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Lab 2: Basic Network Utilities

This lab introduces some basic network monitoring/analysis tools. There are a few exercises along the way. You should write up answers to the ***ping*** and ***traceroute*** exercises and turn them in the next lab. (You should try out each tool, whether it is needed for an exercise or not!).

Prerequisite: Basic understanding of command line utilities of Linux Operating system.

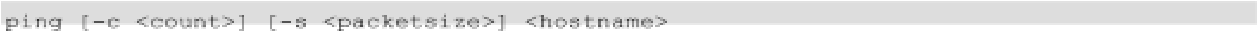
Aim: To study basic computer networking commands such as ping,traceroute,whois,netstat.

Some Basic command line Networking utilities

Start with a few of the most basic command line tools. These commands are available on Unix, including Linux (and the first two, at least, are also for Windows). Some parameters or options might differ on different operating systems. Remember that you can use man <command> to get information about a command and its options.

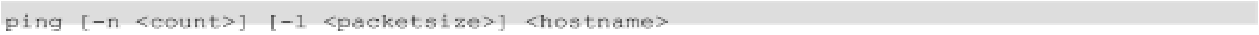
ping — The command ping <host> sends a series of packets and expects to receive a response to each packet. When a return packet is received, ping reports the round trip time (the time between sending the packet and receiving the response). Some routers and firewalls block ping requests, so you might get no response at all. Ping can be used to check whether a computer is up and running, to measure network delay time, and to check for dropped packets indicating network congestion. Note that <host> can be either a domain name or an IP address. By default, ping will send a packet every second indefinitely; stop it with Control-C

Network latency, specifically round trip time (RTT), can be measured using `ping`, which sends ICMP packets. The syntax for the command in Linux or Mac OS is:



```
ping [-c <count>] [-s <packetsize>] <hostname>
```

The syntax in Windows is:



```
ping [-n <count>] [-l <packetsize>] <hostname>
```

The default number of ICMP packets to send is either infinite (in Linux and Mac OS) or 4 (in Windows). The default packet size is either 64 bytes (in Linux) or 32 bytes (in Windows). You can specify either a hostname (e.g., `spit.ac.in`) or an IP address.

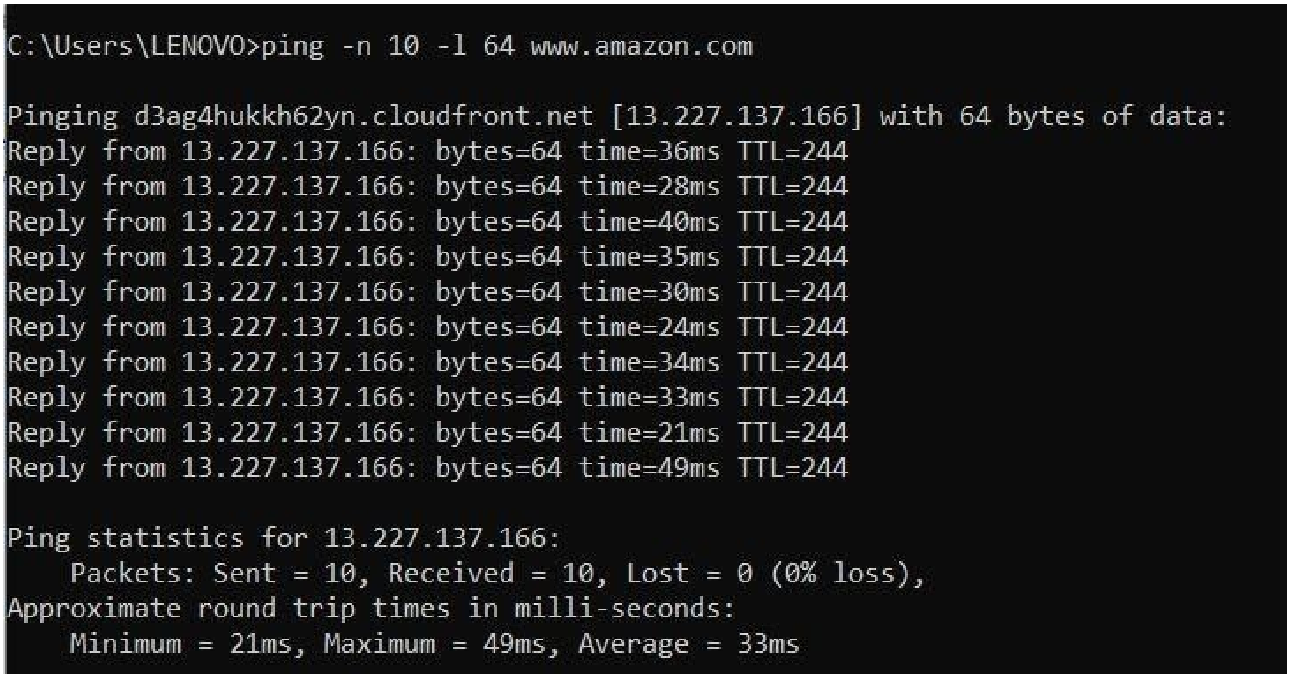
To save the output from `ping` to a file, include a greater than symbol and a file name at the end of the command. For example:

```
ping -c 10 google.com > ping_c10_s64_google.log
```

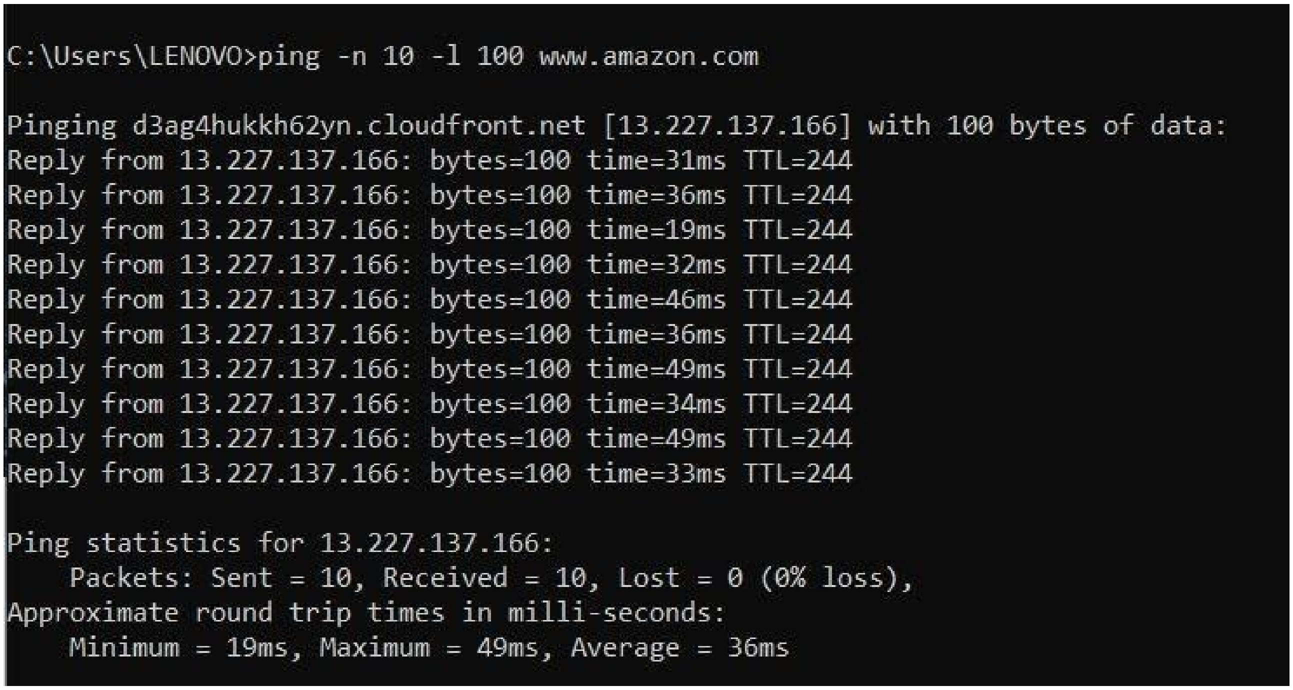
EXPERIMENTS WITH PING

1. Ping the any hosts 10 times (i.e., packet count is 10) with a packet size of 64 bytes, 100 bytes, 500 bytes, 1000 bytes, 1400 bytes

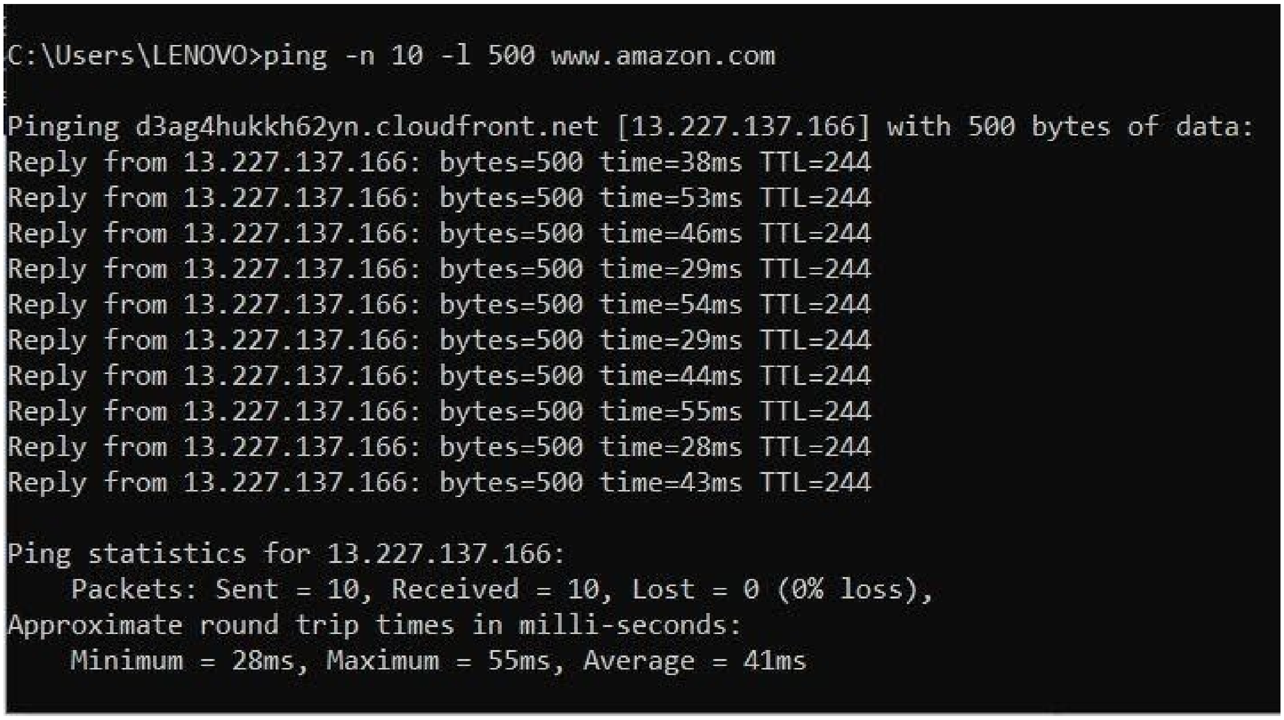
   Ans:



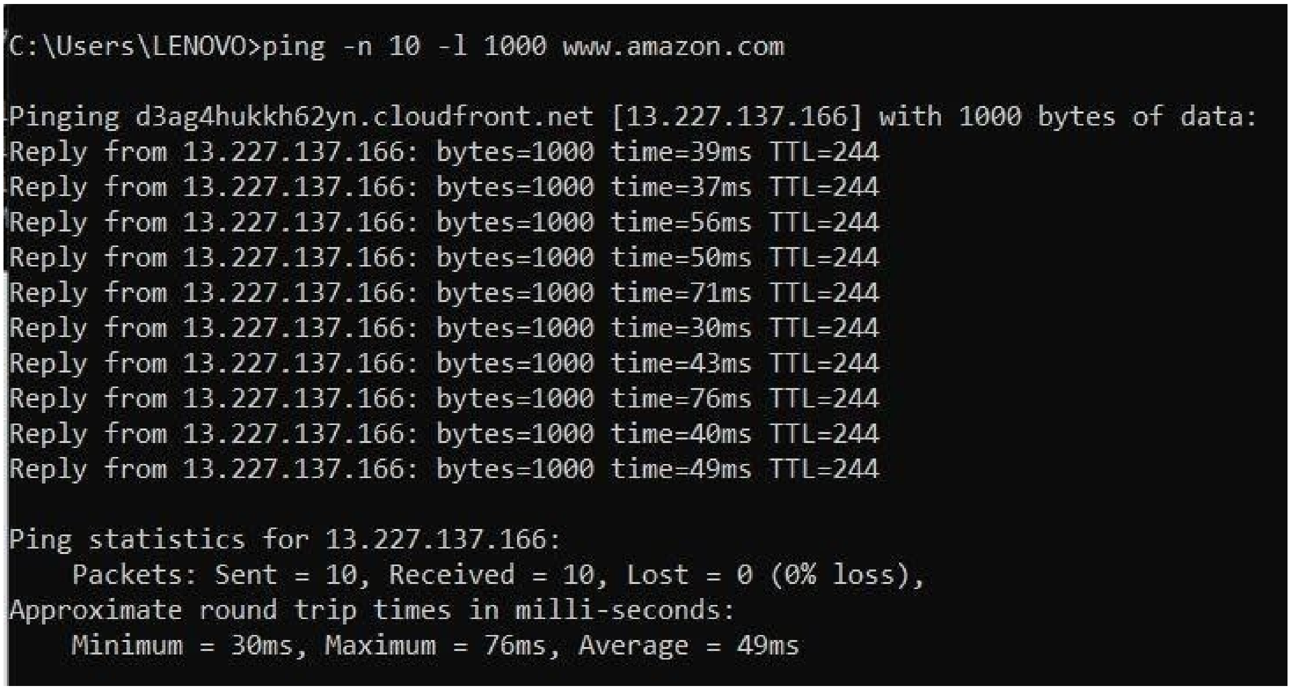
```
C:\Users\LENOVO>ping -n 10 -l 64 www.amazon.com

Pinging d3ag4hukkh62yn.cloudfront.net [13.227.137.166] with 64 bytes of data:
Reply from 13.227.137.166: bytes=64 time=36ms TTL=244
Reply from 13.227.137.166: bytes=64 time=28ms TTL=244
Reply from 13.227.137.166: bytes=64 time=40ms TTL=244
Reply from 13.227.137.166: bytes=64 time=35ms TTL=244
Reply from 13.227.137.166: bytes=64 time=30ms TTL=244
Reply from 13.227.137.166: bytes=64 time=24ms TTL=244
Reply from 13.227.137.166: bytes=64 time=34ms TTL=244
Reply from 13.227.137.166: bytes=64 time=33ms TTL=244
Reply from 13.227.137.166: bytes=64 time=21ms TTL=244
Reply from 13.227.137.166: bytes=64 time=49ms TTL=244

Ping statistics for 13.227.137.166:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 21ms, Maximum = 49ms, Average = 33ms
```



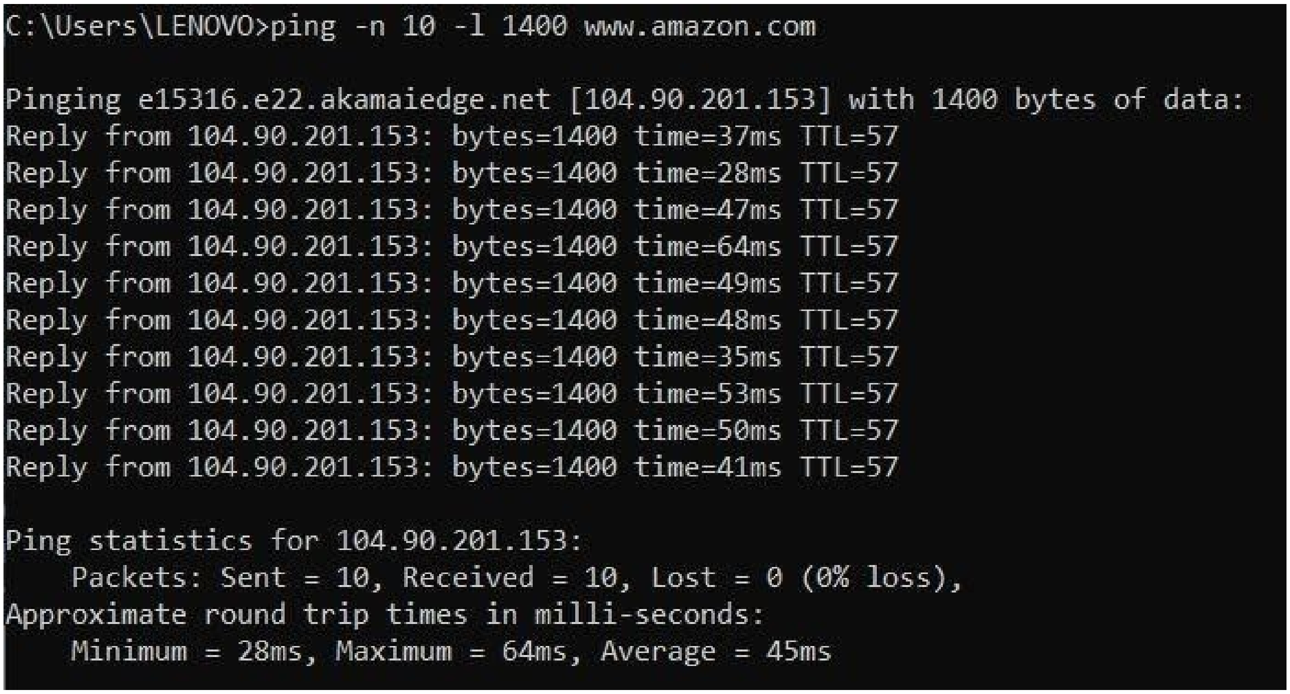
```
C:\Users\LENOVO>ping -n 10 -l 100 www.amazon.com

Pinging d3ag4hukkh62yn.cloudfront.net [13.227.137.166] with 100 bytes of data:
Reply from 13.227.137.166: bytes=100 time=31ms TTL=244
Reply from 13.227.137.166: bytes=100 time=36ms TTL=244
Reply from 13.227.137.166: bytes=100 time=19ms TTL=244
Reply from 13.227.137.166: bytes=100 time=32ms TTL=244
Reply from 13.227.137.166: bytes=100 time=46ms TTL=244
Reply from 13.227.137.166: bytes=100 time=36ms TTL=244
Reply from 13.227.137.166: bytes=100 time=49ms TTL=244
Reply from 13.227.137.166: bytes=100 time=34ms TTL=244
Reply from 13.227.137.166: bytes=100 time=49ms TTL=244
Reply from 13.227.137.166: bytes=100 time=33ms TTL=244

Ping statistics for 13.227.137.166:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 19ms, Maximum = 49ms, Average = 36ms
```



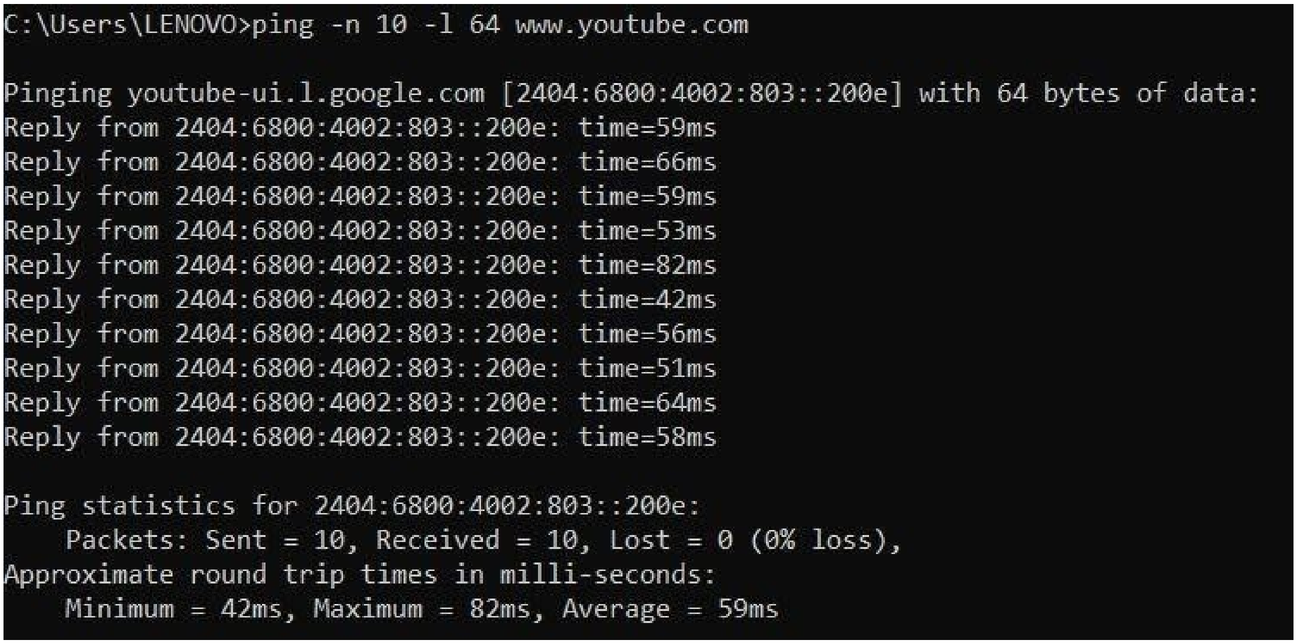
```
C:\Users\LENOVO>ping -n 10 -l 500 www.amazon.com

Pinging d3ag4hukkh62yn.cloudfront.net [13.227.137.166] with 500 bytes of data:
Reply from 13.227.137.166: bytes=500 time=38ms TTL=244
Reply from 13.227.137.166: bytes=500 time=53ms TTL=244
Reply from 13.227.137.166: bytes=500 time=46ms TTL=244
Reply from 13.227.137.166: bytes=500 time=29ms TTL=244
Reply from 13.227.137.166: bytes=500 time=54ms TTL=244
Reply from 13.227.137.166: bytes=500 time=29ms TTL=244
Reply from 13.227.137.166: bytes=500 time=44ms TTL=244
Reply from 13.227.137.166: bytes=500 time=55ms TTL=244
Reply from 13.227.137.166: bytes=500 time=28ms TTL=244
Reply from 13.227.137.166: bytes=500 time=43ms TTL=244

Ping statistics for 13.227.137.166:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 28ms, Maximum = 55ms, Average = 41ms
```



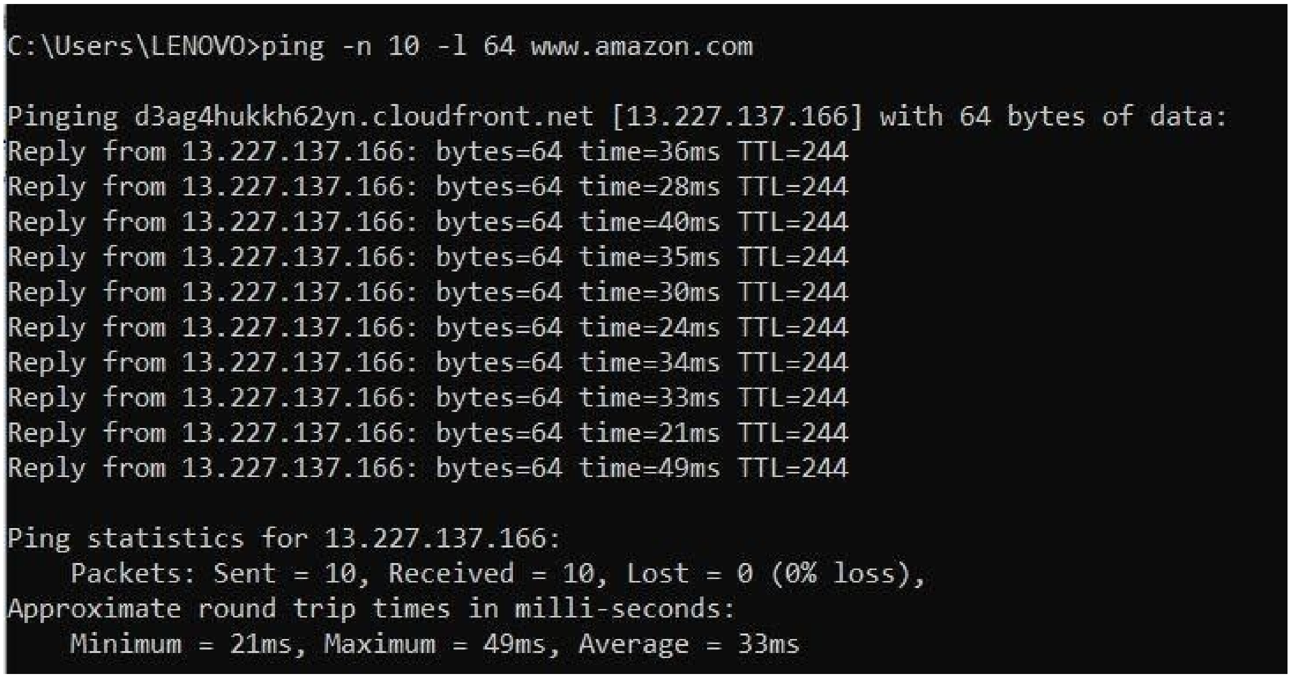
```
C:\Users\LENOVO>ping -n 10 -l 1000 www.amazon.com

Pinging d3ag4hukkh62yn.cloudfront.net [13.227.137.166] with 1000 bytes of data:
Reply from 13.227.137.166: bytes=1000 time=39ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=37ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=56ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=50ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=71ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=30ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=43ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=76ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=40ms TTL=244
Reply from 13.227.137.166: bytes=1000 time=49ms TTL=244

Ping statistics for 13.227.137.166:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 30ms, Maximum = 76ms, Average = 49ms
```



```
C:\Users\LENOVO>ping -n 10 -l 1400 www.amazon.com

Pinging e15316.e22.akamaiedge.net [104.90.201.153] with 1400 bytes of data:
Reply from 104.90.201.153: bytes=1400 time=37ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=28ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=47ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=64ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=49ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=48ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=35ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=53ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=50ms TTL=57
Reply from 104.90.201.153: bytes=1400 time=41ms TTL=57

Ping statistics for 104.90.201.153:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 28ms, Maximum = 64ms, Average = 45ms
```



```
C:\Users\LENOVO>ping -n 10 -l 64 www.youtube.com

Pinging youtube-ui.l.google.com [2404:6800:4002:803::200e] with 64 bytes of data:
Reply from 2404:6800:4002:803::200e: time=59ms
Reply from 2404:6800:4002:803::200e: time=66ms
Reply from 2404:6800:4002:803::200e: time=59ms
Reply from 2404:6800:4002:803::200e: time=53ms
Reply from 2404:6800:4002:803::200e: time=82ms
Reply from 2404:6800:4002:803::200e: time=42ms
Reply from 2404:6800:4002:803::200e: time=56ms
Reply from 2404:6800:4002:803::200e: time=51ms
Reply from 2404:6800:4002:803::200e: time=64ms
Reply from 2404:6800:4002:803::200e: time=58ms

Ping statistics for 2404:6800:4002:803::200e:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 42ms, Maximum = 82ms, Average = 59ms
```



```
C:\Users\LENOVO>ping -n 10 -l 64 www.amazon.com

Pinging d3ag4hukkh62yn.cloudfront.net [13.227.137.166] with 64 bytes of data:
Reply from 13.227.137.166: bytes=64 time=36ms TTL=244
Reply from 13.227.137.166: bytes=64 time=28ms TTL=244
Reply from 13.227.137.166: bytes=64 time=40ms TTL=244
Reply from 13.227.137.166: bytes=64 time=35ms TTL=244
Reply from 13.227.137.166: bytes=64 time=30ms TTL=244
Reply from 13.227.137.166: bytes=64 time=24ms TTL=244
Reply from 13.227.137.166: bytes=64 time=34ms TTL=244
Reply from 13.227.137.166: bytes=64 time=33ms TTL=244
Reply from 13.227.137.166: bytes=64 time=21ms TTL=244
Reply from 13.227.137.166: bytes=64 time=49ms TTL=244

Ping statistics for 13.227.137.166:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 21ms, Maximum = 49ms, Average = 33ms
```

QUESTIONS ABOUT LATENCY

Now look at the results you gathered and answer the following questions about latency. Store your answers in a file named `ping.txt`.

1. Does the average RTT vary between different hosts? What aspects of latency (transmit, propagation, and queueing delay) might impact this and why?

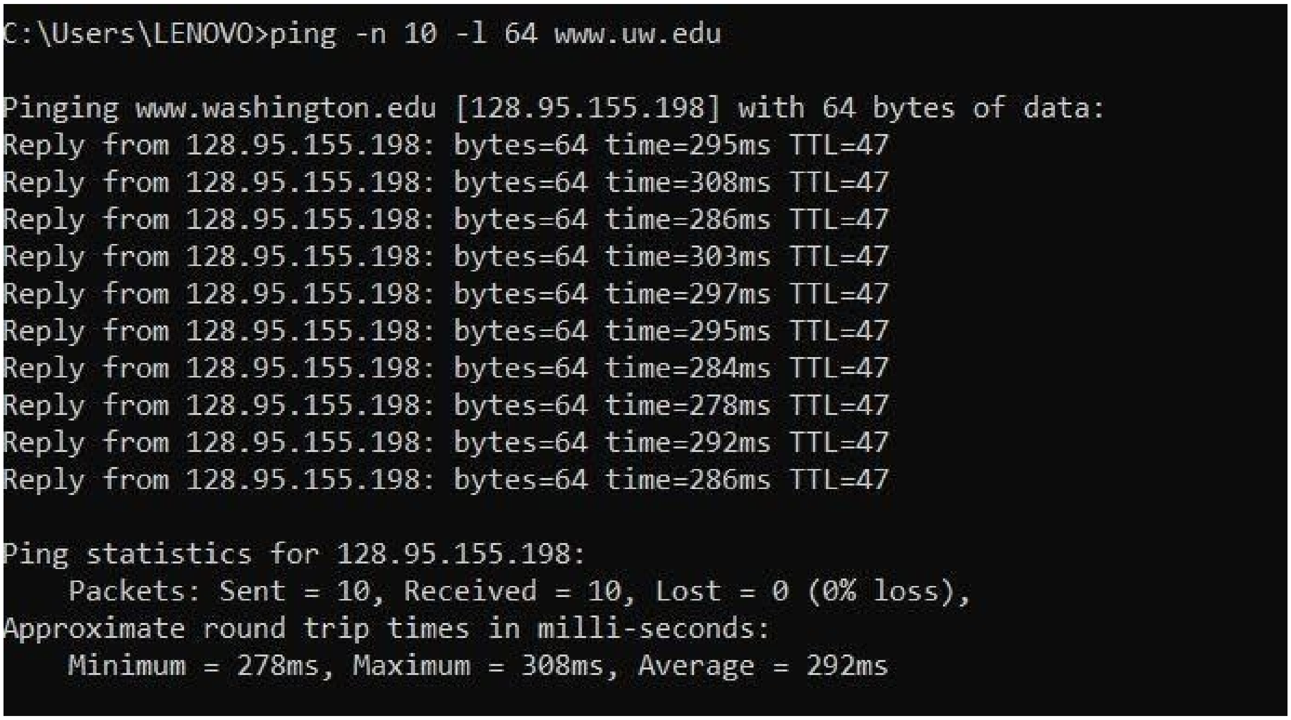
   - We can conclude from the output that average RRT varies between different hosts. Propagation delay might impact this because Propagation delay is the time it takes a bit to propagate from one router to the next.If the distance between the routers is increased and where the server is located, it will take longer time to propagate, that is, there would be more propagation delay.

   - Propagation delay is usually the dominant component in RTT. It ranges from a few milliseconds to hundreds of milliseconds depending on whether the endpoints are separated by a few kilometers or by an entire ocean.
   - The round trip time(RTT) can also be influenced by:
   - Distance – The length a signal has to travel correlates with the time taken for a request to reach a server and a response to reach a browser.
   - Transmission medium – The medium used to route a signal (e.g., copper wire, fiber optic cables) can impact how quickly a request is received by a server and routed back to a user.
   - Number of network hops – Intermediate routers or servers take time to process a signal, increasing RTT. The more hops a signal has to travel through, the higher the RTT.
   - Traffic levels – RTT typically increases when a network is congested with high levels of traffic. Conversely, low traffic times can result in decreased RTT.
   - Server response time – The time taken for a target server to respond to a request depends on its processing capacity, the number of requests being handled and the nature of the request (i.e., how much server-side work is required). A longer server response time increases RTT.
   -

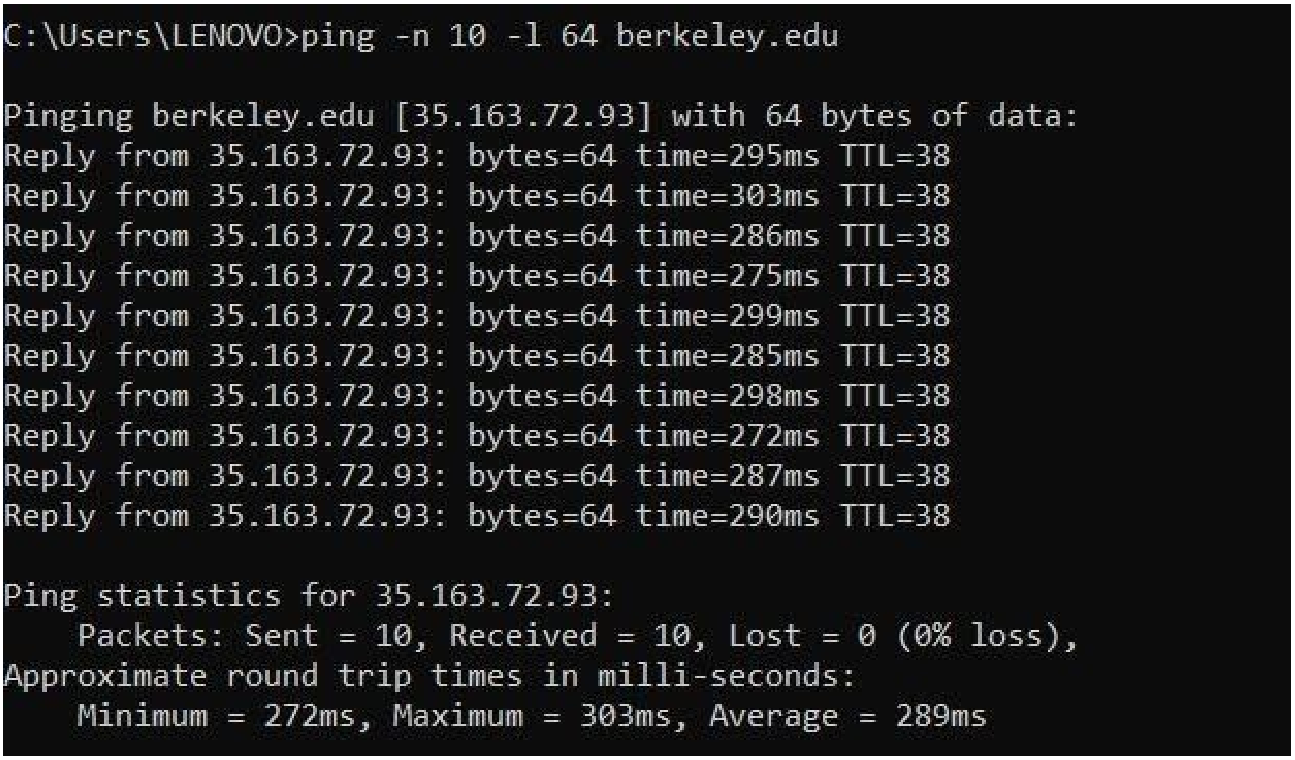
2. Does the average RTT vary with different packet sizes? What aspects of latency (transmit, propagation, and queueing delay) might impact this and why?

   - RTT increases with increase in packet size,on performing experiments we can observe and get the same results.
   - Transmission delay is the time taken to transmit a packet size and bandwidth.Since we are using different packet size RTT for different packet sizes will be impacted because of transmission delay.

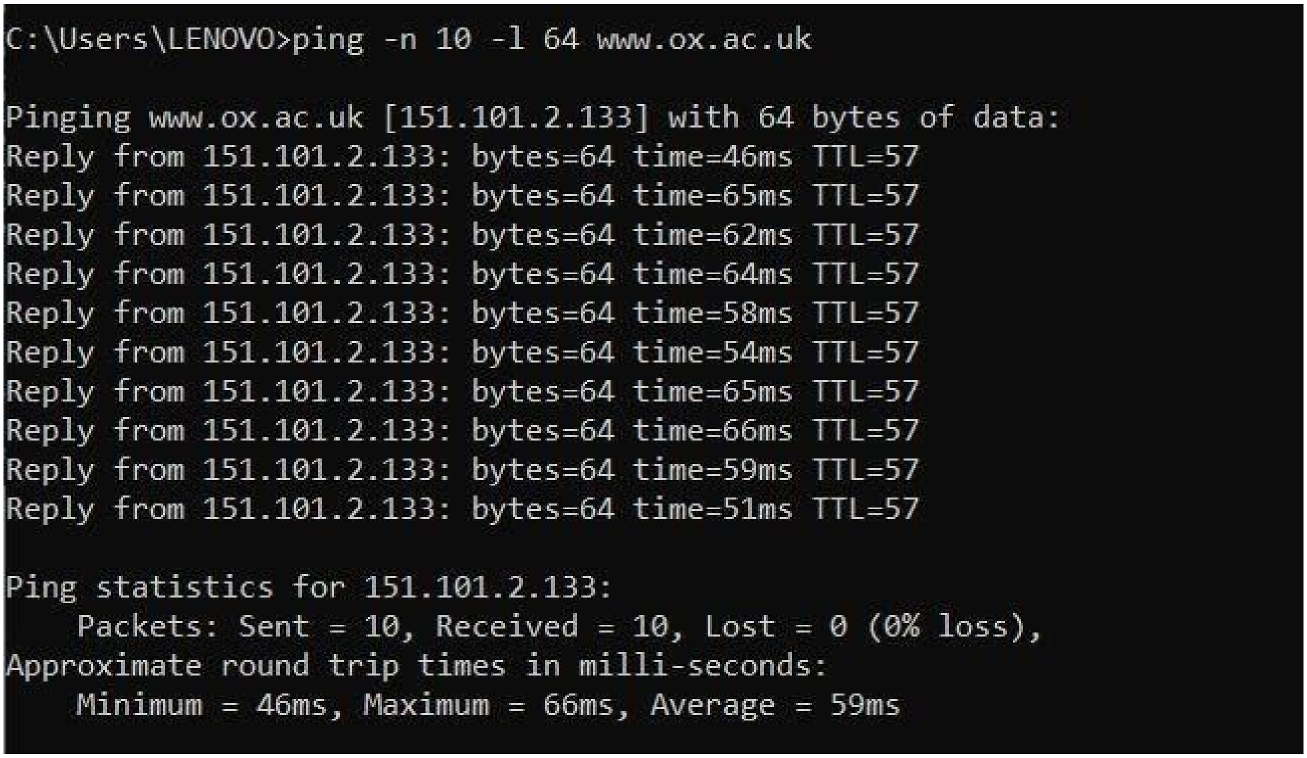
<u>Exercise 1</u>: Experiment with ping to find the round trip times to a variety of destinations. Write up any interesting observations, including in particular how the round trip time compares to the physical distance. Here are a few places from who to get replies: www.uw.edu, www.cornell.edu, berkeley.edu, www.uchicago.edu, www.ox.ac.uk (England), www.u-tokyo.ac.jp (Japan).



```
C:\Users\LENOVO>ping -n 10 -l 64 www.uw.edu

Pinging www.washington.edu [128.95.155.198] with 64 bytes of data:
Reply from 128.95.155.198: bytes=64 time=295ms TTL=47
Reply from 128.95.155.198: bytes=64 time=308ms TTL=47
Reply from 128.95.155.198: bytes=64 time=286ms TTL=47
Reply from 128.95.155.198: bytes=64 time=303ms TTL=47
Reply from 128.95.155.198: bytes=64 time=297ms TTL=47
Reply from 128.95.155.198: bytes=64 time=295ms TTL=47
Reply from 128.95.155.198: bytes=64 time=284ms TTL=47
Reply from 128.95.155.198: bytes=64 time=278ms TTL=47
Reply from 128.95.155.198: bytes=64 time=292ms TTL=47
Reply from 128.95.155.198: bytes=64 time=286ms TTL=47

Ping statistics for 128.95.155.198:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 278ms, Maximum = 308ms, Average = 292ms
```



```
C:\Users\LENOVO>ping -n 10 -l 64 berkeley.edu

Pinging berkeley.edu [35.163.72.93] with 64 bytes of data:
Reply from 35.163.72.93: bytes=64 time=295ms TTL=38
Reply from 35.163.72.93: bytes=64 time=303ms TTL=38
Reply from 35.163.72.93: bytes=64 time=286ms TTL=38
Reply from 35.163.72.93: bytes=64 time=275ms TTL=38
Reply from 35.163.72.93: bytes=64 time=299ms TTL=38
Reply from 35.163.72.93: bytes=64 time=285ms TTL=38
Reply from 35.163.72.93: bytes=64 time=298ms TTL=38
Reply from 35.163.72.93: bytes=64 time=272ms TTL=38
Reply from 35.163.72.93: bytes=64 time=287ms TTL=38
Reply from 35.163.72.93: bytes=64 time=290ms TTL=38

Ping statistics for 35.163.72.93:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 272ms, Maximum = 303ms, Average = 289ms
```

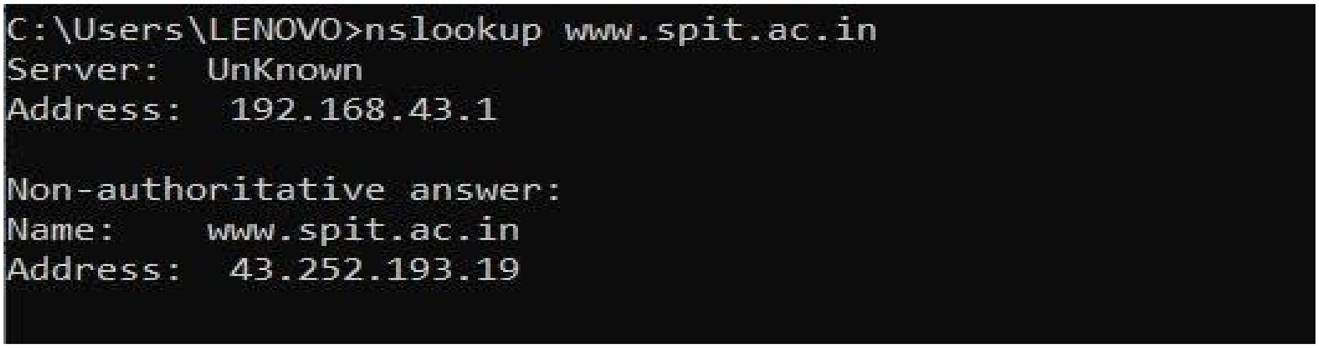


```
C:\Users\LENOVO>ping -n 10 -l 64 www.ox.ac.uk

Pinging www.ox.ac.uk [151.101.2.133] with 64 bytes of data:
Reply from 151.101.2.133: bytes=64 time=46ms TTL=57
Reply from 151.101.2.133: bytes=64 time=65ms TTL=57
Reply from 151.101.2.133: bytes=64 time=62ms TTL=57
Reply from 151.101.2.133: bytes=64 time=64ms TTL=57
Reply from 151.101.2.133: bytes=64 time=58ms TTL=57
Reply from 151.101.2.133: bytes=64 time=54ms TTL=57
Reply from 151.101.2.133: bytes=64 time=65ms TTL=57
Reply from 151.101.2.133: bytes=64 time=66ms TTL=57
Reply from 151.101.2.133: bytes=64 time=59ms TTL=57
Reply from 151.101.2.133: bytes=64 time=51ms TTL=57

Ping statistics for 151.101.2.133:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 46ms, Maximum = 66ms, Average = 59ms
```

- www.uw.edu, berkeley.edu has a country code from USA they have average RTT 442,467 respectively.Since they are located in the same country the difference between average RTT is low.

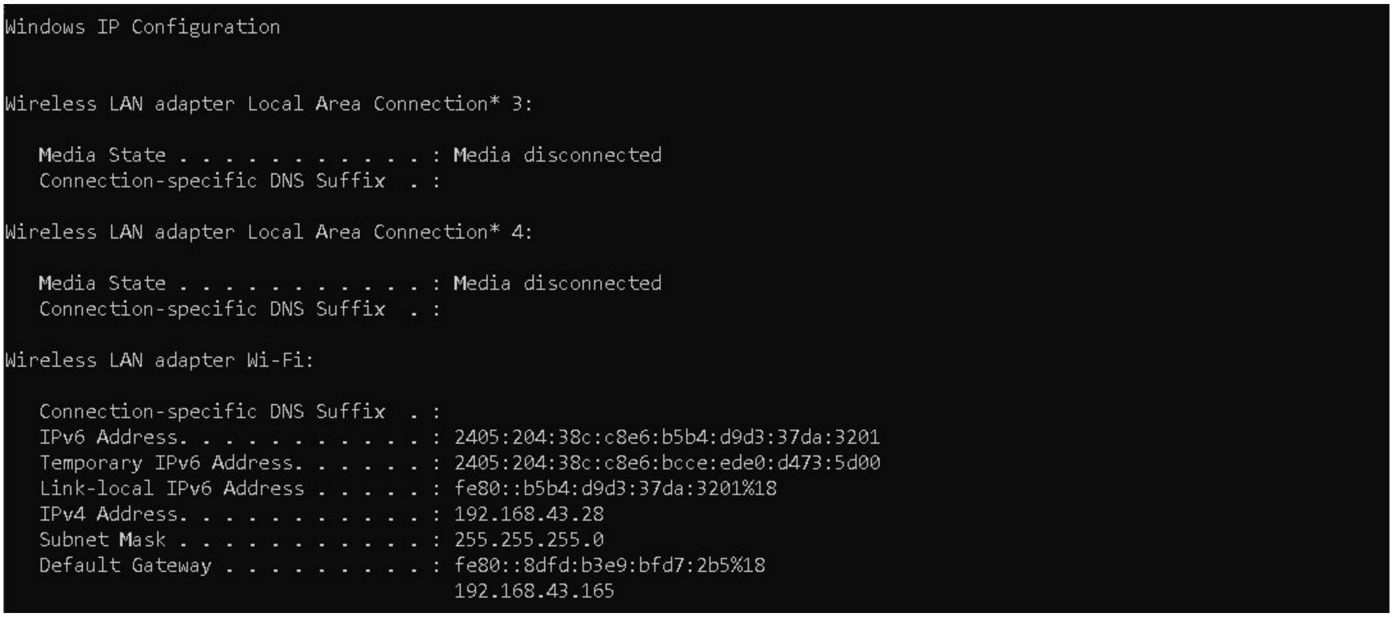
- www.ox.ac.uk has a domain name uk and belongs to the United Kingdom has an average RTT of 72 which is less than the USA since the distance of the UK is less than the USA from us.

nslookup — The command nslookup <host> will do a DNS query to find and report the IP address (or addresses) for a domain name or the domain name corresponding to an IP address. To do this, it contacts a "DNS server." Default DNS servers are part of a computer's network configuration. (For a static IP address in Linux, they are configured in the file /etc/network/interfaces that you encountered in the last lab.) You can specify a different DNS server to be used by nslookup by adding the server name or IP address to the command: nslookup <host> <server>



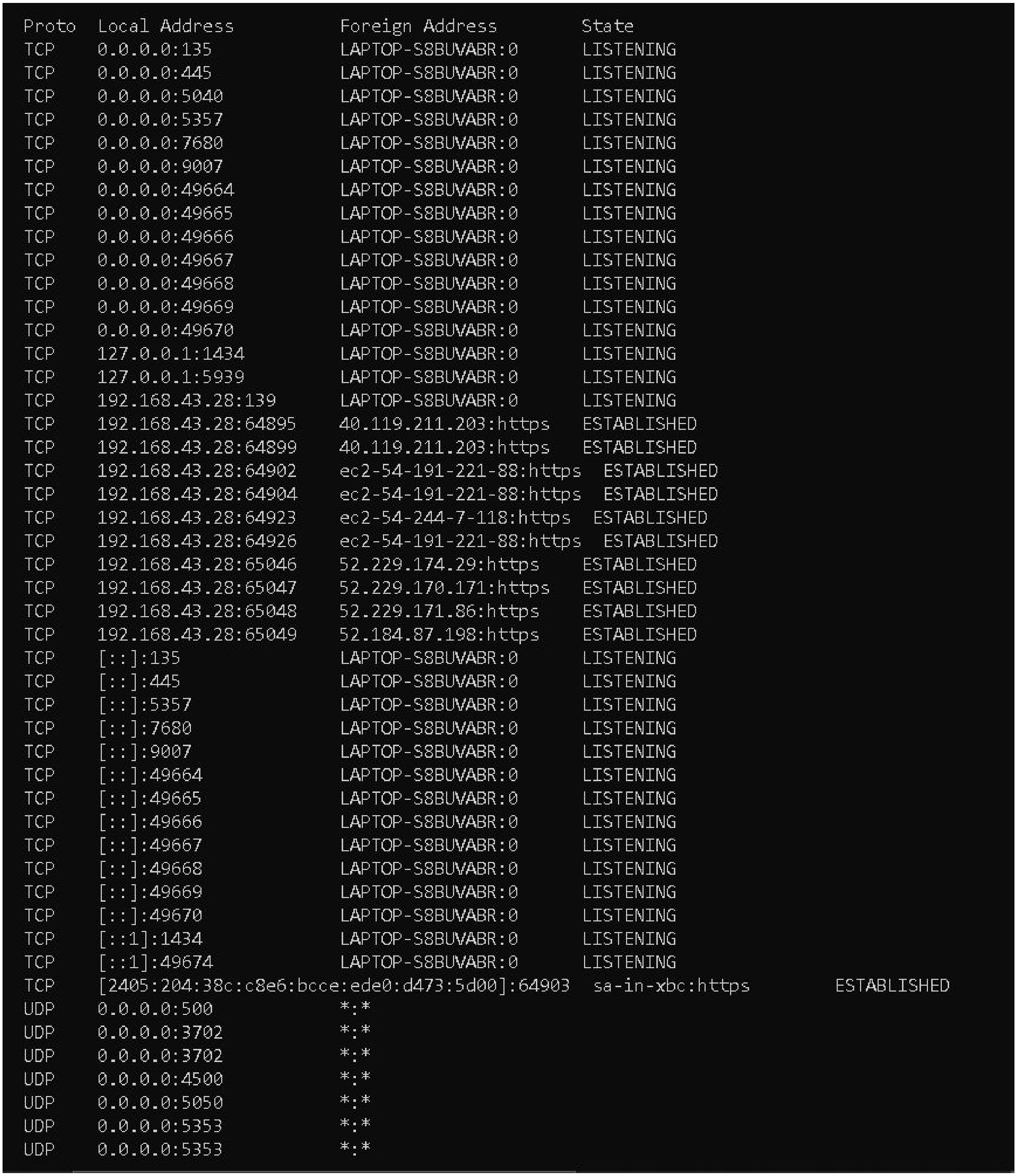
```
C:\Users\LENOVO>nslookup www.spit.ac.in
Server:  UnKnown
Address:  192.168.43.1

Non-authoritative answer:
Name:    www.spit.ac.in
Address:  43.252.193.19
```

ifconfig — You used ifconfig in the previous lab. When used with no parameters, ifconfig reports some information about the computer's network interfaces. This usually includes lo which stands for localhost; it can be used for communication between programs running on the same computer. Linux often has an interface named eth0, which is the first ethernet card. The information is different on Mac OS and Linux, but includes the IP or "inet" address and ethernet or "hardware" address for an ethernet card. On Linux, you get the number of packets received (RX) and sent (TX), as well as the number of bytes transmitted and received. (A better place to monitor network bytes on our Linux computers is in the GUI program System Monitor, if it is installed!!!.)



```
Windows IP Configuration


Wireless LAN adapter Local Area Connection* 3:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Wireless LAN adapter Local Area Connection* 4:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2405:204:38c:c8e6:b5b4:d9d3:37da:3201
   Temporary IPv6 Address. . . . . . : 2405:204:38c:c8e6:bcce:ede0:d473:5d00
   Link-local IPv6 Address . . . . . : fe80::b5b4:d9d3:37da:3201%18
   IPv4 Address. . . . . . . . . . . : 192.168.43.28
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : fe80::8dfd:b3e9:bfd7:2b5%18
                                       192.168.43.165
```

netstat — The netstat command gives information about network connections. I often use netstat -t -n which lists currently open TCP connections (that's the "-t" option) by IP address rather than domain name (that's the "-n" option). Add the option "-l" (lower case ell) to list listening sockets, that is sockets that have been opened by server programs to wait for connection requests from clients: netstat -t -n -l. (On Mac, use netstat -p tcp to list tcp connections, and add "-a" to include listening sockets in the list.)



```
Proto  Local Address          Foreign Address        State
TCP    0.0.0.0:135            LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:445            LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:5040           LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:5357           LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:7680           LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:9007           LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49664          LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49665          LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49666          LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49667          LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49668          LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49669          LAPTOP-S8BUVABR:0      LISTENING
TCP    0.0.0.0:49670          LAPTOP-S8BUVABR:0      LISTENING
TCP    127.0.0.1:1434         LAPTOP-S8BUVABR:0      LISTENING
TCP    127.0.0.1:5939         LAPTOP-S8BUVABR:0      LISTENING
TCP    192.168.43.28:139      LAPTOP-S8BUVABR:0      LISTENING
TCP    192.168.43.28:64895    40.119.211.203:https   ESTABLISHED
TCP    192.168.43.28:64899    40.119.211.203:https   ESTABLISHED
TCP    192.168.43.28:64902    ec2-54-191-221-88:https  ESTABLISHED
TCP    192.168.43.28:64904    ec2-54-191-221-88:https  ESTABLISHED
TCP    192.168.43.28:64923    ec2-54-244-7-118:https  ESTABLISHED
TCP    192.168.43.28:64926    ec2-54-191-221-88:https  ESTABLISHED
TCP    192.168.43.28:65046    52.229.174.29:https    ESTABLISHED
TCP    192.168.43.28:65047    52.229.170.171:https   ESTABLISHED
TCP    192.168.43.28:65048    52.229.171.86:https    ESTABLISHED
TCP    192.168.43.28:65049    52.184.87.198:https    ESTABLISHED
TCP    [::]:135               LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:445               LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:5357              LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:7680              LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:9007              LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49664             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49665             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49666             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49667             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49668             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49669             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::]:49670             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::1]:1434             LAPTOP-S8BUVABR:0      LISTENING
TCP    [::1]:49674            LAPTOP-S8BUVABR:0      LISTENING
TCP    [2405:204:38c:c8e6:bcce:ede0:d473:5d00]:64903  sa-in-xbc:https        ESTABLISHED
UDP    0.0.0.0:500            *:*
UDP    0.0.0.0:3702           *:*
UDP    0.0.0.0:3702           *:*
UDP    0.0.0.0:4500           *:*
UDP    0.0.0.0:5050           *:*
UDP    0.0.0.0:5353           *:*
UDP    0.0.0.0:5353           *:*
```

traceroute — Traceroute is discussed in man utility. The command traceroute <host> will show routers encountered by packets on their way from your computer to a specified <host>. For each n = 1, 2, 3,..., traceroute sends a packet with "time-to-live" (ttl) equal to n. Every time a router forwards a packet, it decreases the ttl of the packet by one. If the ttl drops to zero, the router discards the packet and sends an error message back to the sender of the packet. (Again, as with ping, the packets might be blocked or might not even be sent, so that the error messages will never be received.) The sender gets the identity of the router from the source of the error message. Traceroute will send packets until n reaches some set upper bound or until a packet actually gets through to the destination. It actually does this three times for each n. In this way, it identifies routers that are one step, two steps, three steps, ... away from the source computer. A packet for which no response is received is indicated in the output as a *.

Traceroute is installed on the computers. If was not installed in your virtual server last week, but you can install it with the command sudo apt-get install traceroute

The path taken through a network, can be measured using `traceroute`. The syntax for the command in Linux is:

```
traceroute <hostname>
```

The syntax in Windows is:

```
tracert <hostname>
```

You can specify either a hostname (e.g., `cse.iitb.ac.in`) or an IP address (e.g., `128.105.2.6`).

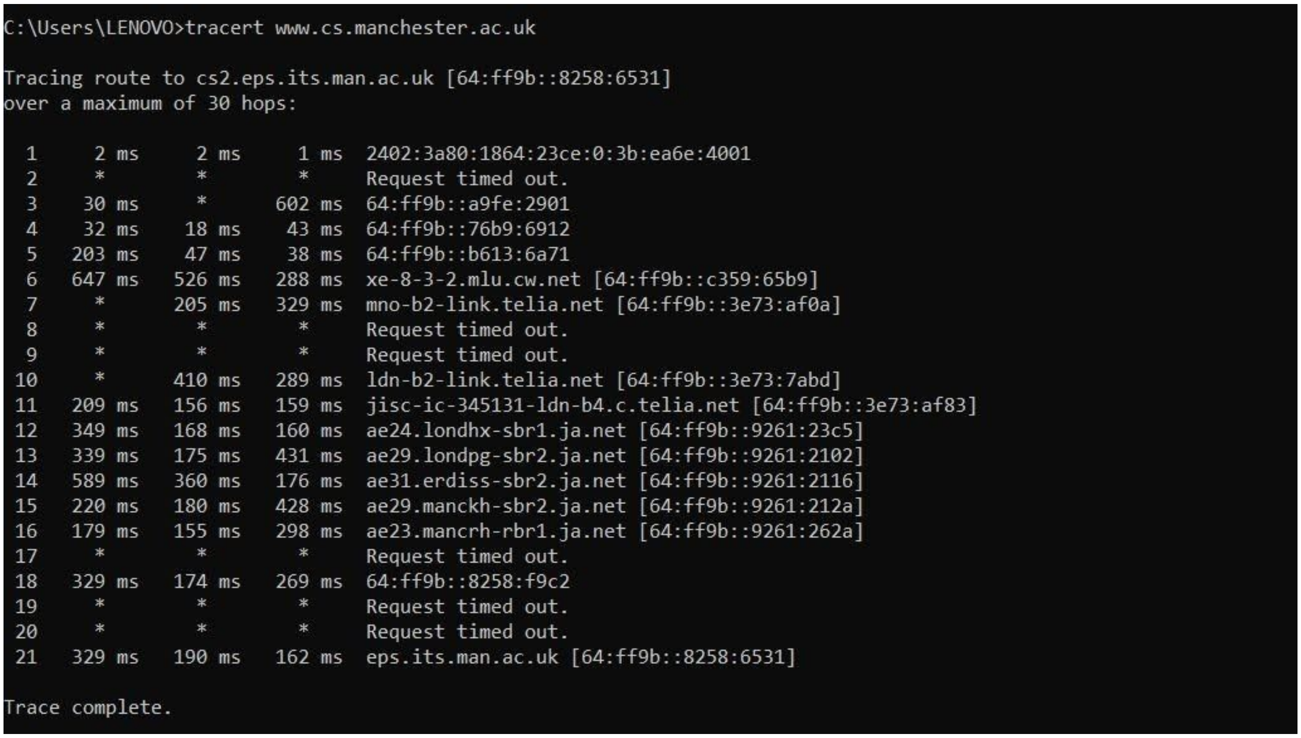
1.2.1 EXPERIMENTS WITH TRACEROUTE

From **your machine** traceroute to the following hosts:

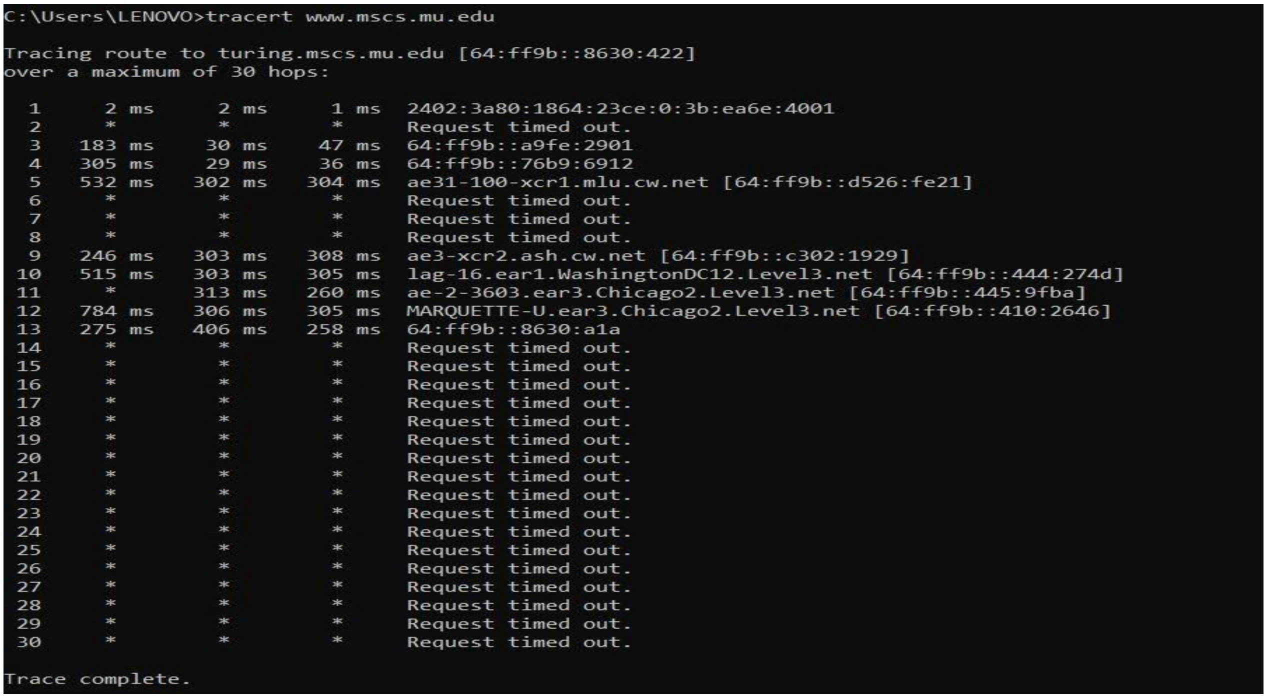
1. ee.iitb.ac.in
2. mscs.mu.edu
3. www.cs.grinnell.edu
4. csail.mit.edu
5. cs.stanford.edu
6. cs.manchester.ac.uk

Store the output of each traceroute command in a separate file named `traceroute_HOSTNAME.log`, replacing `HOSTNAME` with the hostname for end-host you pinged

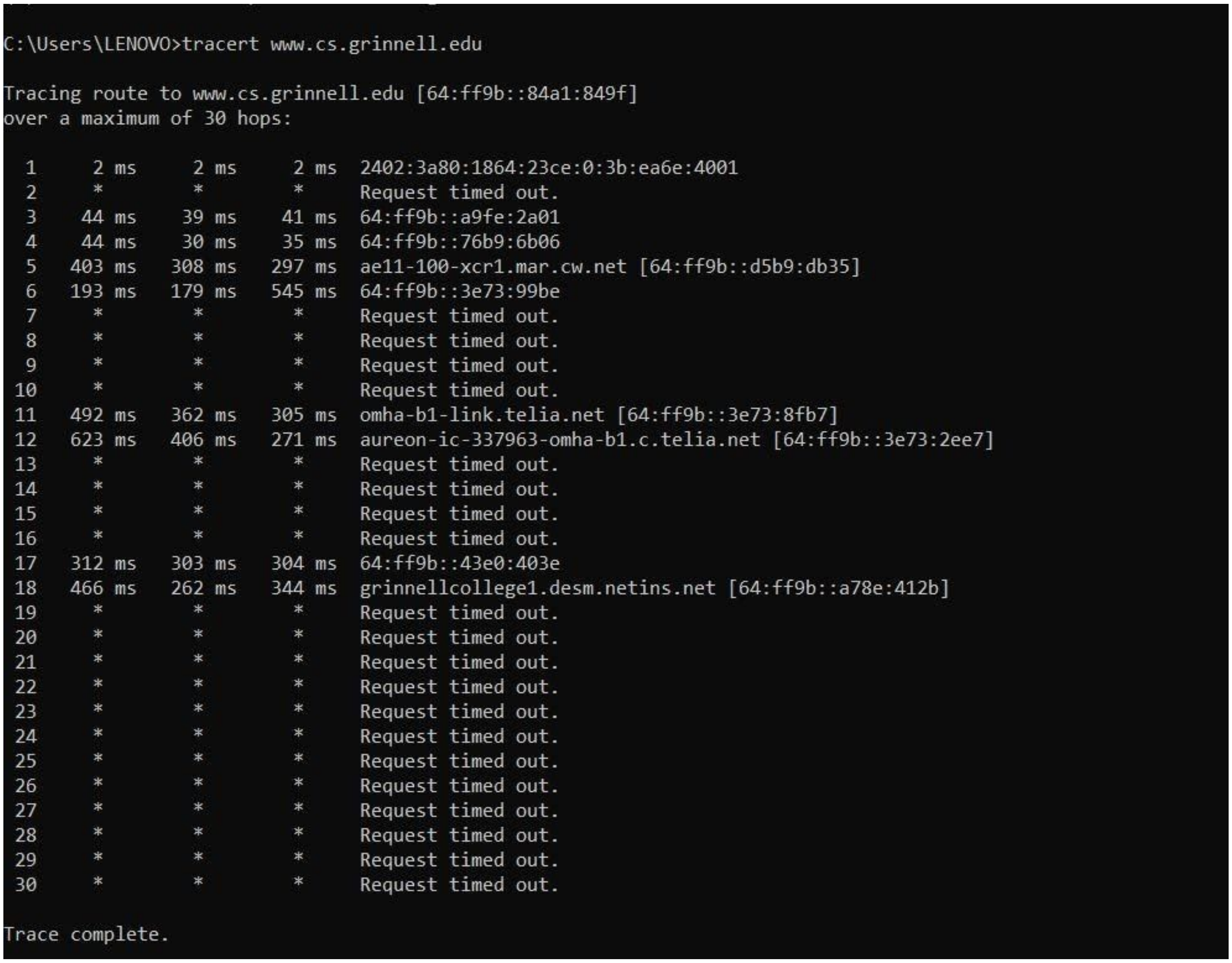
(e.g., `traceroute_ee.iitb.ac.in.log`).



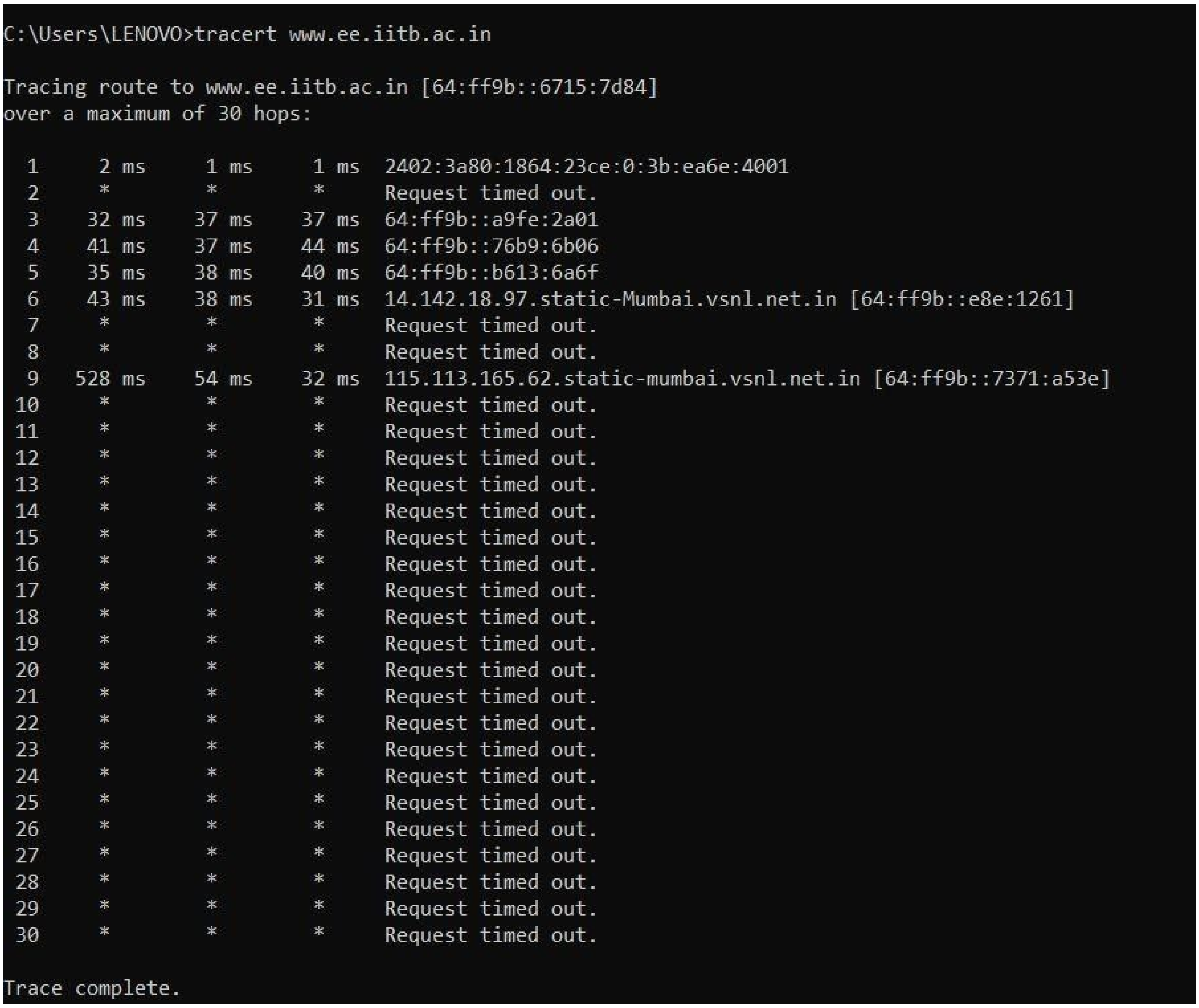
```
C:\Users\LENOVO>tracert www.cs.manchester.ac.uk

Tracing route to cs2.eps.its.man.ac.uk [64:ff9b::8258:6531]
over a maximum of 30 hops:

  1     2 ms     2 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    30 ms     *      602 ms  64:ff9b::a9fe:2901
  4    32 ms    18 ms    43 ms  64:ff9b::76b9:6912
  5   203 ms    47 ms    38 ms  64:ff9b::b613:6a71
  6   647 ms   526 ms   288 ms  xe-8-3-2.mlu.cw.net [64:ff9b::c359:65b9]
  7     *      205 ms   329 ms  mno-b2-link.telia.net [64:ff9b::3e73:af0a]
  8     *        *        *     Request timed out.
  9     *        *        *     Request timed out.
 10     *      410 ms   289 ms  ldn-b2-link.telia.net [64:ff9b::3e73:7abd]
 11   209 ms   156 ms   159 ms  jisc-ic-345131-ldn-b4.c.telia.net [64:ff9b::3e73:af83]
 12   349 ms   168 ms   160 ms  ae24.londhx-sbr1.ja.net [64:ff9b::9261:23c5]
 13   339 ms   175 ms   431 ms  ae29.londpg-sbr2.ja.net [64:ff9b::9261:2102]
 14   589 ms   360 ms   176 ms  ae31.erdiss-sbr2.ja.net [64:ff9b::9261:2116]
 15   220 ms   180 ms   428 ms  ae29.manckh-sbr2.ja.net [64:ff9b::9261:212a]
 16   179 ms   155 ms   298 ms  ae23.mancrh-rbr1.ja.net [64:ff9b::9261:262a]
 17     *        *        *     Request timed out.
 18   329 ms   174 ms   269 ms  64:ff9b::8258:f9c2
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21   329 ms   190 ms   162 ms  eps.its.man.ac.uk [64:ff9b::8258:6531]

Trace complete.
```



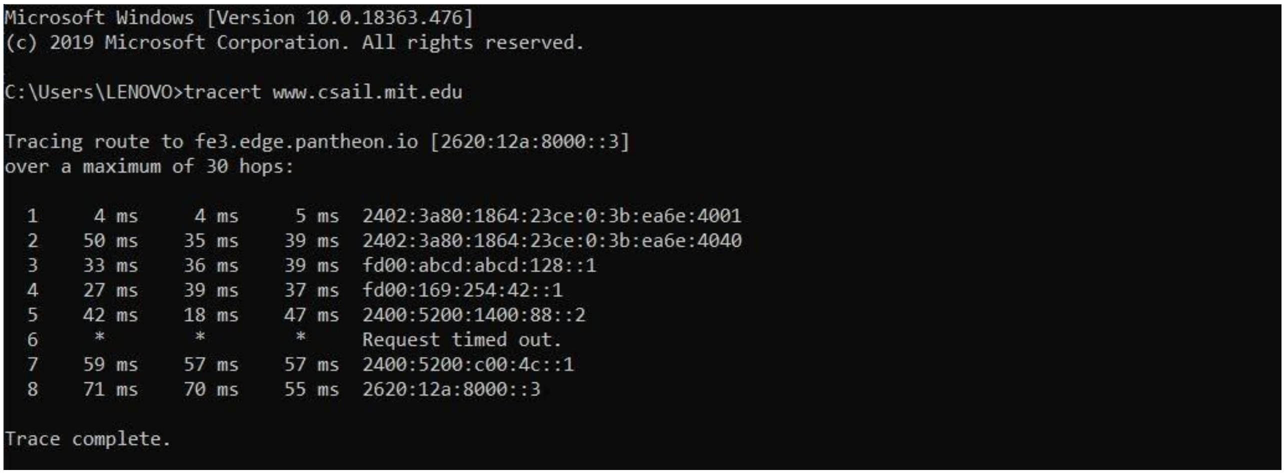
```
C:\Users\LENOVO>tracert www.mscs.mu.edu

Tracing route to turing.mscs.mu.edu [64:ff9b::8630:422]
over a maximum of 30 hops:

  1     2 ms     2 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3   183 ms    30 ms    47 ms  64:ff9b::a9fe:2901
  4   305 ms    29 ms    36 ms  64:ff9b::76b9:6912
  5   532 ms   302 ms   304 ms  ae31-100-xcr1.mlu.cw.net [64:ff9b::d526:fe21]
  6     *        *        *     Request timed out.
  7     *        *        *     Request timed out.
  8     *        *        *     Request timed out.
  9   246 ms   303 ms   308 ms  ae3-xcr2.ash.cw.net [64:ff9b::c302:1929]
 10   515 ms   303 ms   305 ms  lag-16.ear1.WashingtonDC12.Level3.net [64:ff9b::444:274d]
 11     *      313 ms   260 ms  ae-2-3603.ear3.Chicago2.Level3.net [64:ff9b::445:9fba]
 12   784 ms   306 ms   305 ms  MARQUETTE-U.ear3.Chicago2.Level3.net [64:ff9b::410:2646]
 13   275 ms   406 ms   258 ms  64:ff9b::8630:a1a
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```



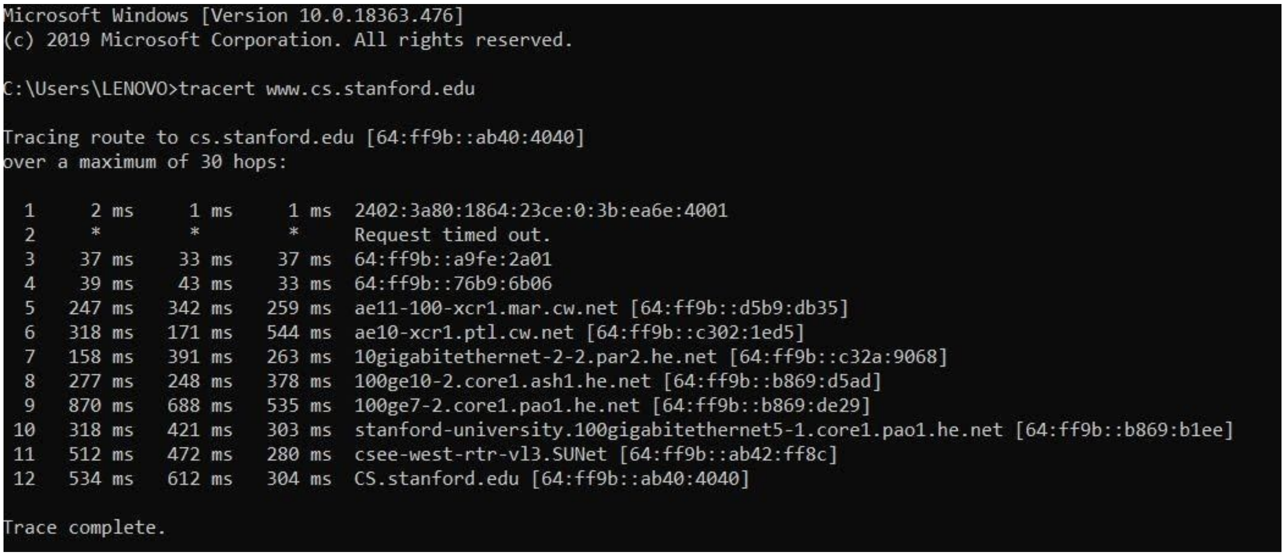
```
C:\Users\LENOVO>tracert www.cs.grinnell.edu

Tracing route to www.cs.grinnell.edu [64:ff9b::84a1:849f]
over a maximum of 30 hops:

  1     2 ms     2 ms     2 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    44 ms    39 ms    41 ms  64:ff9b::a9fe:2a01
  4    44 ms    30 ms    35 ms  64:ff9b::76b9:6b06
  5   403 ms   308 ms   297 ms  ae11-100-xcr1.mar.cw.net [64:ff9b::d5b9:db35]
  6   193 ms   179 ms   545 ms  64:ff9b::3e73:99be
  7     *        *        *     Request timed out.
  8     *        *        *     Request timed out.
  9     *        *        *     Request timed out.
 10     *        *        *     Request timed out.
 11   492 ms   362 ms   305 ms  omha-b1-link.telia.net [64:ff9b::3e73:8fb7]
 12   623 ms   406 ms   271 ms  aureon-ic-337963-omha-b1.c.telia.net [64:ff9b::3e73:2ee7]
 13     *        *        *     Request timed out.
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17   312 ms   303 ms   304 ms  64:ff9b::43e0:403e
 18   466 ms   262 ms   344 ms  grinnellcollege1.desm.netins.net [64:ff9b::a78e:412b]
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```



```
C:\Users\LENOVO>tracert www.ee.iitb.ac.in

Tracing route to www.ee.iitb.ac.in [64:ff9b::6715:7d84]
over a maximum of 30 hops:

  1     2 ms     1 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    32 ms    37 ms    37 ms  64:ff9b::a9fe:2a01
  4    41 ms    37 ms    44 ms  64:ff9b::76b9:6b06
  5    35 ms    38 ms    40 ms  64:ff9b::b613:6a6f
  6    43 ms    38 ms    31 ms  14.142.18.97.static-Mumbai.vsnl.net.in [64:ff9b::e8e:1261]
  7     *        *        *     Request timed out.
  8     *        *        *     Request timed out.
  9   528 ms    54 ms    32 ms  115.113.165.62.static-mumbai.vsnl.net.in [64:ff9b::7371:a53e]
 10     *        *        *     Request timed out.
 11     *        *        *     Request timed out.
 12     *        *        *     Request timed out.
 13     *        *        *     Request timed out.
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```

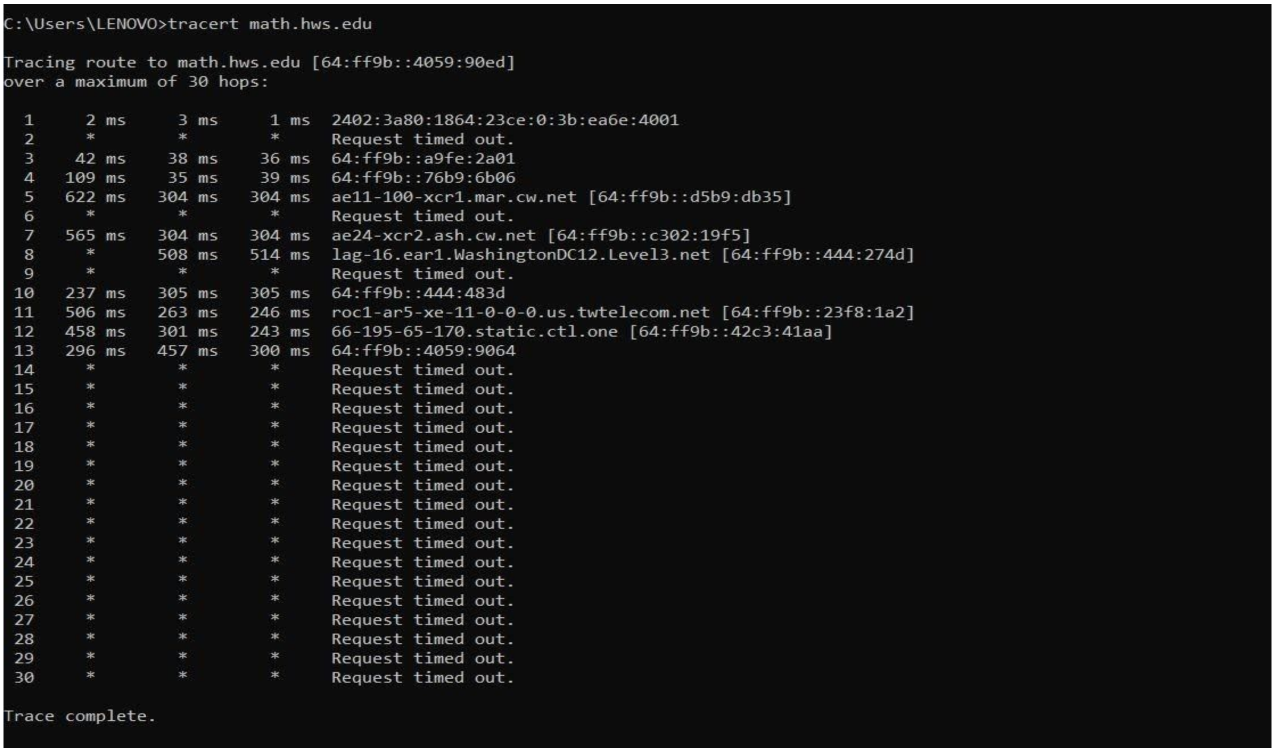


```
Microsoft Windows [Version 10.0.18363.476]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\LENOVO>tracert www.csail.mit.edu

Tracing route to fe3.edge.pantheon.io [2620:12a:8000::3]
over a maximum of 30 hops:

  1     4 ms     4 ms     5 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2    50 ms    35 ms    39 ms  2402:3a80:1864:23ce:0:3b:ea6e:4040
  3    33 ms    36 ms    39 ms  fd00:abcd:abcd:128::1
  4    27 ms    39 ms    37 ms  fd00:169:254:42::1
  5    42 ms    18 ms    47 ms  2400:5200:1400:88::2
  6     *        *        *     Request timed out.
  7    59 ms    57 ms    57 ms  2400:5200:c00:4c::1
  8    71 ms    70 ms    55 ms  2620:12a:8000::3

Trace complete.
```

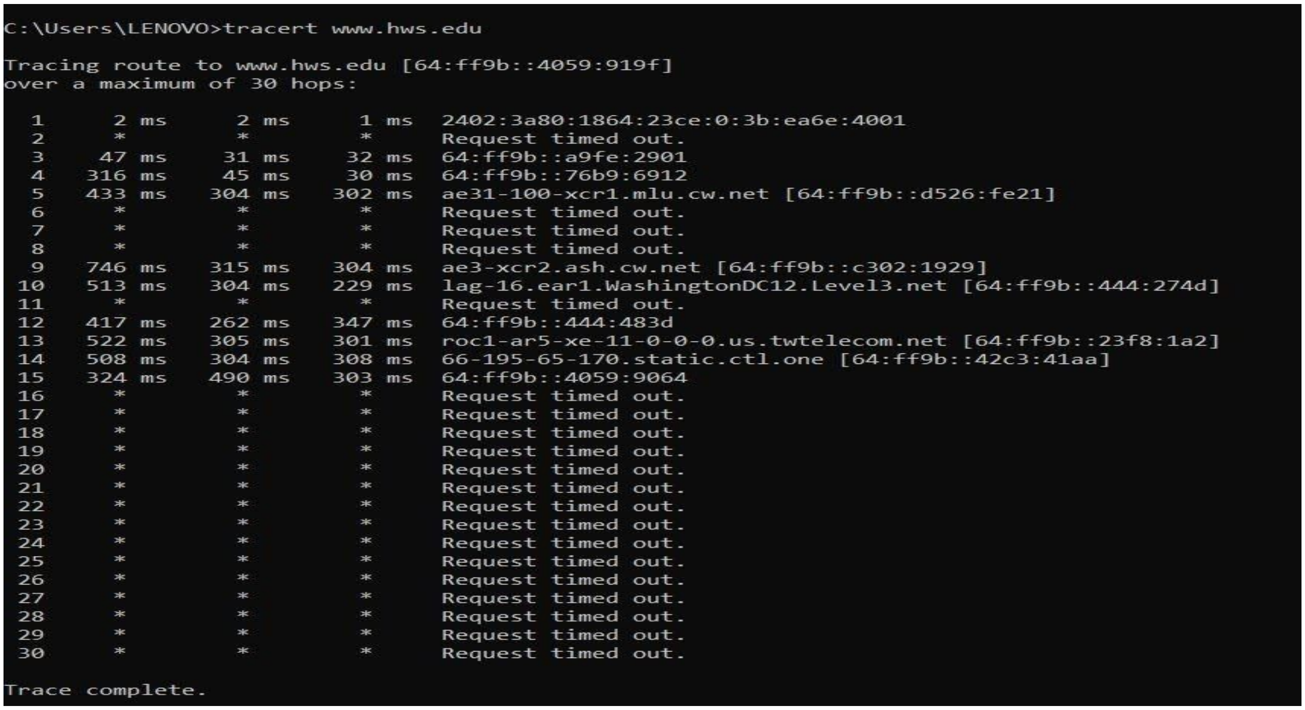


```
Microsoft Windows [Version 10.0.18363.476]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\LENOVO>tracert www.cs.stanford.edu

Tracing route to cs.stanford.edu [64:ff9b::ab40:4040]
over a maximum of 30 hops:

  1     2 ms     1 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    37 ms    33 ms    37 ms  64:ff9b::a9fe:2a01
  4    39 ms    43 ms    33 ms  64:ff9b::76b9:6b06
  5   247 ms   342 ms   259 ms  ae11-100-xcr1.mar.cw.net [64:ff9b::d5b9:db35]
  6   318 ms   171 ms   544 ms  ae10-xcr1.ptl.cw.net [64:ff9b::c302:1ed5]
  7   158 ms   391 ms   263 ms  10gigabitethernet-2-2.par2.he.net [64:ff9b::c32a:9068]
  8   277 ms   248 ms   378 ms  100ge10-2.core1.ash1.he.net [64:ff9b::b869:d5ad]
  9   870 ms   688 ms   535 ms  100ge7-2.core1.pao1.he.net [64:ff9b::b869:de29]
 10   318 ms   421 ms   303 ms  stanford-university.100gigabitethernet5-1.core1.pao1.he.net [64:ff9b::b869:b1ee]
 11   512 ms   472 ms   280 ms  csee-west-rtr-vl3.SUNet [64:ff9b::ab42:ff8c]
 12   534 ms   612 ms   304 ms  CS.stanford.edu [64:ff9b::ab40:4040]

Trace complete.
```

Exercise 2: (Very short.) Use traceroute to trace the route from your computer to math.hws.edu and to www.hws.edu. Explain the difference in the results.



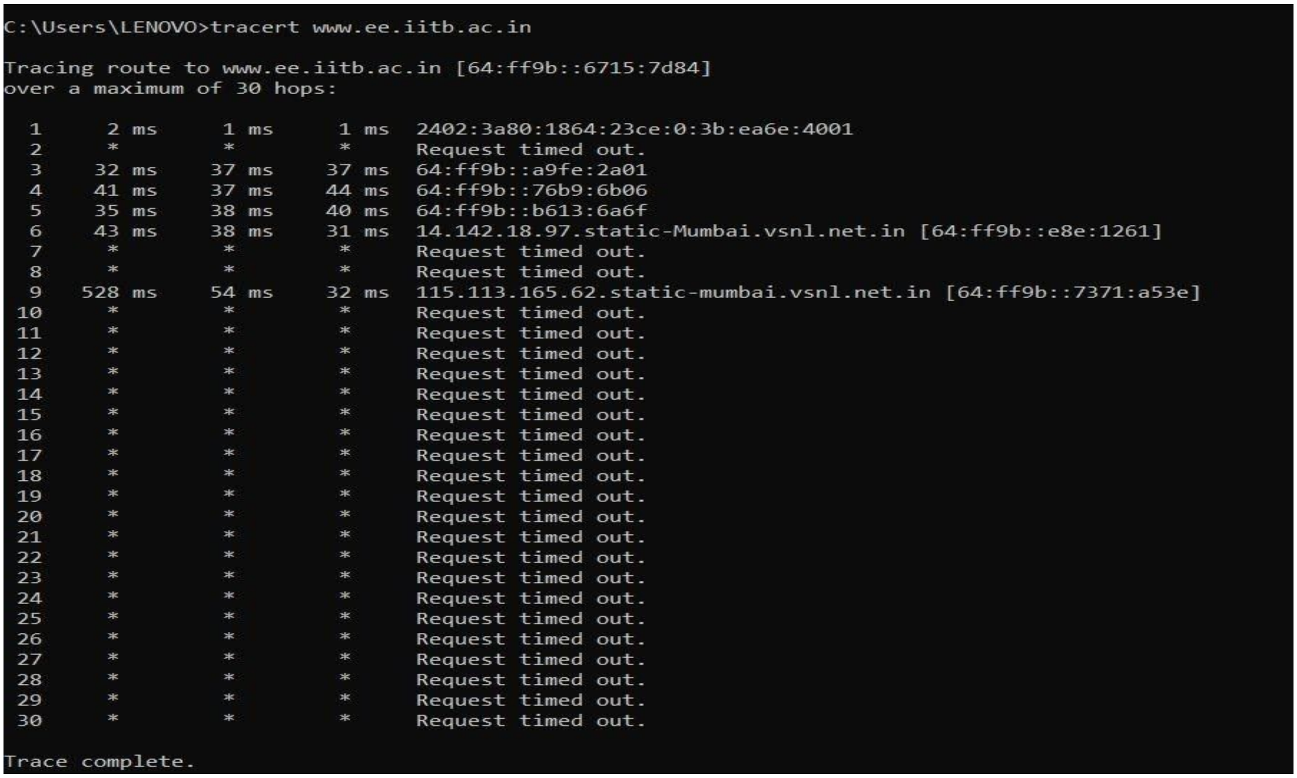
```
C:\Users\LENOVO>tracert math.hws.edu

Tracing route to math.hws.edu [64:ff9b::4059:90ed]
over a maximum of 30 hops:

  1     2 ms     3 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    42 ms    38 ms    36 ms  64:ff9b::a9fe:2a01
  4   109 ms    35 ms    39 ms  64:ff9b::76b9:6b06
  5   622 ms   304 ms   304 ms  ae11-100-xcr1.mar.cw.net [64:ff9b::d5b9:db35]
  6     *        *        *     Request timed out.
  7   565 ms   304 ms   304 ms  ae24-xcr2.ash.cw.net [64:ff9b::c302:19f5]
  8     *      508 ms   514 ms  lag-16.ear1.WashingtonDC12.Level3.net [64:ff9b::444:274d]
  9     *        *        *     Request timed out.
 10   237 ms   305 ms   305 ms  64:ff9b::444:483d
 11   506 ms   263 ms   246 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [64:ff9b::23f8:1a2]
 12   458 ms   301 ms   243 ms  66-195-65-170.static.ctl.one [64:ff9b::42c3:41aa]
 13   296 ms   457 ms   300 ms  64:ff9b::4059:9064
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```



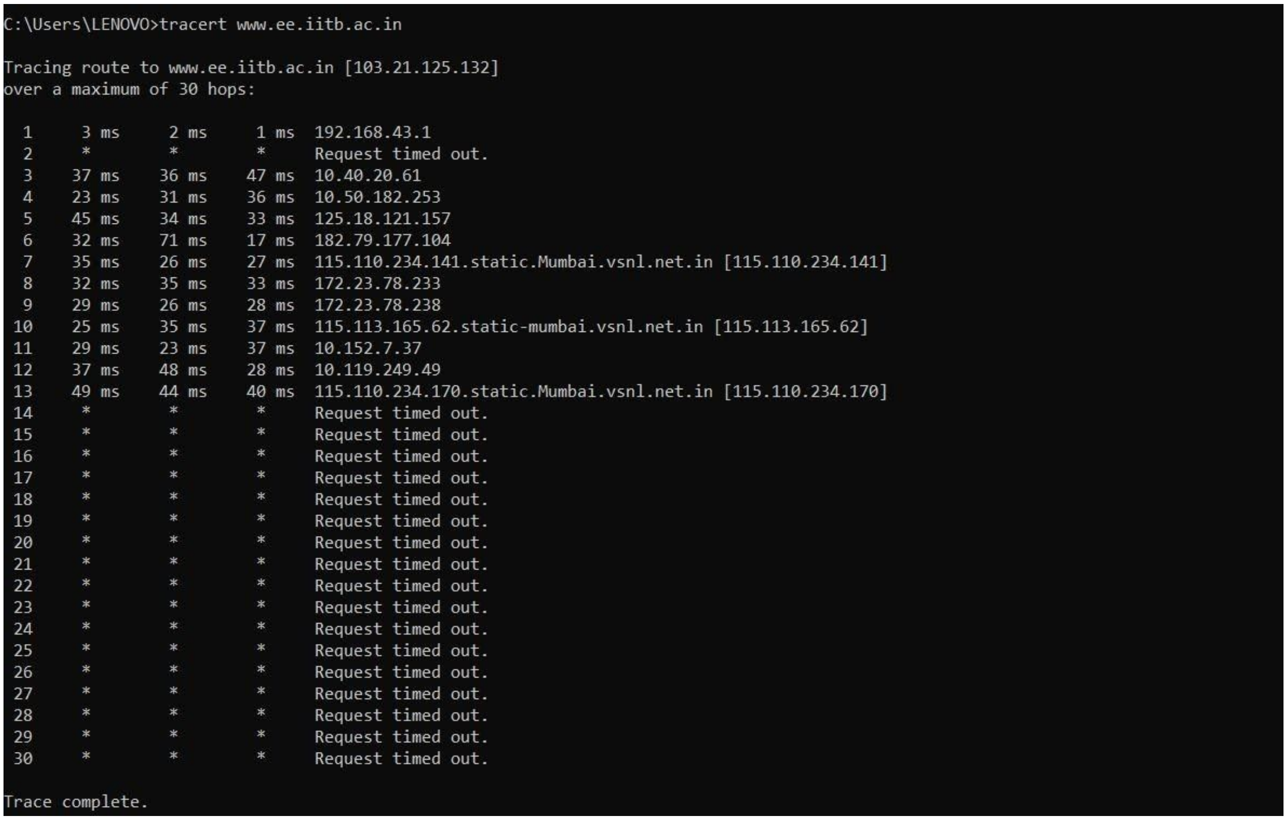
```
C:\Users\LENOVO>tracert www.hws.edu

Tracing route to www.hws.edu [64:ff9b::4059:919f]
over a maximum of 30 hops:

  1     2 ms     2 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    47 ms    31 ms    32 ms  64:ff9b::a9fe:2901
  4   316 ms    45 ms    30 ms  64:ff9b::76b9:6912
  5   433 ms   304 ms   302 ms  ae31-100-xcr1.mlu.cw.net [64:ff9b::d526:fe21]
  6     *        *        *     Request timed out.
  7     *        *        *     Request timed out.
  8     *        *        *     Request timed out.
  9   746 ms   315 ms   304 ms  ae3-xcr2.ash.cw.net [64:ff9b::c302:1929]
 10   513 ms   304 ms   229 ms  lag-16.ear1.WashingtonDC12.Level3.net [64:ff9b::444:274d]
 11     *        *        *     Request timed out.
 12   417 ms   262 ms   347 ms  64:ff9b::444:483d
 13   522 ms   305 ms   301 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [64:ff9b::23f8:1a2]
 14   508 ms   304 ms   308 ms  66-195-65-170.static.ctl.one [64:ff9b::42c3:41aa]
 15   324 ms   490 ms   303 ms  64:ff9b::4059:9064
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```

- There is difference between ip address of both the website at hop 5 www.math.hws.edu goes to ae11-100-xcr1.mar-cw.net whereas www.hws.edu goes to ae31-100-xcr1.mlu.cw.net

<u>Exercise 3:</u> Two packets sent from the same source to the same destination do not necessarily follow the same path through the net. Experiment with some sources that are fairly far away. Can you find cases where packets sent to the same destination follow different paths? How likely does it seem to be? What about when the packets are sent at very different times? Save some of the outputs from traceroute. (You can copy them from the Terminal window by highlighting and right-clicking, then paste into a text editor.) Come back sometime next week, try the same destinations again, and compare the results with the results from today. Report your observations.



```
C:\Users\LENOVO>tracert www.ee.iitb.ac.in

Tracing route to www.ee.iitb.ac.in [64:ff9b::6715:7d84]
over a maximum of 30 hops:

  1     2 ms     1 ms     1 ms  2402:3a80:1864:23ce:0:3b:ea6e:4001
  2     *        *        *     Request timed out.
  3    32 ms    37 ms    37 ms  64:ff9b::a9fe:2a01
  4    41 ms    37 ms    44 ms  64:ff9b::76b9:6b06
  5    35 ms    38 ms    40 ms  64:ff9b::b613:6a6f
  6    43 ms    38 ms    31 ms  14.142.18.97.static-Mumbai.vsnl.net.in [64:ff9b::e8e:1261]
  7     *        *        *     Request timed out.
  8     *        *        *     Request timed out.
  9   528 ms    54 ms    32 ms  115.113.165.62.static-mumbai.vsnl.net.in [64:ff9b::7371:a53e]
 10     *        *        *     Request timed out.
 11     *        *        *     Request timed out.
 12     *        *        *     Request timed out.
 13     *        *        *     Request timed out.
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```



```
C:\Users\LENOVO>tracert www.ee.iitb.ac.in

Tracing route to www.ee.iitb.ac.in [103.21.125.132]
over a maximum of 30 hops:

  1     3 ms     2 ms     1 ms  192.168.43.1
  2     *        *        *     Request timed out.
  3    37 ms    36 ms    47 ms  10.40.20.61
  4    23 ms    31 ms    36 ms  10.50.182.253
  5    45 ms    34 ms    33 ms  125.18.121.157
  6    32 ms    71 ms    17 ms  182.79.177.104
  7    35 ms    26 ms    27 ms  115.110.234.141.static.Mumbai.vsnl.net.in [115.110.234.141]
  8    32 ms    35 ms    33 ms  172.23.78.233
  9    29 ms    26 ms    28 ms  172.23.78.238
 10    25 ms    35 ms    37 ms  115.113.165.62.static-mumbai.vsnl.net.in [115.113.165.62]
 11    29 ms    23 ms    37 ms  10.152.7.37
 12    37 ms    48 ms    28 ms  10.119.249.49
 13    49 ms    44 ms    40 ms  115.110.234.170.static.Mumbai.vsnl.net.in [115.110.234.170]
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```

- On performing this experiment we can observe that two packets sent from the same source to the same destination do not follow the same path.
- On hop 9 in case 1 it takes path 115.113.165.62.static-mumbai.vsnl.net.in whereas in case 2 it is 172.23.78.238
- Same results are obtained on different hops as well.

QUESTIONS ABOUT PATHS

Now look at the results you gathered and answer the following questions about the paths taken by your packets. Store your answers in a file named `traceroute.txt`.

1. Is any part of the path common for all hosts you traceroute?

    - Yes, the first 4 hops of the path is common for all hosts that were traceroute.
    - The tracerouting follows a particular path from the user's IP address through the IP addresses of the ISP and then the path really depends on which access point is ready to respond and which access points or routers have firewalls configured for blocking the requests and accordingly, the destination can be reached through different paths at different times

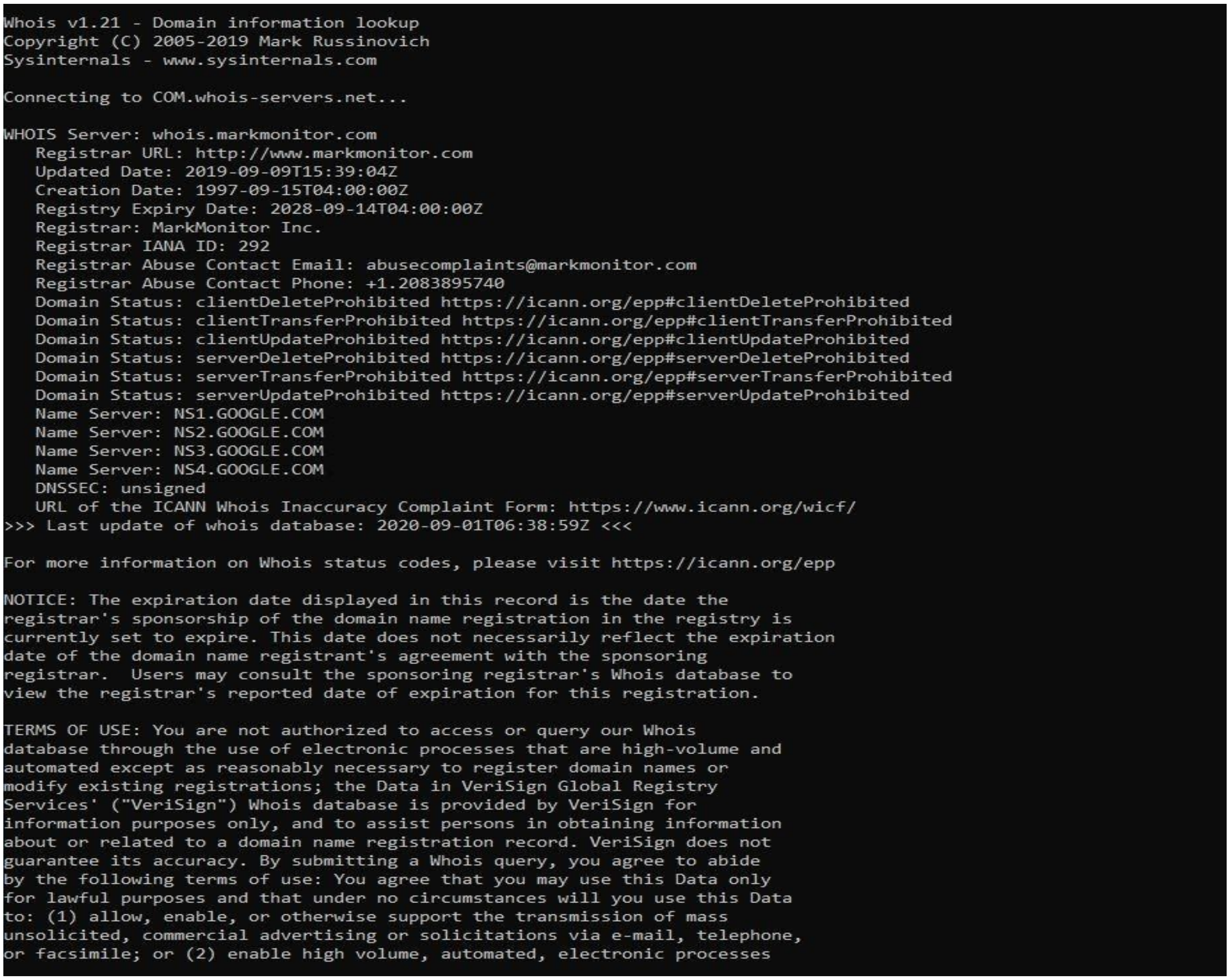
2. Is there a relationship between the number of nodes that show up in the traceroute and the location of the host? If so, what is this relationship?
    - After tracing routes of different hosts each has a maximum of 30hops.
    - www.cs.stanford.edu takes 12 hops while www.ee.iitb.ac.in takes 30 hops while www.cs.manchester.ac.uk takes 18 hops.
    - We can conclude that the number of intermediate devices through which data must pass between source and destination decreases with distance.
    - hop depends on the location of the host. If the distance between the location of the user and that of the destination url is more, then more hops will be required in order to reach the destination as more number of access points will be used for routing

3. Is there a relationship between the number of nodes that show up in the traceroute and latency of the host (from your ping results above)? Does the same relationship hold for all hosts?
    - If the latency of the host causes the traceroute request to get timed out even after the conventional three tries, then it keeps on sending the data packets until the host responds or upto a certain maximum hops.
    - The same relationship may not hold for each host as it really depends on the time which the host takes to respond. If the host responds in the first request itself, the tracerouting stops with a success message.

WhoIs — The *whois* command can give detailed information about domain names and IP addresses. If it is not installed on the computers then install it with command sudo apt-get install whois in. *Whois* can tell you what organization owns or is responsible for the name or address and where to contact them. It often includes a list of domain name servers for the organization.

When using *whois* to look up a domain name, use the simple two-part network name, not an individual computer name (for example, *whois spit.ac.in*).

Exercise 4: (Short.) Use *whois* to investigate a well-known web site such as google.com or amazon.com, and write a couple of sentences about what you find out.



```
Whois v1.21 - Domain information lookup
Copyright (C) 2005-2019 Mark Russinovich
Sysinternals - www.sysinternals.com

Connecting to COM.whois-servers.net...

WHOIS Server: whois.markmonitor.com
   Registrar URL: http://www.markmonitor.com
   Updated Date: 2019-09-09T15:39:04Z
   Creation Date: 1997-09-15T04:00:00Z
   Registry Expiry Date: 2028-09-14T04:00:00Z
   Registrar: MarkMonitor Inc.
   Registrar IANA ID: 292
   Registrar Abuse Contact Email: abusecomplaints@markmonitor.com
   Registrar Abuse Contact Phone: +1.2083895740
   Domain Status: clientDeleteProhibited https://icann.org/epp#clientDeleteProhibited
   Domain Status: clientTransferProhibited https://icann.org/epp#clientTransferProhibited
   Domain Status: clientUpdateProhibited https://icann.org/epp#clientUpdateProhibited
   Domain Status: serverDeleteProhibited https://icann.org/epp#serverDeleteProhibited
   Domain Status: serverTransferProhibited https://icann.org/epp#serverTransferProhibited
   Domain Status: serverUpdateProhibited https://icann.org/epp#serverUpdateProhibited
   Name Server: NS1.GOOGLE.COM
   Name Server: NS2.GOOGLE.COM
   Name Server: NS3.GOOGLE.COM
   Name Server: NS4.GOOGLE.COM
   DNSSEC: unsigned
   URL of the ICANN Whois Inaccuracy Complaint Form: https://www.icann.org/wicf/
>>> Last update of whois database: 2020-09-01T06:38:59Z <<<

For more information on Whois status codes, please visit https://icann.org/epp

NOTICE: The expiration date displayed in this record is the date the
registrar's sponsorship of the domain name registration in the registry is
currently set to expire. This date does not necessarily reflect the expiration
date of the domain name registrant's agreement with the sponsoring
registrar.  Users may consult the sponsoring registrar's Whois database to
view the registrar's reported date of expiration for this registration.

TERMS OF USE: You are not authorized to access or query our Whois
database through the use of electronic processes that are high-volume and
automated except as reasonably necessary to register domain names or
modify existing registrations; the Data in VeriSign Global Registry
Services' ("VeriSign") Whois database is provided by VeriSign for
information purposes only, and to assist persons in obtaining information
about or related to a domain name registration record. VeriSign does not
guarantee its accuracy. By submitting a Whois query, you agree to abide
by the following terms of use: You agree that you may use this Data only
for lawful purposes and that under no circumstances will you use this Data
to: (1) allow, enable, or otherwise support the transmission of mass
unsolicited, commercial advertising or solicitations via e-mail, telephone,
or facsimile; or (2) enable high volume, automated, electronic processes
```

- Domain Name- GOOGLE.COM
- Registrar URL-http://www.markmonitor.com
- Updated Date-2019-09-09T15:39:04Z
- Creation Date-1997-09-15T04:00:00Z
- Contact Us-At +1.8007459229,In Europe, at +44.02032062220

Conclusion: Understood the networking command such as ping,traceroute,whoIs and implemented it.

References:

1. https://en.wikipedia.org/wiki/Hop_(networking)
2. http://docs.netapp.com/ontap-9/index.jsp?topic=%2Fcom.netapp.doc.dot-cm-cmpr-940%2F network traceroute.html
3. https://www.clouddirect.net/knowledge-base/KB0011455/using-traceroute-ping-mtr-and-pathping