateway, which then forwards it to the appropriate destination.

Network mask A network mask, also known as a subnet mask, is used in conjunction with an IP address to determine the network portion and the host portion of the address. It is a binary pattern of bits that help divide an IP address into a network address and a host address. The network mask is typically represented in decimal format as four octets (e.g., `255.255.255.0` for IPv4). It is used in the process of subnetting to identify which part of the IP address identifies the network and which part identifies the individual host within that network.

Hardware address A hardware address, also known as a MAC (Media Access Control) address, is a unique identifier assigned to a network interface card (NIC) by its manufacturer. It is a 48-bit address expressed in hexadecimal format and is used to identify a specific device on a local network. Each NIC in the world has its own unique MAC address, allowing devices to communicate with each other at the data link layer of the networking model.

DNS server A DNS (Domain Name System) server translates human-readable domain names, like www.google.com, into IP addresses that machines can understand. When you enter a URL in a web browser or try to access any internet resource, your device sends a DNS query to a DNS server. The DNS server then looks up the corresponding IP address associated with the domain name and returns it to your device, allowing it to establish a connection to the desired resource.

Running `ifconfig` on our system connected to Wifi gives the following output:

```
root@IdeapadAB:~# ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
  inet 172.31.225.222  netmask 255.255.240.0  broadcast 172.31.239.255
  inet6 fe80::215:5dff:feeb:19f7  prefixlen 64  scopeid 0x20<link>
  ether 00:15:5d:eb:19:f7  txqueuelen 1000  (Ethernet)
  RX packets 149  bytes 20663 (20.6 KB)
  RX errors 0  dropped 0  overruns 0  frame 0
  TX packets 13  bytes 1006 (1.0 KB)
  TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
  inet 127.0.0.1  netmask 255.0.0.0
  inet6 ::1  prefixlen 128  scopeid 0x10<host>
  loop  txqueuelen 1000  (Local Loopback)
  RX packets 0  bytes 0 (0.0 B)
  RX errors 0  dropped 0  overruns 0  frame 0
  TX packets 0  bytes 0 (0.0 B)
  TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

And on running it on mobile hotspot, we get the following output:

```
root@IdeapadAB:~# ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 172.31.225.222  netmask 255.255.240.0  broadcast 172.31.239.255
    inet6 fe80::215:5dff:feeb:19f7  prefixlen 64  scopeid 0x20<link>
    ether 00:15:5d:eb:19:f7  txqueuelen 1000  (Ethernet)
    RX packets 1035  bytes 154375 (154.3 KB)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 103  bytes 8962 (8.9 KB)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1  netmask 255.0.0.0
    inet6 ::1  prefixlen 128  scopeid 0x10<host>
    loop  txqueuelen 1000  (Local Loopback)
    RX packets 0  bytes 0 (0.0 B)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 0  bytes 0 (0.0 B)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

`eth0` and `lo` are two different network interfaces. `eth0` is associated with the Ethernet connection and `lo` is the loopback(localhost) interface.

Here is a description of the various fields in the output:

flags A set of flags that indicate the status of the network interface.

mtu The Maximum Transmission Unit (MTU) is the size of the largest packet that can be transmitted over the network interface without being fragmented. The MTU is typically measured in bytes and can range from 64 to 65535 bytes.

inet The IPv4 address assigned to the network interface.

netmask The subnet mask for the IPv4 address. It helps determine the network and host portions of the IP address.

broadcast The broadcast address for the network. It is used to send data to all devices on the local network.

inet6 The IPv6 link-local address with a prefix length of 64 bits. IPv6 addresses are written in hexadecimal format and are longer than IPv4 addresses.

ether The unique hardware address (MAC address) of the network interface card.

txqueuelen The length of the transmit queue.

RX packets The number of received packets.

TX packets The number of transmitted packets.

RX errors The number of receive errors.

TX errors The number of transmit errors.

dropped The number of dropped packets due to errors.

overruns The number of packets that had data sent beyond their allowed length.

frame The number of packets with framing errors.

collisions The number of packet collisions (i.e., when two devices transmit data at the same time).

The IP address of the smartphone can be found by ”Settings→About phone→Status→IP address”

5.2. ping

This is used to discover if a particular IP address is online or not. For example, in the following code we are pinging www.google.com with packets of size 10 bytes and varying the TTL. We observe that as the TTL decreases, the packet doesn't reach the destination. This is because the TTL is decremented by 1 at each hop and when it reaches 0, the packet is dropped and an ICMP error message is sent back to the source. The source then knows that the packet didn't reach the destination and hence the destination is not online.

```
root@IdeapadAB:~# ping -c 3 -s 50 -t 10 www.google.com
PING www.google.com (142.250.195.4) 50(78) bytes of data.
58 bytes from del12s09-in-f4.1e100.net (142.250.195.4): icmp_seq=1 ttl=55 time=82.3 ms
58 bytes from del12s09-in-f4.1e100.net (142.250.195.4): icmp_seq=2 ttl=55 time=67.1 ms
58 bytes from del12s09-in-f4.1e100.net (142.250.195.4): icmp_seq=3 ttl=55 time=33.1 ms

--- www.google.com ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 33.130/60.834/82.271/20.545 ms
root@IdeapadAB:~# ping -c 3 -s 50 -t 9 www.google.com
PING www.google.com (142.250.195.4) 50(78) bytes of data.
From 142.251.52.213 (142.251.52.213) icmp_seq=1 Time to live exceeded
From 142.251.52.213 (142.251.52.213) icmp_seq=2 Time to live exceeded
From 142.251.52.213 (142.251.52.213) icmp_seq=3 Time to live exceeded

--- www.google.com ping statistics ---
3 packets transmitted, 0 received, +3 errors, 100% packet loss, time 2299ms
pipe 2
```

5.3. traceroute

This gives you the sequence of routers that a packet traverses to get to a particular destination.

```
C:\Users\Anish>tracert iitd.ac.in

Tracing route to iitd.ac.in [103.27.9.24]
over a maximum of 30 hops:

1     3 ms     4 ms     3 ms  192.168.107.98
2    39 ms    29 ms    21 ms  10.50.97.29
3    54 ms    46 ms    23 ms  10.50.97.223
4    58 ms    25 ms    34 ms  10.50.97.77
5   190 ms    30 ms    46 ms  dsl-ncr-dynamic-017.24.23.125.airtelbroadband.in [125.23.24.17]
6    63 ms    37 ms    27 ms  116.119.109.76
7    51 ms    38 ms    26 ms  49.44.187.164
8     *        *        *     Request timed out.
9     *        *        *     Request timed out.
10    38 ms    27 ms    27 ms  136.232.148.178
11     *        *        *     Request timed out.
12     *        *        *     Request timed out.
13     *        *        *     Request timed out.
14    53 ms    36 ms    60 ms  103.27.9.24
15    85 ms    35 ms    36 ms  103.27.9.24
16   148 ms   101 ms    86 ms  103.27.9.24

Trace complete.
```

5.4. nslookup

This command helps you communicate with DNS servers to get the IP address for a particular hostname.

5.5. `nmap`

This is a handy network diagnostics tool that you can use to discover which hosts are online in the network, and even try to infer what operating system the hosts might be running.

5.6. `wireshark`

This is a very useful tool to sniff packets on the wire (or wireless medium). Sniffed data is parsed by wireshark and presented in an easily readable format with details of the protocols being used at different layers.