Yug Vajani
2018130059
Batch D
Roll no 64

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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 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.

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 receieve 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 reponse 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

```
C:\Users\Yug Vajani>ping -n 10 -l 64 google.com

Pinging google.com [216.58.203.46] with 64 bytes of data:
Reply from 216.58.203.46: bytes=64 time=15ms TTL=116
Reply from 216.58.203.46: bytes=64 time=22ms TTL=116
Reply from 216.58.203.46: bytes=64 time=55ms TTL=116
Reply from 216.58.203.46: bytes=64 time=20ms TTL=116
Reply from 216.58.203.46: bytes=64 time=91ms TTL=116
Reply from 216.58.203.46: bytes=64 time=114ms TTL=116
Reply from 216.58.203.46: bytes=64 time=26ms TTL=116
Reply from 216.58.203.46: bytes=64 time=14ms TTL=116
Reply from 216.58.203.46: bytes=64 time=53ms TTL=116
Reply from 216.58.203.46: bytes=64 time=47ms TTL=116

Ping statistics for 216.58.203.46:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 14ms, Maximum = 114ms, Average = 45ms
```

Observation

IP address 216.58.203.36 is pinged 10 times with 64 bytes packets when host google.com is pinged. The average RTT is 45 ms

```
C:\Users\Yug Vajani>ping -n 10 -l 100 google.com

Pinging google.com [216.58.203.46] with 100 bytes of data:
Reply from 216.58.203.46: bytes=68 (sent 100) time=9ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=10ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=10ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=10ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=19ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=12ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=10ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=104ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=18ms TTL=116
Reply from 216.58.203.46: bytes=68 (sent 100) time=16ms TTL=116

Ping statistics for 216.58.203.46:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 9ms, Maximum = 104ms, Average = 21ms
```

Observation

- When google.com is pinged with 10 packets of size 100 bytes, IP address 216.58.203.36 is pinged. This IP address is different from the previous one.
- The average RTT is 21 ms. The overall time is much less compared to the pinging with 10 byte packets. This could be because this server is faster than the previous one.

```
C:\Users\Yug Vajani>ping -n 10 -l 500 google.com

Pinging google.com [172.217.26.238] with 500 bytes of data:
Reply from 172.217.26.238: bytes=68 (sent 500) time=13ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=15ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=20ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=25ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=90ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=12ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=31ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=13ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=23ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 500) time=16ms TTL=113

Ping statistics for 172.217.26.238:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 12ms, Maximum = 90ms, Average = 25ms
```

Observation

- When google.com is pinged with 10 packets of size 500 bytes, IP address 172.217.26.238 is pinged. This IP address is again different from the previous ones and has average RTT= 25ms.
- So, the server is different for different packet sizes.
- The average RTT is larger than the previous ping results.

```
C:\Users\Yug Vajani>ping -n 10 -l 1000 google.com

Pinging google.com [172.217.26.238] with 1000 bytes of data:
Reply from 172.217.26.238: bytes=68 (sent 1000) time=13ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=13ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=18ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=36ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=17ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=53ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=32ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=12ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=30ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1000) time=13ms TTL=113

Ping statistics for 172.217.26.238:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 12ms, Maximum = 53ms, Average = 23ms
```

Observation

When google.com is pinged with 10 packets of size 1000 bytes, IP address 172.217.26.238 is pinged. This address is the same as that for ping with 500 bytes and the average RTT=23ms.

```
C:\Users\Yug Vajani>ping -n 10 -l 1400 google.com

Pinging google.com [172.217.26.238] with 1400 bytes of data:
Reply from 172.217.26.238: bytes=68 (sent 1400) time=17ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=172ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=198ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=29ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=14ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=93ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=13ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=22ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=66ms TTL=113
Reply from 172.217.26.238: bytes=68 (sent 1400) time=163ms TTL=113

Ping statistics for 172.217.26.238:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 13ms, Maximum = 198ms, Average = 78ms
```

Observation

When google.com is pinged with 10 packets of size 1400 bytes, IP address 172.217.26.238 is pinged. This address is the same as that for ping with 500 bytes and 1000 bytes and average RTT=78ms.

```
C:\Users\Yug Vajani>ping -n 10 -l 64 www.stanford.edu

Pinging 89wyd637cdel.wpeproxy.com [104.18.168.96] with 64 bytes of data:
Reply from 104.18.168.96: bytes=64 time=27ms TTL=55
Reply from 104.18.168.96: bytes=64 time=26ms TTL=55
Reply from 104.18.168.96: bytes=64 time=33ms TTL=55
Reply from 104.18.168.96: bytes=64 time=28ms TTL=55
Reply from 104.18.168.96: bytes=64 time=36ms TTL=55
Reply from 104.18.168.96: bytes=64 time=28ms TTL=55
Reply from 104.18.168.96: bytes=64 time=26ms TTL=55
Reply from 104.18.168.96: bytes=64 time=31ms TTL=55
Reply from 104.18.168.96: bytes=64 time=27ms TTL=55
Reply from 104.18.168.96: bytes=64 time=33ms TTL=55

Ping statistics for 104.18.168.96:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 26ms, Maximum = 36ms, Average = 29ms
```

```
C:\Users\Yug Vajani>ping -n 10 -l 100 www.stanford.edu

Pinging 89wyd637cdel.wpeproxy.com [104.18.168.96] with 100 bytes of data:
Reply from 104.18.168.96: bytes=100 time=29ms TTL=55
Reply from 104.18.168.96: bytes=100 time=27ms TTL=55
Reply from 104.18.168.96: bytes=100 time=32ms TTL=55
Reply from 104.18.168.96: bytes=100 time=29ms TTL=55
Reply from 104.18.168.96: bytes=100 time=28ms TTL=55
Reply from 104.18.168.96: bytes=100 time=27ms TTL=55
Reply from 104.18.168.96: bytes=100 time=28ms TTL=55
Reply from 104.18.168.96: bytes=100 time=130ms TTL=55
Reply from 104.18.168.96: bytes=100 time=28ms TTL=55
Reply from 104.18.168.96: bytes=100 time=27ms TTL=55

Ping statistics for 104.18.168.96:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 27ms, Maximum = 130ms, Average = 38ms
```

```
C:\Users\Yug Vajani>ping -n 10 -l 500 www.stanford.edu

Pinging 89wyd637cdel.wpeproxy.com [104.18.168.96] with 500 bytes of data:
Reply from 104.18.168.96: bytes=500 time=27ms TTL=55
Reply from 104.18.168.96: bytes=500 time=34ms TTL=55
Reply from 104.18.168.96: bytes=500 time=95ms TTL=55
Reply from 104.18.168.96: bytes=500 time=27ms TTL=55
Reply from 104.18.168.96: bytes=500 time=45ms TTL=55
Reply from 104.18.168.96: bytes=500 time=31ms TTL=55
Reply from 104.18.168.96: bytes=500 time=28ms TTL=55
Reply from 104.18.168.96: bytes=500 time=28ms TTL=55
Reply from 104.18.168.96: bytes=500 time=27ms TTL=55
Reply from 104.18.168.96: bytes=500 time=27ms TTL=55

Ping statistics for 104.18.168.96:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 27ms, Maximum = 95ms, Average = 36ms
```

```
C:\Users\Yug Vajani>ping -n 10 -l 1000 www.stanford.edu

Pinging 89wyd637cdel.wpeproxy.com [104.18.168.96] with 1000 bytes of data:
Reply from 104.18.168.96: bytes=1000 time=33ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=29ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=31ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=36ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=32ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=31ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=30ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=35ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=31ms TTL=55
Reply from 104.18.168.96: bytes=1000 time=30ms TTL=55

Ping statistics for 104.18.168.96:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 29ms, Maximum = 36ms, Average = 31ms
```

```
C:\Users\Yug Vajani>ping -n 10 -l 1400 www.stanford.edu

Pinging 89wyd637cdel.wpeproxy.com [104.18.168.96] with 1400 bytes of data:
Reply from 104.18.168.96: bytes=1400 time=31ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=29ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=32ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=36ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=29ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=28ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=82ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=68ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=240ms TTL=55
Reply from 104.18.168.96: bytes=1400 time=163ms TTL=55

Ping statistics for 104.18.168.96:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 28ms, Maximum = 240ms, Average = 73ms
```

Here the avearge RTT is almost in increasing order as the size of packets increase.

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?

Ans. Round-trip time (RTT) is the duration in milliseconds (ms) it takes for a network request to go from a starting point to a destination and back again to the starting point[1].

RTT is an important metric in determining the health of a connection on a local network or the larger Internet, and is commonly utilised by network administrators to diagnose the speed and reliability of network connections.

Delay may differ slightly, depending on the location of the specific pair of communicating endpoints. Engineers usually report both the maximum and average delay, and they divide the delay into several parts[2]:

• Processing delay – time it takes a router to process the packet header, depends on the processing speed of the switch

• Queuing delay – time the packet spends in routing queues depends on the number of packets, size of the packet and bandwidth

• Transmission delay – time it takes to push the packet's bits onto the link depends on size of the packet and the bandwidth of the network.

• Propagation delay – time for a signal to reach its destination depends on distance and propagation speed.

A certain minimum level of delay is experienced by signals due to the time it takes to transmit a packet serially through a link. This delay is extended by more variable levels of delay due to network congestion. IP network delays can range from a few milliseconds to several hundred milliseconds. So yes , Average RTT does vary between different hosts due to queuing delay as we can see in above example the average RTT was calculated for google.com and yahoo.com differs .This is due to propagation delay as it depends on distance and due to queuing delay as the packet may be in queue.

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

Ans. Yes, the average RTT increases with packet size as Queuing delay and Transmission delay increases as they both rely on size of packets eventually increasing the average RTT's

Exercise 1: 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 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\Yug Vajani>ping -n 10 -l 64 www.ox.ac.uk

Pinging www.ox.ac.uk [151.101.130.133] with 64 bytes of data:
Reply from 151.101.130.133: bytes=64 time=369ms TTL=55
Reply from 151.101.130.133: bytes=64 time=26ms TTL=55
Reply from 151.101.130.133: bytes=64 time=31ms TTL=55
Reply from 151.101.130.133: bytes=64 time=78ms TTL=55
Reply from 151.101.130.133: bytes=64 time=285ms TTL=55
Reply from 151.101.130.133: bytes=64 time=110ms TTL=55
Reply from 151.101.130.133: bytes=64 time=54ms TTL=55
Reply from 151.101.130.133: bytes=64 time=69ms TTL=55
Reply from 151.101.130.133: bytes=64 time=48ms TTL=55
Reply from 151.101.130.133: bytes=64 time=85ms TTL=55

Ping statistics for 151.101.130.133:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 26ms, Maximum = 369ms, Average = 115ms
```

Fig.1 Ping www.ox.ac.uk with 64 packet size with packet count 10

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

Pinging www.washington.edu [128.95.155.135] with 64 bytes of data:
Reply from 128.95.155.135: bytes=64 time=286ms TTL=46
Reply from 128.95.155.135: bytes=64 time=277ms TTL=46
Reply from 128.95.155.135: bytes=64 time=338ms TTL=46
Reply from 128.95.155.135: bytes=64 time=351ms TTL=46
Reply from 128.95.155.135: bytes=64 time=291ms TTL=46
Reply from 128.95.155.135: bytes=64 time=294ms TTL=46
Reply from 128.95.155.135: bytes=64 time=263ms TTL=46
Reply from 128.95.155.135: bytes=64 time=268ms TTL=46
Reply from 128.95.155.135: bytes=64 time=268ms TTL=46
Reply from 128.95.155.135: bytes=64 time=337ms TTL=46

Ping statistics for 128.95.155.135:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 263ms, Maximum = 351ms, Average = 297ms
```

Fig.2 Ping uw.edu with 64 packet size with packet count 10

```
C:\Users\Yug Vajani>ping -n 10 -l 64 www.cornell.edu

Pinging ucomm-gw1.cornell.media3.us [20.42.25.107] with 64 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 20.42.25.107:
    Packets: Sent = 10, Received = 0, Lost = 10 (100% loss),
```

Fig.3 Ping www.cornell.edu with 64 packet size with packet count 10

```
C:\Users\Yug Vajani>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=277ms TTL=37
Reply from 35.163.72.93: bytes=64 time=262ms TTL=37
Reply from 35.163.72.93: bytes=64 time=283ms TTL=36
Reply from 35.163.72.93: bytes=64 time=271ms TTL=36
Reply from 35.163.72.93: bytes=64 time=266ms TTL=36
Reply from 35.163.72.93: bytes=64 time=260ms TTL=36
Reply from 35.163.72.93: bytes=64 time=266ms TTL=36
Reply from 35.163.72.93: bytes=64 time=267ms TTL=36
Reply from 35.163.72.93: bytes=64 time=382ms TTL=36
Reply from 35.163.72.93: bytes=64 time=269ms TTL=36

Ping statistics for 35.163.72.93:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 260ms, Maximum = 382ms, Average = 280ms
```

Fig.4 Ping Berkeley.edu with 64 packet size with packet count 10

```
C:\Users\Yug Vajani>ping -n 10 -l 64 www.uchicago.edu

Pinging wsee2.elb.uchicago.edu [3.224.151.213] with 64 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 3.224.151.213:
    Packets: Sent = 10, Received = 0, Lost = 10 (100% loss),
```

Fig.5 Ping www.uchicago.edu with 64 packet size with packet count 10

```
C:\Users\Yug Vajani>ping -n 10 -l 64 www.u-tokyo.ac.jp

Pinging www.u-tokyo.ac.jp [210.152.243.234] with 64 bytes of data:
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 210.152.243.234:
    Packets: Sent = 10, Received = 0, Lost = 10 (100% loss),
```

Fig.6 Ping www.u-tokyo.ac.jp with 64 packet size with packet count 10

Observation

The average RTT varies for different destinations for the same packet size. The reasons for this are:

- **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.[4]

- **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.[3]

- **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.

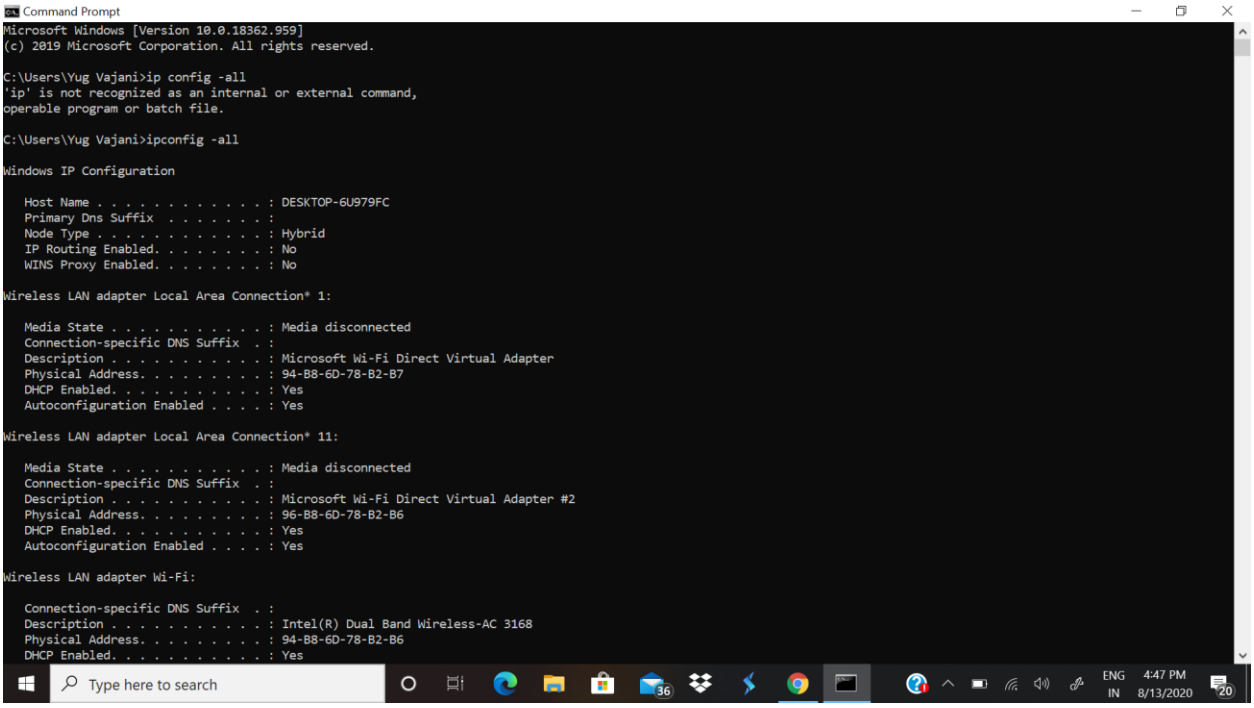
nslookup — The command nslookup <host> will do a DNS query to find and report the IP address (or addresses) for a domain name or the domain name corresponding to an IP address. To do this, it contacts a "DNS server." Default DNS servers are part of a computer's network configuration. (For a static IP 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 nslokup by adding the server name or IP address to the command: nslookup <host> <server>

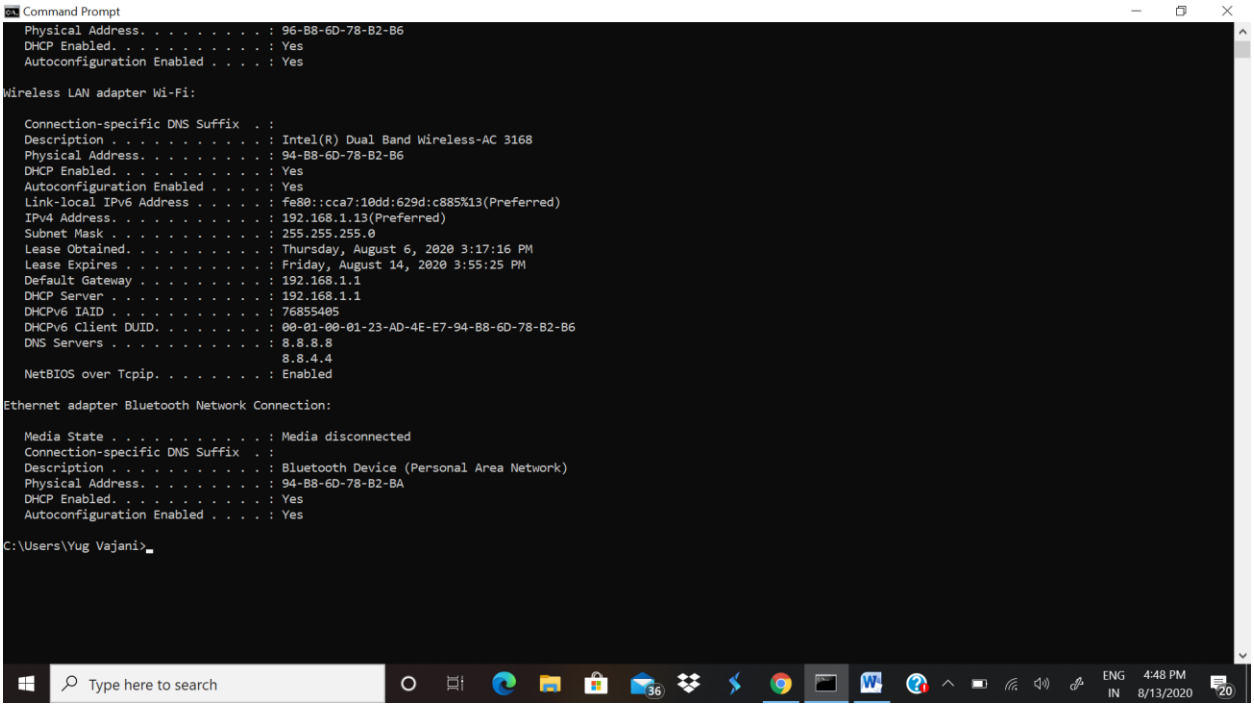
ifconfig — You used ifconfig in the previous lab. When used with no parameters, ifconfig reports some information about the computer's network interfaces. This usually includes lo which stands for localhost; it can be used for communication between programs running on the same computer. Linux often has 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!!!.)

In Windows we use the following command instead of ifconfig

Command – ip config –all

ipconfig (standing for "Internet Protocol configuration") is a console application program of some computer operating systems that displays all current TCP/IP network configuration values and refreshes Dynamic Host Configuration Protocol (DHCP) and Domain Name System (DNS) settings.[1]





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.)

C:\Users\Yug Vajani>netstat -n

Active Connections

Proto	Local Address	Foreign Address	State
TCP	127.0.0.1:49672	127.0.0.1:49673	ESTABLISHED
TCP	127.0.0.1:49673	127.0.0.1:49672	ESTABLISHED
TCP	127.0.0.1:49674	127.0.0.1:49807	ESTABLISHED
TCP	127.0.0.1:49674	127.0.0.1:49855	ESTABLISHED
TCP	127.0.0.1:49675	127.0.0.1:49676	ESTABLISHED
TCP	127.0.0.1:49676	127.0.0.1:49675	ESTABLISHED
TCP	127.0.0.1:49682	127.0.0.1:49963	ESTABLISHED
TCP	127.0.0.1:49690	127.0.0.1:49691	ESTABLISHED
TCP	127.0.0.1:49691	127.0.0.1:49690	ESTABLISHED
TCP	127.0.0.1:49694	127.0.0.1:61900	ESTABLISHED
TCP	127.0.0.1:49695	127.0.0.1:49696	ESTABLISHED
TCP	127.0.0.1:49696	127.0.0.1:49695	ESTABLISHED
TCP	127.0.0.1:49697	127.0.0.1:49698	ESTABLISHED
TCP	127.0.0.1:49698	127.0.0.1:49697	ESTABLISHED
TCP	127.0.0.1:49699	127.0.0.1:61900	ESTABLISHED
TCP	127.0.0.1:49700	127.0.0.1:49701	ESTABLISHED
TCP	127.0.0.1:49701	127.0.0.1:49700	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49726	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49730	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49731	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49732	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49734	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49737	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49750	ESTABLISHED
TCP	127.0.0.1:49707	127.0.0.1:49771	ESTABLISHED
TCP	127.0.0.1:49717	127.0.0.1:49718	ESTABLISHED
TCP	127.0.0.1:49718	127.0.0.1:49717	ESTABLISHED
TCP	127.0.0.1:49719	127.0.0.1:61900	ESTABLISHED
TCP	127.0.0.1:49720	127.0.0.1:49721	ESTABLISHED
TCP	127.0.0.1:49721	127.0.0.1:49720	ESTABLISHED
TCP	127.0.0.1:49726	127.0.0.1:49707	ESTABLISHED
TCP	127.0.0.1:49730	127.0.0.1:49707	ESTABLISHED
TCP	127.0.0.1:49731	127.0.0.1:49707	ESTABLISHED
TCP	127.0.0.1:49732	127.0.0.1:49707	ESTABLISHED
TCP	127.0.0.1:49734	127.0.0.1:49707	ESTABLISHED
TCP	127.0.0.1:49737	127.0.0.1:49707	ESTABLISHED

```
TCP    127.0.0.1:49741        127.0.0.1:49742        ESTABLISHED
TCP    127.0.0.1:49742        127.0.0.1:49741        ESTABLISHED
TCP    127.0.0.1:49743        127.0.0.1:61900        ESTABLISHED
TCP    127.0.0.1:49744        127.0.0.1:49745        ESTABLISHED
TCP    127.0.0.1:49745        127.0.0.1:49744        ESTABLISHED
TCP    127.0.0.1:49746        127.0.0.1:49747        ESTABLISHED
TCP    127.0.0.1:49747        127.0.0.1:49746        ESTABLISHED
TCP    127.0.0.1:49750        127.0.0.1:49707        ESTABLISHED
TCP    127.0.0.1:49771        127.0.0.1:49707        ESTABLISHED
TCP    127.0.0.1:49772        127.0.0.1:49773        ESTABLISHED
TCP    127.0.0.1:49773        127.0.0.1:49772        ESTABLISHED
TCP    127.0.0.1:49805        127.0.0.1:49806        ESTABLISHED
TCP    127.0.0.1:49806        127.0.0.1:49805        ESTABLISHED
TCP    127.0.0.1:49807        127.0.0.1:49674        ESTABLISHED
TCP    127.0.0.1:49808        127.0.0.1:49809        ESTABLISHED
TCP    127.0.0.1:49809        127.0.0.1:49808        ESTABLISHED
TCP    127.0.0.1:49853        127.0.0.1:49854        ESTABLISHED
TCP    127.0.0.1:49854        127.0.0.1:49853        ESTABLISHED
TCP    127.0.0.1:49855        127.0.0.1:49674        ESTABLISHED
TCP    127.0.0.1:49856        127.0.0.1:49857        ESTABLISHED
TCP    127.0.0.1:49857        127.0.0.1:49856        ESTABLISHED
TCP    127.0.0.1:49963        127.0.0.1:49682        ESTABLISHED
TCP    127.0.0.1:50421        127.0.0.1:50422        ESTABLISHED
TCP    127.0.0.1:50422        127.0.0.1:50421        ESTABLISHED
TCP    127.0.0.1:50458        127.0.0.1:50459        ESTABLISHED
TCP    127.0.0.1:50459        127.0.0.1:50458        ESTABLISHED
TCP    127.0.0.1:50493        127.0.0.1:50494        ESTABLISHED
TCP    127.0.0.1:50494        127.0.0.1:50493        ESTABLISHED
TCP    127.0.0.1:61900        127.0.0.1:49694        ESTABLISHED
TCP    127.0.0.1:61900        127.0.0.1:49699        ESTABLISHED
TCP    127.0.0.1:61900        127.0.0.1:49719        ESTABLISHED
TCP    127.0.0.1:61900        127.0.0.1:49743        ESTABLISHED
TCP    192.168.1.13:50356     40.90.189.152:443      ESTABLISHED
TCP    192.168.1.13:50526     49.44.206.37:443       ESTABLISHED
TCP    192.168.1.13:50534     49.44.206.37:443       ESTABLISHED
TCP    192.168.1.13:50535     49.44.206.37:443       ESTABLISHED
TCP    192.168.1.13:50541     49.44.205.227:80       CLOSE_WAIT
TCP    192.168.1.13:50552     5.62.54.89:80          ESTABLISHED
TCP    192.168.1.13:50569     74.125.24.188:5228     ESTABLISHED
TCP    192.168.1.13:50592     5.45.58.137:80         ESTABLISHED
TCP    192.168.1.13:50612     8.8.8.8:443            ESTABLISHED
TCP    192.168.1.13:50633     157.240.16.52:443      ESTABLISHED
TCP    192.168.1.13:50666     172.217.160.195:443    ESTABLISHED
TCP    192.168.1.13:50682     216.58.199.227:443     TIME_WAIT
```

```
  TCP    192.168.1.13:50683     216.58.199.227:443     ESTABLISHED
  TCP    192.168.1.13:50684     8.8.4.4:443            ESTABLISHED
  TCP    192.168.1.13:50685     216.58.203.46:443      ESTABLISHED
  TCP    192.168.1.13:50687     204.79.197.200:443     ESTABLISHED
  TCP    192.168.1.13:50688     13.233.45.163:80       TIME_WAIT
  TCP    192.168.1.13:50690     13.107.246.254:443     ESTABLISHED
  TCP    192.168.1.13:50691     13.107.136.254:443     ESTABLISHED
  TCP    192.168.1.13:50692     13.107.53.254:443      ESTABLISHED
  TCP    192.168.1.13:50693     204.79.197.222:443     ESTABLISHED
  TCP    192.168.1.13:50694     157.240.16.52:443      ESTABLISHED
  TCP    192.168.1.13:50695     13.233.45.163:80       TIME_WAIT
  TCP    192.168.1.13:50696     49.44.194.49:80        TIME_WAIT
  TCP    [::1]:49683            [::1]:49684            ESTABLISHED
  TCP    [::1]:49684            [::1]:49683            ESTABLISHED
  TCP    [::1]:49685            [::1]:49686            ESTABLISHED
  TCP    [::1]:49686            [::1]:49685            ESTABLISHED
  TCP    [::1]:49687            [::1]:49689            ESTABLISHED
  TCP    [::1]:49688            [::1]:49692            ESTABLISHED
  TCP    [::1]:49689            [::1]:49687            ESTABLISHED
  TCP    [::1]:49692            [::1]:49688            ESTABLISHED
```

telnet — Telnet is an old program for remote login. It's not used so much for that any more, since it has no security features. But basically, all it does is open a connection to a server and allow server and client to send lines of plain text to each other. It can be used to check that it's possible to connect to a server and, if the server communicates in plain text, even to interact with the server by hand. Since the Web uses a plain text protocol, you can use telnet to connect to a web client and play the part of the web browser. I will suggest that you to do this with your own web server when you write it, but you might want to try it now. When you use telnet in this way, you need to specify both the host and the port number to which you want to connect: telent <host> <port>. For example, to connect to the web server on www.spit.ac.in: telnet spit.ac.in 80

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., cs.iitb.ac.in) or an IP address (e.g., 128.105.2.6).

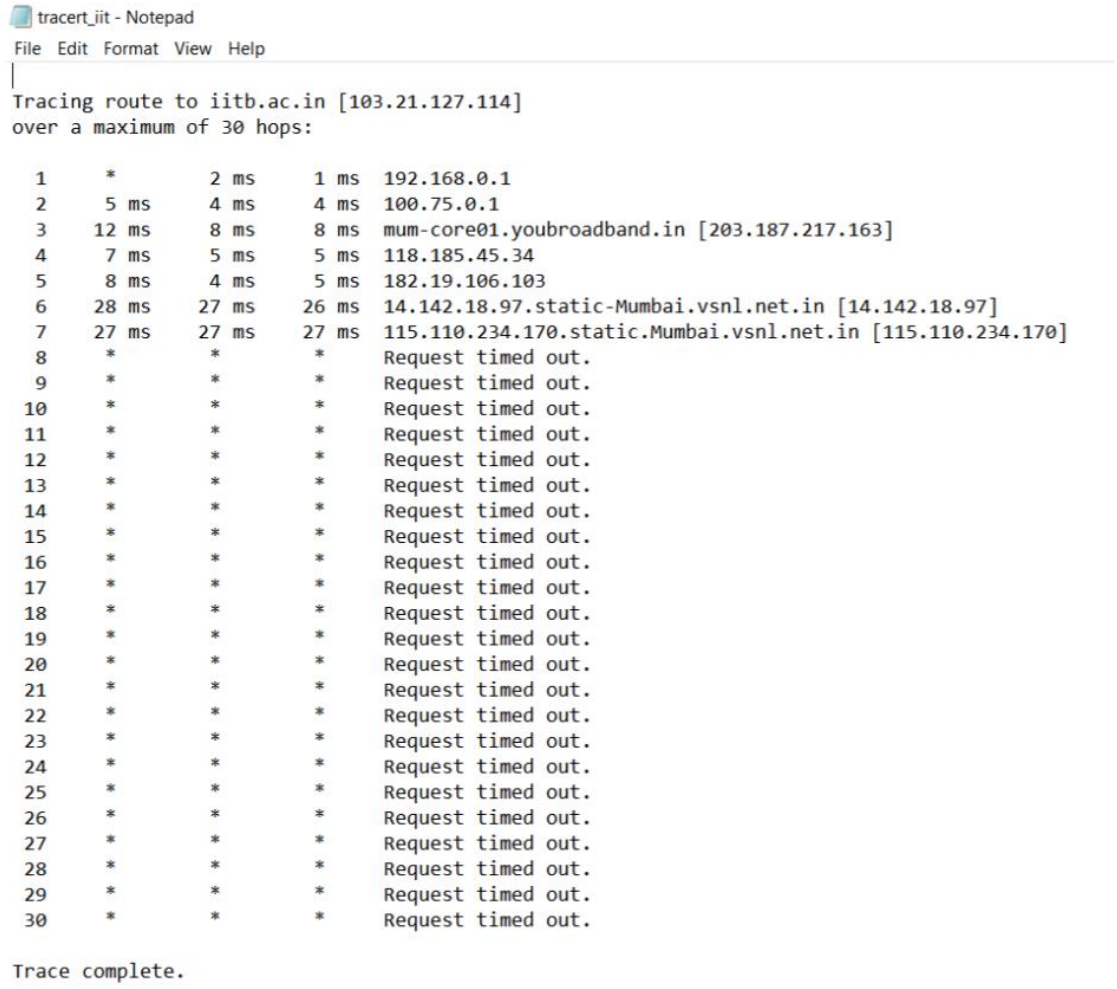
1.2.1 EXPERIMENTS WITH TRACEROUTE

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).

Tracing route to iit.ac.in



tracert_iit - Notepad

File Edit Format View Help

```
Tracing route to iitb.ac.in [103.21.127.114]
over a maximum of 30 hops:

  1     *        2 ms     1 ms  192.168.0.1
  2     5 ms     4 ms     4 ms  100.75.0.1
  3    12 ms     8 ms     8 ms  mum-core01.youbroadband.in [203.187.217.163]
  4     7 ms     5 ms     5 ms  118.185.45.34
  5     8 ms     4 ms     5 ms  182.19.106.103
  6    28 ms    27 ms    26 ms  14.142.18.97.static-Mumbai.vsnl.net.in [14.142.18.97]
  7    27 ms    27 ms    27 ms  115.110.234.170.static.Mumbai.vsnl.net.in [115.110.234.170]
  8     *        *        *     Request timed out.
  9     *        *        *     Request timed out.
 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.
```

Tracing route to mscs.mu.edu

tracert_mscs - Notepad

File Edit Format View Help

```
Tracing route to mscs.mu.edu [134.48.4.5]
over a maximum of 30 hops:

  1     1 ms     1 ms     1 ms  192.168.0.1
  2    94 ms     6 ms     5 ms  100.75.0.1
  3     9 ms    10 ms     8 ms  mum-core01.youbroadband.in [203.187.217.163]
  4     8 ms     4 ms     5 ms  118.185.45.34
  5   110 ms   108 ms   135 ms  xe-8-3-2.mlu.cw.net [195.89.101.185]
  6   198 ms   192 ms   193 ms  ae0-xcr1.mlb.cw.net [195.2.25.98]
  7   193 ms     *      195 ms  ae4-pcr1.ptl.cw.net [195.2.9.89]
  8   187 ms   189 ms   187 ms  et-7-1-0-xcr1.nyh.cw.net [195.2.24.241]
  9   192 ms   192 ms   193 ms  ae3-xcr2.ash.cw.net [195.2.25.41]
 10   193 ms   193 ms   195 ms  lag-16.ear1.WashingtonDC12.Level3.net [4.68.39.77]
 11     *        *        *     Request timed out.
 12   211 ms   212 ms   212 ms  MARQUETTE-U.ear3.Chicago2.Level3.net [4.16.38.70]
 13   212 ms   212 ms   212 ms  134.48.10.26
 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.
```

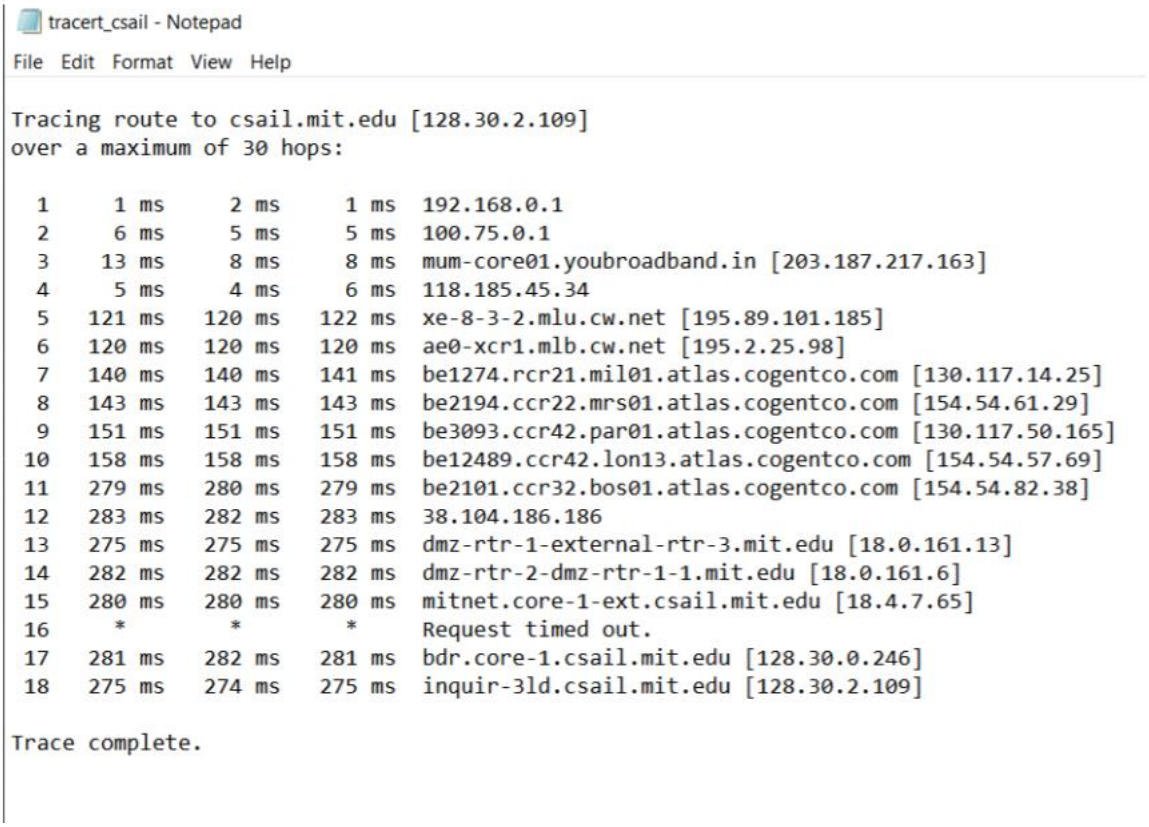
Tracing route to www.cs.grinnell.edu

tracert_grinell - Notepad

File Edit Format View Help

```
Tracing route to www.cs.grinnell.edu [132.161.132.159]
over a maximum of 30 hops:

  1     2 ms     2 ms     1 ms  192.168.0.1
  2     5 ms     4 ms     5 ms  100.75.0.1
  3     9 ms    14 ms    23 ms  mum-core01.youbroadband.in [203.187.217.163]
  4     5 ms     5 ms     5 ms  118.185.45.34
  5   109 ms   109 ms   110 ms  xe-8-3-2.mlu.cw.net [195.89.101.185]
  6   129 ms   129 ms   129 ms  mno-b2-link.telia.net [62.115.175.10]
  7   221 ms   221 ms   221 ms  prs-bb3-link.telia.net [62.115.116.154]
  8   220 ms   221 ms   220 ms  ldn-bb3-link.telia.net [62.115.134.93]
  9     *        *        *     Request timed out.
 10   210 ms     *      210 ms  chi-b23-link.telia.net [62.115.137.59]
 11   219 ms   220 ms   220 ms  omha-b1-link.telia.net [62.115.143.183]
 12   219 ms   219 ms   220 ms  aureon-ic-337963-omha-b1.c.telia.net [62.115.46.231]
 13   280 ms   277 ms   276 ms  ins-oc4-lo0.omah.netins.net [167.142.66.77]
 14   270 ms   270 ms   270 ms  ins-wc1-0-0-1-7.wdmn.netins.net [167.142.67.73]
 15   270 ms   270 ms   274 ms  ins-wc2-et-0-0-1-6.wdmn.netins.net [167.142.67.85]
 16   283 ms   282 ms   282 ms  167.142.58.40
 17   274 ms   273 ms   273 ms  67.224.64.62
 18   284 ms   283 ms   284 ms  grinnellcollege1.desm.netins.net [167.142.65.43]
 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.
```

Tracing route to csail.mit.edu



tracert_csail - Notepad

File Edit Format View Help

```
Tracing route to csail.mit.edu [128.30.2.109]
over a maximum of 30 hops:

  1     1 ms     2 ms     1 ms  192.168.0.1
  2     6 ms     5 ms     5 ms  100.75.0.1
  3    13 ms     8 ms     8 ms  mum-core01.youbroadband.in [203.187.217.163]
  4     5 ms     4 ms     6 ms  118.185.45.34
  5   121 ms   120 ms   122 ms  xe-8-3-2.mlu.cw.net [195.89.101.185]
  6   120 ms   120 ms   120 ms  ae0-xcr1.mlb.cw.net [195.2.25.98]
  7   140 ms   140 ms   141 ms  be1274.rcr21.mil01.atlas.cogentco.com [130.117.14.25]
  8   143 ms   143 ms   143 ms  be2194.ccr22.mrs01.atlas.cogentco.com [154.54.61.29]
  9   151 ms   151 ms   151 ms  be3093.ccr42.par01.atlas.cogentco.com [130.117.50.165]
 10   158 ms   158 ms   158 ms  be12489.ccr42.lon13.atlas.cogentco.com [154.54.57.69]
 11   279 ms   280 ms   279 ms  be2101.ccr32.bos01.atlas.cogentco.com [154.54.82.38]
 12   283 ms   282 ms   283 ms  38.104.186.186
 13   275 ms   275 ms   275 ms  dmz-rtr-1-external-rtr-3.mit.edu [18.0.161.13]
 14   282 ms   282 ms   282 ms  dmz-rtr-2-dmz-rtr-1-1.mit.edu [18.0.161.6]
 15   280 ms   280 ms   280 ms  mitnet.core-1-ext.csail.mit.edu [18.4.7.65]
 16     *        *        *     Request timed out.
 17   281 ms   282 ms   281 ms  bdr.core-1.csail.mit.edu [128.30.0.246]
 18   275 ms   274 ms   275 ms  inquir-3ld.csail.mit.edu [128.30.2.109]

Trace complete.
```

Tracing route to cs.stanford.edu

traceroute_cs.stanford - Notepad

File Edit Format View Help

```
Tracing route to cs.stanford.edu [171.64.64.64]
over a maximum of 30 hops:

  1    <1 ms     1 ms    <1 ms  192.168.1.1
  2     9 ms     9 ms     8 ms  DESKTOP-6U979FC [0.0.0.0]
  3   103 ms   124 ms    13 ms  125.99.88.133
  4    17 ms     9 ms    12 ms  203.212.193.30
  5    19 ms     9 ms   118 ms  202.88.130.245
  6    10 ms    18 ms     9 ms  mail.megtec.in [125.99.119.2]
  7    20 ms    19 ms    12 ms  136.232.27.245.static.jio.com [136.232.27.245]
  8    10 ms    10 ms    48 ms  49.45.4.253
  9   241 ms   161 ms   142 ms  103.198.140.54
 10   107 ms   106 ms   105 ms  103.198.140.54
 11   136 ms   145 ms   135 ms  hurricane-electric.telecity2.nl-ix.net [193.239.116.14]
 12   150 ms   137 ms   141 ms  100ge8-1.core1.lon3.he.net [184.104.193.193]
 13   172 ms   141 ms   157 ms  100ge14-1.core1.lon2.he.net [184.105.64.237]
 14   199 ms   203 ms   199 ms  100ge13-2.core1.nyc4.he.net [72.52.92.166]
 15   276 ms   258 ms   257 ms  100ge8-1.core1.sjc2.he.net [184.105.81.218]
 16   259 ms   254 ms   254 ms  100ge1-1.core1.pao1.he.net [72.52.92.158]
 17   259 ms   254 ms   254 ms  stanford-university.100gigabitethernet5-1.core1.pao1.he.net [184.105.177.238]
 18   262 ms   259 ms   379 ms  csee-west-rtr-vl3.SUNet [171.66.255.140]
 19   287 ms   258 ms   265 ms  CS.stanford.edu [171.64.64.64]

Trace complete.
```

Tracing route to cs.machester.ac.uk

tracert_manchester - Notepad

File Edit Format View Help

```
Tracing route to cs.manchester.ac.uk [130.88.101.49]
over a maximum of 30 hops:

  1     2 ms     2 ms     2 ms  192.168.0.1
  2     5 ms     5 ms     5 ms  100.75.0.1
  3    34 ms    11 ms     9 ms  mum-core01.youbroadband.in [203.187.217.163]
  4     6 ms     6 ms     6 ms  118.185.45.34
  5   123 ms   124 ms   122 ms  xe-8-3-2.mlu.cw.net [195.89.101.185]
  6   141 ms   142 ms   142 ms  mno-b2-link.telia.net [62.115.175.10]
  7   169 ms   169 ms     *     prs-bb4-link.telia.net [62.115.116.168]
  8   167 ms     *        *     ldn-bb4-link.telia.net [62.115.114.228]
  9     *      261 ms   169 ms  ldn-b2-link.telia.net [62.115.120.239]
 10   136 ms   136 ms   136 ms  jisc-ic-345131-ldn-b4.c.telia.net [62.115.175.131]
 11   137 ms   137 ms   137 ms  ae24.londhx-sbr1.ja.net [146.97.35.197]
 12   138 ms   137 ms   141 ms  ae29.londpg-sbr2.ja.net [146.97.33.2]
 13   141 ms   141 ms   141 ms  ae31.erdiss-sbr2.ja.net [146.97.33.22]
 14   142 ms   142 ms   142 ms  ae29.manckh-sbr2.ja.net [146.97.33.42]
 15   142 ms   142 ms   143 ms  ae23.mancrh-rbr1.ja.net [146.97.38.42]
 16   143 ms     *        *     universityofmanchester.ja.net [146.97.169.2]
 17   144 ms   145 ms   143 ms  130.88.249.194
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20   143 ms   143 ms   143 ms  eps.its.man.ac.uk [130.88.101.49]

Trace complete.
```

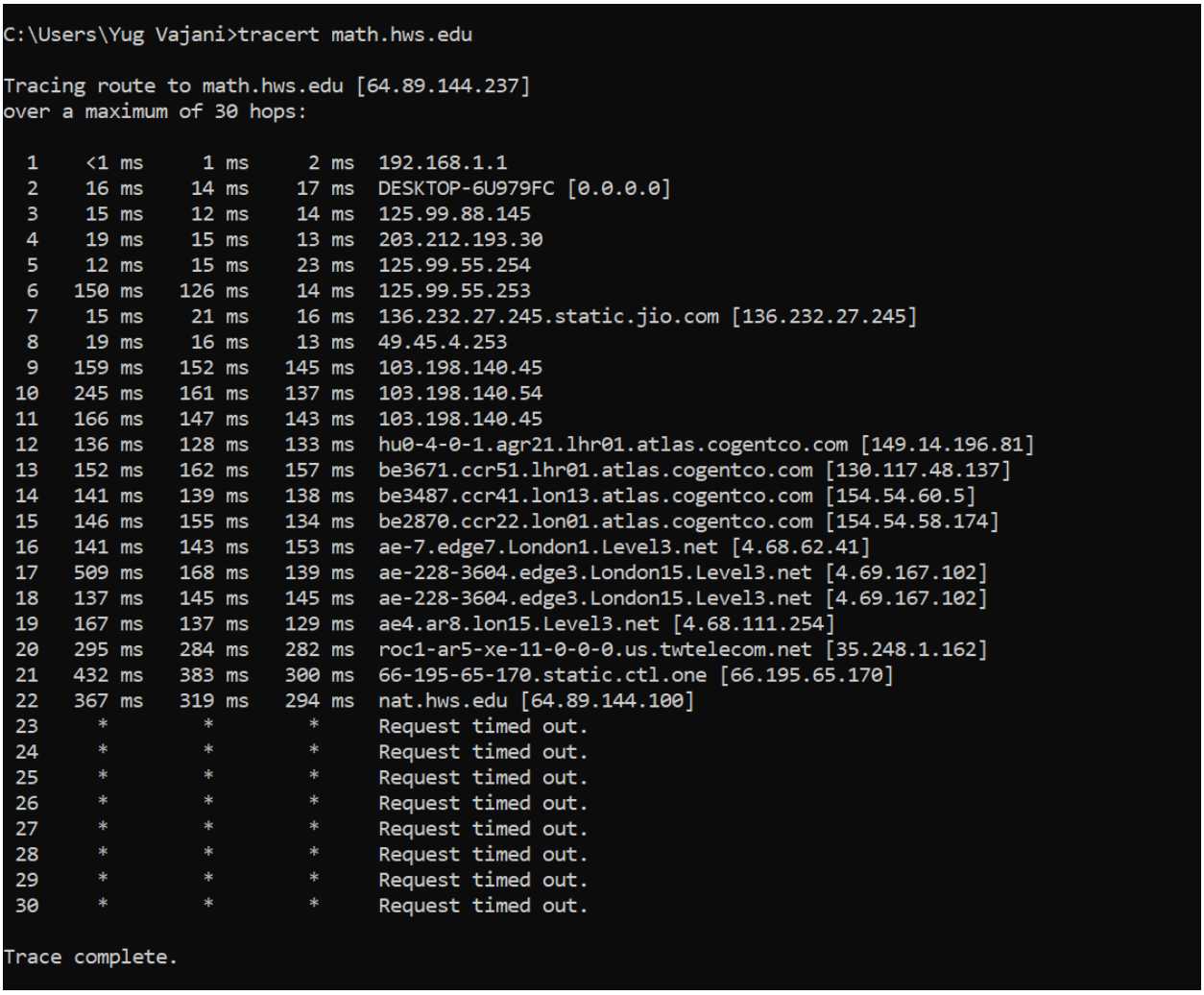
Exercise 2: (Very short.) Use traceroute to trace the route from your computer to math.hws.edu and to www.hws.edu. Explain the difference in the results.

```
C:\Users\Yug Vajani>tracert math.hws.edu

Tracing route to math.hws.edu [64.89.144.237]
over a maximum of 30 hops:

  1    <1 ms     1 ms     2 ms  192.168.1.1
  2    16 ms    14 ms    17 ms  DESKTOP-6U979FC [0.0.0.0]
  3    15 ms    12 ms    14 ms  125.99.88.145
  4    19 ms    15 ms    13 ms  203.212.193.30
  5    12 ms    15 ms    23 ms  125.99.55.254
  6   150 ms   126 ms    14 ms  125.99.55.253
  7    15 ms    21 ms    16 ms  136.232.27.245.static.jio.com [136.232.27.245]
  8    19 ms    16 ms    13 ms  49.45.4.253
  9   159 ms   152 ms   145 ms  103.198.140.45
 10   245 ms   161 ms   137 ms  103.198.140.54
 11   166 ms   147 ms   143 ms  103.198.140.45
 12   136 ms   128 ms   133 ms  hu0-4-0-1.agr21.lhr01.atlas.cogentco.com [149.14.196.81]
 13   152 ms   162 ms   157 ms  be3671.ccr51.lhr01.atlas.cogentco.com [130.117.48.137]
 14   141 ms   139 ms   138 ms  be3487.ccr41.lon13.atlas.cogentco.com [154.54.60.5]
 15   146 ms   155 ms   134 ms  be2870.ccr22.lon01.atlas.cogentco.com [154.54.58.174]
 16   141 ms   143 ms   153 ms  ae-7.edge7.London1.Level3.net [4.68.62.41]
 17   509 ms   168 ms   139 ms  ae-228-3604.edge3.London15.Level3.net [4.69.167.102]
 18   137 ms   145 ms   145 ms  ae-228-3604.edge3.London15.Level3.net [4.69.167.102]
 19   167 ms   137 ms   129 ms  ae4.ar8.lon15.Level3.net [4.68.111.254]
 20   295 ms   284 ms   282 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
 21   432 ms   383 ms   300 ms  66-195-65-170.static.ctl.one [66.195.65.170]
 22   367 ms   319 ms   294 ms  nat.hws.edu [64.89.144.100]
 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\Yug Vajani>tracert www.hws.edu

Tracing route to www.hws.edu [64.89.145.159]
over a maximum of 30 hops:

  1     2 ms     5 ms     1 ms  192.168.1.1
  2    14 ms     9 ms    14 ms  DESKTOP-6U979FC [0.0.0.0]
  3    34 ms    16 ms    11 ms  125.99.88.133
  4    15 ms     9 ms    16 ms  203.212.193.30
  5    14 ms    14 ms    18 ms  125.99.55.254
  6    17 ms    69 ms    13 ms  125.99.55.253
  7    90 ms    25 ms    51 ms  136.232.27.245.static.jio.com [136.232.27.245]
  8    86 ms    86 ms    91 ms  49.45.4.253
  9   147 ms   143 ms   150 ms  103.198.140.45
 10   221 ms   216 ms   213 ms  103.198.140.29
 11   138 ms   141 ms   142 ms  103.198.140.45
 12   226 ms   198 ms   222 ms  hu0-4-0-1.agr21.lhr01.atlas.cogentco.com [149.14.196.81]
 13   138 ms   139 ms   136 ms  be3671.ccr51.lhr01.atlas.cogentco.com [130.117.48.137]
 14   150 ms   141 ms   141 ms  be3487.ccr41.lon13.atlas.cogentco.com [154.54.60.5]
 15   143 ms   153 ms   143 ms  be2870.ccr22.lon01.atlas.cogentco.com [154.54.58.174]
 16     *      133 ms     *     lag-3.ear2.London2.Level3.net [4.68.72.185]
 17   125 ms   126 ms   143 ms  ae-118-3504.edge3.London15.Level3.net [4.69.167.86]
 18   139 ms   131 ms   138 ms  ae-118-3504.edge3.London15.Level3.net [4.69.167.86]
 19   131 ms   139 ms   130 ms  ae4.ar8.lon15.Level3.net [4.68.111.254]
 20   276 ms   362 ms   265 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
 21   312 ms   281 ms   373 ms  66-195-65-170.static.ctl.one [66.195.65.170]
 22   280 ms   322 ms   362 ms  nat.hws.edu [64.89.144.100]
 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.
```

From the above results, we can see that the source i.e. the first hop is the same and some variations in the round trip time can be observed. The first column shows that process of routing has started and the last column shows the default gateway. The route remains the same upto the ISP and after the ISP the the route is different.

Exercise 3: 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\Yug Vajani>tracert math.hws.edu

Tracing route to math.hws.edu [64.89.144.237]
over a maximum of 30 hops:

  1    <1 ms     1 ms     2 ms  192.168.1.1
  2    16 ms    14 ms    17 ms  DESKTOP-6U979FC [0.0.0.0]
  3    15 ms    12 ms    14 ms  125.99.88.145
  4    19 ms    15 ms    13 ms  203.212.193.30
  5    12 ms    15 ms    23 ms  125.99.55.254
  6   150 ms   126 ms    14 ms  125.99.55.253
  7    15 ms    21 ms    16 ms  136.232.27.245.static.jio.com [136.232.27.245]
  8    19 ms    16 ms    13 ms  49.45.4.253
  9   159 ms   152 ms   145 ms  103.198.140.45
 10   245 ms   161 ms   137 ms  103.198.140.54
 11   166 ms   147 ms   143 ms  103.198.140.45
 12   136 ms   128 ms   133 ms  hu0-4-0-1.agr21.lhr01.atlas.cogentco.com [149.14.196.81]
 13   152 ms   162 ms   157 ms  be3671.ccr51.lhr01.atlas.cogentco.com [130.117.48.137]
 14   141 ms   139 ms   138 ms  be3487.ccr41.lon13.atlas.cogentco.com [154.54.60.5]
 15   146 ms   155 ms   134 ms  be2870.ccr22.lon01.atlas.cogentco.com [154.54.58.174]
 16   141 ms   143 ms   153 ms  ae-7.edge7.London1.Level3.net [4.68.62.41]
 17   509 ms   168 ms   139 ms  ae-228-3604.edge3.London15.Level3.net [4.69.167.102]
 18   137 ms   145 ms   145 ms  ae-228-3604.edge3.London15.Level3.net [4.69.167.102]
 19   167 ms   137 ms   129 ms  ae4.ar8.lon15.Level3.net [4.68.111.254]
 20   295 ms   284 ms   282 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
 21   432 ms   383 ms   300 ms  66-195-65-170.static.ctl.one [66.195.65.170]
 22   367 ms   319 ms   294 ms  nat.hws.edu [64.89.144.100]
 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.
```

Traceroute to math.hws.edu on 19/08/2020

```
C:\Users\Yug Vajani>tracert -h 30 math.hws.edu

Tracing route to math.hws.edu [64.89.144.237]
over a maximum of 30 hops:

  1    24 ms    <1 ms     1 ms  192.168.1.1
  2    10 ms     8 ms    12 ms  DESKTOP-6U979FC [0.0.0.0]
  3    11 ms     8 ms    16 ms  125.99.88.133
  4     9 ms     9 ms    18 ms  203.212.193.30
  5    13 ms    13 ms    20 ms  202.88.130.245
  6     8 ms    19 ms    10 ms  mail.megtec.in [125.99.119.2]
  7    13 ms    10 ms    11 ms  136.232.27.245.static.jio.com [136.232.27.245]
  8    12 ms    16 ms    12 ms  49.45.4.253
  9   143 ms   148 ms   146 ms  103.198.140.45
 10   139 ms   137 ms   141 ms  103.198.140.54
 11   139 ms   138 ms   138 ms  103.198.140.45
 12   133 ms   133 ms   135 ms  hu0-4-0-1.agr21.lhr01.atlas.cogentco.com [149.14.196.81]
 13   132 ms   135 ms   162 ms  be3671.ccr51.lhr01.atlas.cogentco.com [130.117.48.137]
 14   134 ms   174 ms   133 ms  be3487.ccr41.lon13.atlas.cogentco.com [154.54.60.5]
 15   147 ms   147 ms   145 ms  be2870.ccr22.lon01.atlas.cogentco.com [154.54.58.174]
 16     *      141 ms   140 ms  lag-3.ear2.London2.Level3.net [4.68.72.185]
 17   143 ms   142 ms   145 ms  ae-115-3501.edge3.London15.Level3.net [4.69.167.74]
 18   189 ms   141 ms   269 ms  ae-115-3501.edge3.London15.Level3.net [4.69.167.74]
 19   335 ms   157 ms   142 ms  ae4.ar8.lon15.Level3.net [4.68.111.254]
 20   366 ms   305 ms   306 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
 21   272 ms   272 ms   276 ms  66-195-65-170.static.ctl.one [66.195.65.170]
 22   278 ms   272 ms   293 ms  nat.hws.edu [64.89.144.100]
 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.
```

Traceroute to math.hws.edu on 26/08/2020

From the above experiments, I can conclude that for the same source and same destination, the packets sent at different times have different RTT's and take different paths through the net, which is clear from above figures.

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 tracerouted?

   Ans. Yes, the path to my ISP is always the same, and then the path depends on which access point is ready to respond.

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?

   Ans. There is a proportional relationship between the number of nodes that show up in the traceroute and the loacation of the host.

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?

   Ans. Since the two hosts were of the same institution there were certain nodes that were common on running the tracert command. There is a direct relationship between the number of nodes and the latency of the host. The amount of latency is largely dependent on how far the visitor is from the server location and how many nodes the signal has to travel through.

Whois — The *whois* command can give detailed information about domain names and IP saddresses. 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.

Exercise 5: (Should be short.) Because of NAT, the domain name *spit.ac.in* has a different IP address outside of SPIT than it does on campus. Using information in this lab and working on a home computer, find the outside IP address for spit.ac.in. Explain how you did it.

Geolocation — A geolocation service tries to tell, approximately, where a given IP address is located physically. They can't be completely accurate—but they probably get at least the country right most of the time.

This geolocation program is not installed on our computers, but you can access one on the command line using the *curl* command, which can send HTTP requests and display the response. The following command uses *curl* to contact a public web service that will look up an IP address for you: curl ipinfo.io/<IP-address>. For a specific example:

curl ipinfo.io/129.64.99.200

```
C:\Users\Yug Vajani>curl ipinfo.io/124.64.99.200
{
  "ip": "124.64.99.200",
  "city": "Beijing",
  "region": "Beijing",
  "country": "CN",
  "loc": "39.9075,116.3972",
  "org": "AS4808 China Unicom Beijing Province Network",
  "timezone": "Asia/Shanghai",
  "readme": "https://ipinfo.io/missingauth"
}
C:\Users\Yug Vajani>
```

(As you can see, you get back more than just the location.)

Exercise 6: Find a few IP addresses that are connected to the web server on spit.ac.in right now, and determine where those IP addresses are located. (I'm expecting that there will be several; if not, try again in a few minutes or sometime later.) Find one that is far from Geneva, NY. Explain how you did it.

CONCLUSION:

Successfully implemented basic command line Networking utilities namely ping, ifconfig and traceroute and observed variations in the outputs for each, thereby gaining further knowledge about the sending and receiving of packets.

- Different routes are chosen for different packet sizes i.e. the route taken for 10 byte sized packets may be different than the route taken by 100 bytes packets.
- Distance plays a role in time taken to transfer packets.
- Also learned about some basic command line network utilities.

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