1. • a.
Using the normal traceroute command all packets were getting blocked for many websites. Upon searching the internet, I found this post, https://serverfault.com/questions/153018/traceroute-does-not-work-output-is-but-network-is-fine/665759, suggesting that by default, traceroute uses UDP ports which might be blocked by some firewalls. It suggested to use the -I option which then would use ICMP (Internet Control Message Protocol). Less packet blocks were seen then.
For IIT Delhi website, still some packets were being dropped. So i tried amazon.in, flipkart.in and flipkart.com

traceroute to **www.amazon.in** (23.34.253.211), 30 hops max, 60 byte packets
1 192.168.1.1 (192.168.1.1) 2.175 ms 2.152 ms 2.147 ms
2 117.221.192.1 (117.221.192.1) 3.306 ms 3.301 ms 3.297 ms
3 218.248.175.97 (218.248.175.97) 3.454 ms 3.450 ms 3.446 ms
4 218.248.59.254 (218.248.59.254) 4.728 ms 4.724 ms 4.719 ms
5 a23-212-5-1.deploy.static.akamaitechnologies.com (23.212.5.1) 13.602 ms 13.974 ms 14.296 ms
6 a23-34-253-211.deploy.static.akamaitechnologies.com (23.34.253.211) 11.457 ms 13.307 ms 10.876 ms

traceroute to **www.flipkart.in** (184.168.131.241), 30 hops max, 60 byte packets
1 192.168.1.1 (192.168.1.1) 2.662 ms 2.616 ms 2.603 ms
2 117.221.192.1 (117.221.192.1) 3.933 ms 3.924 ms 3.915 ms
3 218.248.175.97 (218.248.175.97) 3.903 ms 3.893 ms 3.883 ms
4 218.248.175.102 (218.248.175.102) 4.182 ms 4.173 ms 5.921 ms
5 117.216.207.202 (117.216.207.202) 11.797 ms 11.788 ms 11.779 ms
6 * 117.216.207.203 (117.216.207.203) 12.092 ms 9.647 ms
7 115.110.78.173 (115.110.78.173) 43.476 ms 33.087 ms 33.020 ms
8 * * *
9 ix-ae-0-100.tcore1.mlv-mumbai.as6453.net (180.87.38.5) 35.343 ms 35.331 ms 35.320 ms
10 if-ae-2-2.tcore2.mlv-mumbai.as6453.net (180.87.38.2) 225.717 ms 225.707 ms 225.696 ms
11 * * *
12 if-ae-17-2.tcore1.ldn-london.as6453.net (80.231.130.130) 202.052 ms 202.047 ms 192.718 ms
13 * * *
14 * * *
15 ae6.ibrmb1205-02.phx3.bb.godaddy.com (4.28.83.74) 306.770 ms 306.757 ms 306.744 ms
16 * * *
17 148.72.32.11 (148.72.32.11) 299.600 ms 299.680 ms 299.656 ms
18 ip-184-168-0-117.ip.secureserver.net (184.168.0.117) 292.853 ms 307.150 ms 300.424 ms
19 ip-184-168-1-134.ip.secureserver.net (184.168.1.134) 300.338 ms 300.320 ms 307.571 ms
20 184.168.131.241 (184.168.131.241) 307.496 ms 307.479 ms 307.467 ms 21 ip-184-168-131-241.ip.secureserver.net (184.168.131.241) 306.466 ms 306.411 ms 306.398 ms

traceroute to **www.flipkart.com** (163.53.78.110), 30 hops max, 60 byte packets
1 192.168.1.1 (192.168.1.1) 2.555 ms 2.473 ms 2.458 ms
2 117.221.192.1 (117.221.192.1) 3.230 ms 3.761 ms 3.750 ms
3 218.248.175.97 (218.248.175.97) 3.735 ms 3.725 ms 3.714 ms
4 218.248.175.106 (218.248.175.106) 4.385 ms 4.465 ms 4.300 ms
5 117.216.207.202 (117.216.207.202) 9.820 ms 9.808 ms 9.796 ms
6 117.216.207.203 (117.216.207.203) 9.782 ms 11.223 ms 8.801 ms
7 * * *
8 * * *

9 * * *
10 * * *
11 * * *
12 163.53.78.110 (163.53.78.110) 52.544 ms 52.540 ms 52.042 ms

- b.
  Flipkart.com is hosted on Indian network (163.53.78.110) whereas on contrary Flipkart.in is hosted on godaddy server in US (184.168.131.241). Though typing flipkart.in directs one to flipkart.com.
  192.168.1.1 is the only private IP that I could find, corresponding to my netwotk.
  There is no node using Ipv4. We can enforce Ipv4 by giving -4 argrument to traceroute and -6 to enforce Ipv6.

- c.
  Ping command has a maximum value of 127992 bytes on my system. On running , ping -s 204800 www.amazon.in, I got an invalid argument error saying ping: invalid argument: '204800': out of range: 0 $\leq$ value $\leq$ 127992.

2. The python script is zipped along with the report

3. - a.

Source	www.iitd.ac.in	www.utah.edu	www.uct.ac.za	www.facebook.com	www.google.com
Laptop	13	34	16(last reachable (S.A. IP))	10	14
Canada (tera-byte.com)	16 (last reachable(Delhi I.P.))	25	20(last reachable (SA IP))	7	12
Germany(han.de)	12 (last reachable(Delhi IP))	29	14(last reachable(SA IP))	9	8

The number of hops between nodes of the same continent seem to be less than the number of hops between different continents, though it is not a hard and fast rule since hops between Canada server and utah.edu is more than that of iitd website. (though in IITD's case we have the last reachable node only)
The number of hops in Facebook is generally less than compared to Google. This can be due to the fact that Google has servers in US whereas Facebook has servers in many countries.

- b.
  The latencies are in ms.

Source	www.iitd.ac.in	www.utah.edu	www.uct.ac.za	www.facebook.com	www.google.com
Laptop	50.8	409.5	306.5 (last reachable)	9	21
Canada (tera-byte.com)	287.7 (last reachable)	50.9	260.3 (last reachable)	21.4	21.6
Germany(han.de)	155 (last reachable)	153.6	162.5 (last reachable)	6.9	4.5

The latencies are generally positively correlated to number of hops but this is not a compulsory rule since Canada and Utah have only around 50 ms latency even if the number of hops is higher. This can be attributed to the fact that some hops in case of iitd server connection might be transcontinental having very high latency due to higher distance to be covered.
Findings:
  - Facebook's Delhi server responded, thus the low latency.
  - Google's server was in USA, but so is utah's, but utah's hop and latency are both high, indicating google has some kind of its own network.
  - Interestingly, both facebbok and iitd's servers are in delhi but facebook's response is very fast. The distinction could not be reasoned because the iitd server connection went into ip addresses which didnt show up in the traceroute (* * *).

  - All the three IP addresses of the last reachable hop for the South Africa website were the same (154.114.124.1).

- c.

Source	www.iitd.ac.in	www.utah.edu	www.uct.ac.za	www.facebook.com	www.google.com
Laptop	103.27.9.24	155.98.186.21	137.158.154.230	157.240.198.35	216.58.199.164
Canada (tera-byte.com)	103.27.9.24	155.98.186.21	137.158.154.230	157.240.3.35	172.217.14.196
Germany(han.de)	103.27.9.24	155.98.186.21	137.158.154.230	157.240.27.35	172.217.21.196

  The educational sites are resolved to the same IP address.
  Google and Facebook have resolved to different IPs since they want the users from around the world to access the content as soon as possible. So they peer with regional ISPs.

- d.
  All the traceroutes were done from my laptop.
  I have taken the IPs of the google server since all were in US. Facebook's servers were in Ireland, Delhi and US, so maybe it might not give the right picture.
  The time when I did 'd' part is different from the first three. So some subtle changes are seen.

  traceroute to **216.58.199.164** (216.58.199.164), 30 hops max, 60 byte packets
  1 192.168.1.1 (192.168.1.1) 8.637 ms 6.212 ms 8.151 ms
  2 117.221.192.1 (117.221.192.1) 8.137 ms 8.126 ms 8.115 ms
  3 218.248.175.97 (218.248.175.97) 8.101 ms 8.091 ms 8.081 ms
  4 218.248.175.102 (218.248.175.102) 8.659 ms 9.562 ms 9.551 ms
  5 * * *
  6 117.216.207.203 (117.216.207.203) 14.873 ms 11.618 ms 9.219 ms
  7 **72.14.220.152** (72.14.220.152) 9.095 ms 9.030 ms 9.015 ms
  8 172.253.68.91 (172.253.68.91) 8.999 ms 9.112 ms 9.101 ms
  9 74.125.244.195 (74.125.244.195) 10.731 ms 10.722 ms 10.710 ms
  10 72.14.235.154 (72.14.235.154) 31.003 ms 30.992 ms 31.891 ms
  11 108.170.248.161 (108.170.248.161) 31.878 ms 31.867 ms 31.795 ms
  12 209.85.142.121 (209.85.142.121) 31.619 ms 33.414 ms 30.970 ms
  13 216.58.199.164 (216.58.199.164) 30.406 ms 30.396 ms 30.384 ms

  traceroute to **172.217.14.196** (172.217.14.196), 30 hops max, 60 byte packets
  1 192.168.1.1 (192.168.1.1) 3.339 ms 3.274 ms 4.209 ms
  2 117.221.192.1 (117.221.192.1) 4.256 ms 4.319 ms 4.522 ms
  3 218.248.175.97 (218.248.175.97) 4.565 ms 4.769 ms 4.758 ms
  4 218.248.107.174 (218.248.107.174) 5.456 ms 5.447 ms 14.172 ms
  5 117.216.207.202 (117.216.207.202) 10.185 ms 10.175 ms 10.164 ms
  6 117.216.207.203 (117.216.207.203) 11.125 ms 11.084 ms 8.587 ms
  7 **72.14.220.152** (72.14.220.152) 7.985 ms 7.932 ms 8.757 ms
  8 172.253.68.91 (172.253.68.91) 8.740 ms 8.791 ms 8.777 ms
  9 74.125.244.195 (74.125.244.195) 9.320 ms 9.304 ms 9.290 ms
  10 72.14.239.11 (72.14.239.11) 49.452 ms 49.435 ms 49.420 ms
  11 209.85.242.157 (209.85.242.157) 79.672 ms * *
  12 * 216.239.41.114 (216.239.41.114) 142.742 ms *
  13 * * *
  14 142.250.237.161 (142.250.237.161) 331.494 ms 331.484 ms 331.475 ms
  15 74.125.243.193 (74.125.243.193) 331.464 ms 297.947 ms 297.882 ms
  16 209.85.254.237 (209.85.254.237) 297.860 ms 297.849 ms 297.839 ms
  17 sea30s01-in-f4.1e100.net (172.217.14.196) 297.826 ms 297.815 ms 297.804 ms

  traceroute to **172.217.21.196** (172.217.21.196), 30 hops max, 60 byte packets
  1 192.168.1.1 (192.168.1.1) 5.604 ms 3.186 ms 4.898 ms

2 117.221.192.1 (117.221.192.1) 4.103 ms 4.094 ms 4.085 ms
3 218.248.175.97 (218.248.175.97) 5.097 ms 5.088 ms 5.080 ms
4 218.248.175.106 (218.248.175.106) 5.891 ms 5.881 ms 5.872 ms
5 117.216.207.202 (117.216.207.202) 10.762 ms 10.754 ms 10.745 ms
6 117.216.207.203 (117.216.207.203) 10.733 ms 10.437 ms 7.937 ms
7 **72.14.220.152** (72.14.220.152) 8.654 ms 8.609 ms 8.596 ms
8 172.253.68.91 (172.253.68.91) 8.583 ms 8.684 ms 8.675 ms
9 74.125.244.194 (74.125.244.194) 9.109 ms 9.100 ms 9.090 ms
10 72.14.239.59 (72.14.239.59) 48.397 ms 48.389 ms 48.379 ms
11 209.85.247.227 (209.85.247.227) 81.036 ms 81.027 ms 80.965 ms
12 66.249.94.140 (66.249.94.140) 144.979 ms 143.433 ms 143.414 ms
13 142.250.232.160 (142.250.232.160) 232.530 ms 232.527 ms 297.843 ms
14 108.170.235.196 (108.170.235.196) 297.791 ms 297.779 ms 297.770 ms
15 172.253.74.22 (172.253.74.22) 297.757 ms 297.748 ms 297.824 ms
16 142.250.235.26 (142.250.235.26) 297.726 ms 297.717 ms 297.794 ms
17 142.250.231.185 (142.250.231.185) 297.782 ms 297.774 ms 323.462 ms
18 216.239.59.1 (216.239.59.1) 323.375 ms 323.359 ms 323.347 ms
19 172.253.65.167 (172.253.65.167) 460.158 ms 457.679 ms 457.659 ms
20 209.85.245.230 (209.85.245.230) 457.643 ms 457.632 ms 457.621 ms
21 209.85.244.159 (209.85.244.159) 457.607 ms 457.597 ms 457.665 ms
22 209.85.240.112 (209.85.240.112) 457.651 ms 457.642 ms 457.631 ms
23 108.170.252.65 (108.170.252.65) 381.798 ms 381.734 ms 381.721 ms
24 108.170.235.247 (108.170.235.247) 382.481 ms 374.862 ms 373.214 ms
25 fra16s12-in-f196.1e100.net (172.217.21.196) 369.821 ms 369.813 ms 369.804 ms

Findings

- paths to different IPs of the same provider (Google) and same country take different paths.
- paths to IP addresses resolved as google.com from Canada and Germany traceroute servers are longer.
- The paths initially overlap (until 72.14.220.152), which is a Google IP, and then diverges. For Canada anf Germany IPs, the requests to circulate within the Google network until getting the requests.
- This **might** be due to Google giving less priority to India request on a IP which is resolved for Canada and Germany.

- e.
  - **India, Czech Republic, Germany** have peering for both Facebook and Google.
  - **Canada** might not have peering for both since the latencies and hops were high.
  - **Greece** does not have peering for Google. Below it the traceroute. The requests go into IP address of United Kingdom
    traceroute to www.google.com (216.58.205.68), 30 hops max, 60 byte packets
    1 cslab254.cs.aueb.gr (195.251.248.254) 0.272 ms 0.243 ms 0.202 ms
    2 aueb-2-gw.kolettir.access-link.grnet.gr (62.217.98.202) 1.273 ms 1.146 ms 1.239 ms
    3 grnet-ias-geant-gw.mx1.ath2.gr.geant.net (83.97.88.65) **(UK)** 2.375 ms 2.449 ms 2.406 ms
    4 ae0.mx2.ath.gr.geant.net (62.40.98.140) **(UK)** 27.786 ms 27.739 ms 27.775 ms
    5 ae2.mx1.mil2.it.geant.net (62.40.98.150) **(UK)** 27.732 ms 27.633 ms 26.841 ms
    6 72.14.203.32 (72.14.203.32) 27.204 ms 27.022 ms 28.347 ms
    7 108.170.245.65 (108.170.245.65) 28.087 ms 28.155 ms 27.191 ms
    8 216.239.42.9 (216.239.42.9) 29.326 ms 216.239.42.11 (216.239.42.11) 27.995 ms 216.239.42.9 (216.239.42.9) 29.341 ms
    9 mil04s25-in-f4.1e100.net (216.58.205.68) 28.327 ms 28.051 ms 28.239 ms

  - Similar is the scene for Facebook. It does not peer with Greek networks. Requests go to IP addreess of UK.

traceroute to www.facebook.com (31.13.84.36), 30 hops max, 60 byte packets
1 cslab254.cs.aueb.gr (195.251.248.254) 0.166 ms 0.153 ms 0.138 ms
2 aueb-2-gw.kolettir.access-link.grnet.gr (62.217.98.202) 1.068 ms 1.128 ms 1.211 ms
3 grnet-ias-geant-gw.mx1.ath2.gr.geant.net (83.97.88.65) 1.975 ms 1.972 ms 1.936 ms
4 ae0.mx1.vie.at.geant.net (62.40.98.147) **(UK)** 30.968 ms 29.651 ms 29.643 ms
5 ae22.pr04.vie1.tfbnw.net (103.4.98.46) 32.873 ms 76.312 ms 32.831 ms
6 po104.psw04.vie1.tfbnw.net (31.13.29.3) 29.560 ms po104.psw02.vie1.tfbnw.net (31.13.28.25) 29.655 ms
po104.psw01.vie1.tfbnw.net (31.13.27.197) 30.665 ms 7 157.240.38.177 (157.240.38.177) 28.415 ms 157.240.38.155 (157.240.38.155) 29.670 ms 173.252.67.171 (173.252.67.171) 29.367 ms
8 edge-star-mini-shv-01-vie1.facebook.com (31.13.84.36) 29.497 ms 28.178 ms 28.326 ms