

DCCN - 2

Ping Command

Ping is a command-line utility, available on virtually any operating system with network connectivity, that acts as a test to see if a networked device is reachable. The ping command sends a request over the network to a specific device. A successful ping results in a response from the computer that was pinged back to the originating computer. It is used to check the network connectivity between host and server/host. This command takes as input the IP address or the URL and sends a data packet to the specified address with the message "PING" and get a response from the server/host this time is recorded which is called latency. Fast ping low latency means faster connection.

The ping command operates by sending Internet Control Message Protocol (ICMP) Echo Request messages to the destination computer and waiting for a response. How many of those responses are returned, and how long it takes for them to return, are the two major pieces of information that the ping command provides.

Round-trip time (RTT) is the duration, measured in milliseconds, from when a browser sends a request to when it receives a response from a server. It's a key performance metric for web applications and one of the main factors, along with Time to First Byte (TTFB), when measuring page load time and network latency.

Experiments :

1. Ping a host 10 times with packet size of 64:

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

Pinging google.com [172.217.160.174] with 64 bytes of data:
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119
Reply from 172.217.160.174: bytes=64 time=2ms TTL=119
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119
Reply from 172.217.160.174: bytes=64 time=10ms TTL=119
Reply from 172.217.160.174: bytes=64 time=2ms TTL=119
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119
Reply from 172.217.160.174: bytes=64 time=3ms TTL=119

Ping statistics for 172.217.160.174:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 2ms, Maximum = 10ms, Average = 3ms
```

2. Ping a host 10 times with packet size of 100:

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

Pinging google.com [172.217.160.174] with 100 bytes of data:
Reply from 172.217.160.174: bytes=68 (sent 100) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 100) time=3ms TTL=119

Ping statistics for 172.217.160.174:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 3ms, Average = 2ms
```

3. Ping a host 10 times with packet size of 500:

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

Pinging google.com [172.217.160.174] with 500 bytes of data:
Reply from 172.217.160.174: bytes=68 (sent 500) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=5ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=11ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=6ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 500) time=3ms TTL=119

Ping statistics for 172.217.160.174:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 11ms, Average = 4ms
```

4. Ping a host 10 times with packet size of 1000:

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

Pinging google.com [172.217.160.174] with 1000 bytes of data:
Reply from 172.217.160.174: bytes=68 (sent 1000) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=16ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1000) time=3ms TTL=119

Ping statistics for 172.217.160.174:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 2ms, Maximum = 16ms, Average = 4ms
```

5. Ping a host 10 times with packet size of 1400:

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

Pinging google.com [172.217.160.174] with 1400 bytes of data:
Reply from 172.217.160.174: bytes=68 (sent 1400) time=7ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=6ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=2ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=4ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=5ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=3ms TTL=119
Reply from 172.217.160.174: bytes=68 (sent 1400) time=25ms TTL=119

Ping statistics for 172.217.160.174:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 2ms, Maximum = 25ms, Average = 6ms
```

Questions About Latency:

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

Average RTT varies between different hosts. There are many factors that affect RTT, including propagation delay, processing delay, queueing delay, encoding delay as well as physical distance.

Following are the list of factors :

- The nature of the transmission medium - the way in which connections are made affects how fast the connection moves; connections made over optical fiber will behave differently than connections made over copper. Likewise, a connection made over a wireless frequency will behave differently than that of a satellite communication.
- Local area network (LAN) traffic - the amount of traffic on the local area network can bottleneck a connection before it ever reaches the larger Internet. For example, if many users are using streaming video service simultaneously, round-trip time may be inhibited even though the external network has excess capacity and is functioning normally.
- Server response time – the amount of time it takes a server to process and respond to a request is a potential bottleneck in network latency. When a server is overwhelmed with requests, such as during a DDoS attack, its ability to respond efficiently can be inhibited, resulting in increased RTT.
- Node count and congestion – depending on the path that a connection takes across the Internet, it may be routed or “hop” through a different number of intermediate nodes. Generally speaking, the greater the number of nodes a connection touches the slower it will be. A node may also experience network congestion from other network traffic, which will slow down the connection and increase RTT.
- Physical distance – although a connection optimized by a CDN can often reduce the number of hops required to reach a destination, there is no way of getting around the limitation imposed by the speed of light; the distance between a start and end point is a limiting factor in network connectivity that can only be reduced by moving content closer to the requesting users. To overcome this obstacle, a CDN will cache content closer to the requesting users, thereby reducing 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 packet size as propagation delay and transmission delay increase with packet size.

Traceroute command

The traceroute command sends probe packets that start with a maximum time-to-live (TTL) value of one. The system listens for an Internet Control Message Protocol (ICMP) error message in response to the TTL expiry, and records the source that sent the ICMP error message. The system repeats this process and increments the TTL value by 1 for each hop in the route to the final destination. The traceroute command uses ICMP Time Exceeded messages to trace a network route.

The traceroute command can show you the path a packet of information takes from your computer to a location you specify. It will list all the routers it passes through until its destination, or if it fails and is

discarded, where exactly it happens. Additionally, it will tell you how long each ‘hop’ from a router to a router takes.

Experiments:

1. ee.iitb.ac.in

```
D:\>tracert ee.iitb.ac.in
Unable to resolve target system name ee.iitb.ac.in.

D:\>_
```

2. mscs.mu.edu

```
Command Prompt
D:\>tracert mscs.mu.edu

Tracing route to mscs.mu.edu [134.48.4.5]
over a maximum of 30 hops:
  0  1 ms  1 ms  2 ms  192.168.0.1
  1  4 ms  2 ms  2 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  2  3 ms  2 ms  2 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  3  3 ms  2 ms  4 ms  124.155.242.121
  4  6 ms  3 ms  2 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  5  *  *  6 ms  dhcp-192-196-29.in2cable.com [203.192.196.29]
  6  6 ms  4 ms  5 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  7  5 ms  4 ms  5 ms  172.23.78.237
  8  7 ms  5 ms  6 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
  9 128 ms 127 ms 170 ms if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 10 127 ms 134 ms 124 ms if-ae-21-2.tcore1.pye-paris.as6453.net [80.231.154.288]
 11 126 ms 173 ms 126 ms if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 12  *  *  *  Request timed out.
 13  *  *  *  Request timed out.
 14  * 220 ms 236 ms ae-2-3603.ear3.Chicago2.Level3.net [4.69.159.186]
 15 228 ms 259 ms 307 ms MARQUETTE-U.ear3.Chicago2.Level3.net [4.16.38.70]
 16 313 ms 250 ms 249 ms 134.48.10.26
 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.

D:\>_
```

3. www.cs.grinnell.edu

```
D:\>tracert www.cs.grinnell.edu

Tracing route to www.cs.grinnell.edu [132.161.132.159]
over a maximum of 30 hops:
  0  1 ms  3 ms  6 ms  192.168.0.1
  1  6 ms  4 ms  2 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  2 14 ms  2 ms  3 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  3  6 ms  4 ms  3 ms  124.155.242.121
  4  4 ms  3 ms  3 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  5 14 ms 38 ms  9 ms  dhcp-192-196-29.in2cable.com [203.192.196.29]
  6  5 ms  3 ms  4 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  7  *  * 37 ms  172.23.78.237
  8 30 ms 20 ms 29 ms  172.31.244.45
  9 28 ms 25 ms 24 ms  ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
 10 321 ms 311 ms 294 ms if-ae-9-2.tcore2.mlv-mumbai.as6453.net [180.87.37.10]
 11 261 ms 252 ms  *  if-ae-12-2.tcore1.l78-london.as6453.net [180.87.39.21]
 12 254 ms 247 ms 299 ms if-ae-66-9.tcore2.nto-newyork.as6453.net [80.231.130.20]
 13 248 ms 247 ms 309 ms if-ae-26-2.tcore1.ct8-chicago.as6453.net [216.6.81.29]
 14  *  *  *  Request timed out.
 15  *  *  *  Request timed out.
 16  *  *  *  Request timed out.
 17 266 ms 304 ms 303 ms et3-1-0-0.agr03.desm01-ia.us.windstream.net [40.128.250.43]
 18 301 ms 303 ms 303 ms ae4-0.pe04.grnl01-ia.us.windstream.net [40.128.248.35]
 19 323 ms 304 ms 303 ms ae7-0.pe05.grnl01-ia.us.windstream.net [40.138.127.29]
 20 278 ms 277 ms 304 ms grnl-static-grinnellcollege0-0001.flex.iowatelecom.net [69.66.111.181]
 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.
```

4. csail.mit.edu

```
Command Prompt

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

  0  4 ms  1 ms  1 ms  192.168.0.1
  1  3 ms  2 ms  11 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  2  4 ms  2 ms  2 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  3  23 ms  49 ms  5 ms  124.155.242.121
  4  3 ms  3 ms  8 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  5  *  *  *  Request timed out.
  6  4 ms  4 ms  4 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  7  4 ms  4 ms  4 ms  172.23.78.237
  8  11 ms  5 ms  4 ms  ix-ae-9-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
  9  246 ms  203 ms  203 ms  if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 10  299 ms  303 ms  203 ms  if-ae-2-2.tcore2.wyn-marseille.as6453.net [80.231.217.2]
 11  199 ms  200 ms  *  if-ae-9-2.tcore2.l78-london.as6453.net [80.231.200.14]
 12  210 ms  243 ms  204 ms  if-ae-4-2.tcore2.n0v-newyork.as6453.net [80.231.131.158]
 13  233 ms  282 ms  204 ms  if-ae-2-2.tcore1.n0v-newyork.as6453.net [216.6.90.21]
 14  222 ms  202 ms  203 ms  if-ae-7-5.tcore1.nto-newyork.as6453.net [63.243.128.141]
 15  202 ms  205 ms  205 ms  if-ae-9-2.tcore1.n75-newyork.as6453.net [63.243.128.122]
 16  251 ms  230 ms  202 ms  66.110.96.138
 17  216 ms  213 ms  239 ms  be-10390-cr02.newyork.ny.ibone.comcast.net [68.86.83.89]
 18  216 ms  212 ms  215 ms  be-1402-cs04.newyork.ny.ibone.comcast.net [96.110.38.45]
 19  249 ms  249 ms  252 ms  14.42.110.96.in-addr.arpa [96.110.42.14]
 20  254 ms  253 ms  301 ms  ae0-0-eg-bstpmall74w.boston.ma.boston.comcast.net [68.86.238.34]
 21  248 ms  343 ms  308 ms  50-201-57-174-static.hfc.comcastbusiness.net [50.201.57.174]
 22  250 ms  352 ms  304 ms  dmz-rtr-1-external-rtr-3.mit.edu [18.0.161.13]
 23  252 ms  250 ms  320 ms  dmz-rtr-2-dmz-rtr-1-2.mit.edu [18.0.162.6]
 24  246 ms  293 ms  304 ms  mitnet.core-1-ext.csail.mit.edu [18.4.7.65]
 25  *  *  *  Request timed out.
 26  293 ms  255 ms  259 ms  bdr.core-1.csail.mit.edu [128.30.0.246]
 27  270 ms  250 ms  256 ms  inquire-3ld.csail.mit.edu [128.30.2.109]

Trace complete.

D:\>
```

5. cs.stanford.edu

```
D:\>tracert cs.stanford.edu

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

  0  1 ms  1 ms  1 ms  192.168.0.1
  1  4 ms  3 ms  3 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  2  4 ms  2 ms  2 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  3  5 ms  6 ms  5 ms  124.155.242.121
  4  3 ms  2 ms  3 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  5  12 ms  35 ms  *  dhcp-192-196-29.in2cable.com [203.192.196.29]
  6  3 ms  3 ms  4 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  7  5 ms  4 ms  4 ms  172.23.78.237
  8  20 ms  21 ms  20 ms  172.31.244.45
  9  25 ms  24 ms  25 ms  ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
 10  337 ms  305 ms  302 ms  if-ae-10-4.tcore2.svw-singapore.as6453.net [180.87.67.16]
 11  307 ms  303 ms  303 ms  if-ae-7-2.tcore2.lvw-losangeles.as6453.net [180.87.15.26]
 12  305 ms  307 ms  299 ms  if-ae-2-2.tcore1.lvw-losangeles.as6453.net [66.110.59.1]
 13  303 ms  303 ms  303 ms  las-b24-link.teliana.net [80.239.128.214]
 14  233 ms  276 ms  304 ms  palo-b24-link.teliana.net [62.115.119.90]
 15  311 ms  304 ms  304 ms  palo-b1-link.teliana.net [62.115.122.169]
 16  240 ms  270 ms  238 ms  hurricane-ic-308019-palo-b1.c.teliana.net [80.239.167.174]
 17  345 ms  303 ms  303 ms  stanford-university.100gigabitethernet5-1.core1.pao1.he.net [184.105.177.238]
 18  294 ms  303 ms  303 ms  csee-west-rtr-v13.SUNet [171.66.255.140]
 19  311 ms  303 ms  304 ms  CS.stanford.edu [171.64.64.64]

Trace complete.
```

6. cs.manchester.ac.uk

```
D:\>tracert cs.manchester.ac.uk

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

  1    7 ms    1 ms    2 ms  192.168.0.1
  2    2 ms    3 ms    2 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  3    2 ms    2 ms    2 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  4    3 ms    3 ms    5 ms  124.155.242.121
  5    2 ms    3 ms    4 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  6    9 ms    *        6 ms  dhcp-192-196-29.in2cable.com [203.192.196.29]
  7    6 ms    3 ms    4 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  8    4 ms    3 ms    3 ms  172.23.78.237
  9    4 ms    3 ms    4 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
 10    *      127 ms   127 ms  if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 11    *      119 ms   118 ms  if-ae-21-2.tcore1.pye-paris.as6453.net [80.231.154.208]
 12  126 ms   126 ms   126 ms  if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 13    *      127 ms   126 ms  80.231.153.66
 14  125 ms   122 ms   122 ms  ae-1-9.bear1.Manchesteruk1.Level3.net [4.69.167.38]
 15  133 ms   134 ms   134 ms  JANET.bear1.Manchester1.Level3.net [212.187.174.238]
 16  130 ms   131 ms   130 ms  ae22.manckh-sbr2.ja.net [146.97.35.189]
 17  131 ms   130 ms   130 ms  ae23.mancrh-rbr1.ja.net [146.97.38.42]
 18  142 ms    *        *      universityofmanchester.ja.net [146.97.169.2]
 19  133 ms   131 ms   131 ms  130.88.249.194
 20    *        *        *      Request timed out.
 21  131 ms   131 ms   136 ms  gw-jh.its.manchester.ac.uk [130.88.250.32]
 22  131 ms   132 ms   132 ms  eps.its.man.ac.uk [130.88.101.49]

Trace complete.
```

Ipconfig/ifconfig command

Internet Protocol Configuration (Windows) is a command line utility that is used to manage the IP address assigned to the machine it is running in. Used without any additional parameters, it displays the computer's currently assigned IP, subnet mask and default gateway addresses.

ifconfig is a system administration utility in Unix-like operating systems for network interface configuration. The utility is a command-line interface tool and is also used in the system startup scripts of many operating systems. It has features for configuring, controlling, and querying TCP/IP network interface parameters

```
D:\>ipconfig

Windows IP Configuration

Wireless LAN adapter Local Area Connection* 3:

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

Wireless LAN adapter Local Area Connection* 12:

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

Wireless LAN adapter Wi-Fi:

    Connection-specific DNS Suffix  . :
    Link-local IPv6 Address . . . . . : fe80::ac4e:5a28:485e:9f2a%5
    IPv4 Address. . . . . : 192.168.0.110
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.0.1

D:\>
```

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. :

Round trip time increases as physical distance increases.

Average RTT for cambridge(UK) : 135ms

Average RTT for stanford(USA) : 250ms


```

D:\>ping www.cam.ac.uk

Pinging www.cam.ac.uk [128.232.132.8] with 32 bytes of data:
Reply from 128.232.132.8: bytes=32 time=130ms TTL=43
Reply from 128.232.132.8: bytes=32 time=131ms TTL=43
Reply from 128.232.132.8: bytes=32 time=130ms TTL=43
Reply from 128.232.132.8: bytes=32 time=150ms TTL=43

Ping statistics for 128.232.132.8:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 130ms, Maximum = 150ms, Average = 135ms

D:\>ping cs.stanford.edu

Pinging cs.stanford.edu [171.64.64.64] with 32 bytes of data:
Reply from 171.64.64.64: bytes=32 time=249ms TTL=50
Reply from 171.64.64.64: bytes=32 time=252ms TTL=50
Reply from 171.64.64.64: bytes=32 time=250ms TTL=50
Reply from 171.64.64.64: bytes=32 time=250ms TTL=50

Ping statistics for 171.64.64.64:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 249ms, Maximum = 252ms, Average = 250ms

```

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

maths.hws.edu:

```

C:\>tracert math.hws.edu [64.89.144.237]
Tracing route to math.hws.edu [64.89.144.237]
over a maximum of 30 hops:
  0  0 ms  0 ms  0 ms  192.168.0.1
  1  5 ms  3 ms  4 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  2  7 ms  2 ms  4 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  3  5 ms  4 ms  3 ms  124.155.242.121
  4  5 ms  2 ms  3 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  5  *  7 ms  *  dhcp-192-196-29.in2cable.com [203.192.196.29]
  6  5 ms  3 ms  4 ms  14.143.59.13.static-mumbai.vsnl.net.in [14.143.59.13]
  7  18 ms  13 ms  33 ms  172.23.78.233
  8  7 ms  4 ms  8 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
  9  213 ms  201 ms  127 ms  if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 10  208 ms  202 ms  200 ms  if-ae-8-1600.tcore1.pye-paris.as6453.net [80.231.217.6]
 11  198 ms  201 ms  201 ms  if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 12  *  *  *  Request timed out.
 13  208 ms  203 ms  202 ms  ae-1-3104.edge3.Paris1.Level3.net [4.69.161.110]
 14  222 ms  200 ms  201 ms  global-crossing-xe-level3.paris1.level3.net [4.68.63.230]
 15  310 ms  304 ms  295 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
 16  322 ms  301 ms  303 ms  66.195.65-170.static.clt.one [66.195.65.170]
 17  287 ms  224 ms  310 ms  64.89.144.100
 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.

```

www.hws.edu :

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

  1    2 ms    1 ms    1 ms  192.168.0.1
  2   10 ms    6 ms    6 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  3    3 ms    2 ms    2 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  4    5 ms    3 ms    3 ms  124.155.242.121
  5    5 ms    3 ms    3 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  6    8 ms    8 ms    *     dhcp-192-196-29.in2cable.com [203.192.196.29]
  7    5 ms    3 ms    4 ms  14.143.59.13.static-mumbai.vsnl.net.in [14.143.59.13]
  8    5 ms    4 ms    5 ms  172.23.78.233
  9    5 ms    6 ms    4 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
 10   188 ms  299 ms  200 ms  if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 11   205 ms  127 ms  171 ms  if-ae-8-1600.tcore1.pye-paris.as6453.net [80.231.217.6]
 12   173 ms  201 ms  201 ms  if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 13    *      209 ms  201 ms  80.231.153.66
 14   217 ms  201 ms  203 ms  ae-1-3104.edge3.Paris1.Level3.net [4.69.161.110]
 15   209 ms  129 ms  130 ms  global-crossing-xe-level3.paris1.level3.net [4.68.63.230]
 16   276 ms  304 ms  304 ms  roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
 17   326 ms  299 ms  306 ms  66-195-65-170.static.clt.one [66.195.65.170]
 18   302 ms  303 ms  209 ms  64.89.144.100
 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.
```

The above screenshots show that the path taken by traceroute are exactly the same in our case. There can be different routes taken to the same destination though. A domain name might have multiple IP addresses associated. If this is the case, multiple traces may access two or more IP addresses. This will yield trace paths that differ from one another, even if the origin and destinations are the same.

Domains may also use multiple servers for its subdomains. Tracing the path to the base domain might result in a completely different path when tracing to the subdomain.

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.

Route 1 :

```
D:\>tracert cs.manchester.ac.uk

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

  1    7 ms    1 ms    2 ms  192.168.0.1
  2    2 ms    3 ms    2 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  3    2 ms    2 ms    2 ms  5.244.189.203.in-addr.arpa [203.189.244.5]
  4    3 ms    3 ms    5 ms  124.155.242.121
  5    2 ms    3 ms    4 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  6    9 ms    *        6 ms  dhcp-192-196-29.in2cable.com [203.192.196.29]
  7    6 ms    3 ms    4 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  8    4 ms    3 ms    3 ms  172.23.78.237
  9    4 ms    3 ms    4 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
 10    *      127 ms  127 ms  if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 11    *      119 ms  118 ms  if-ae-21-2.tcore1.pye-paris.as6453.net [80.231.154.208]
 12  126 ms  126 ms  126 ms  if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 13    *      127 ms  126 ms  80.231.153.66
 14  125 ms  122 ms  122 ms  ae-1-9.bear1.Manchesteruk1.Level3.net [4.69.167.38]
 15  133 ms  134 ms  134 ms  JANET.bear1.Manchester1.Level3.net [212.187.174.238]
 16  130 ms  131 ms  130 ms  ae22.manckh-sbr2.ja.net [146.97.35.189]
 17  131 ms  130 ms  130 ms  ae23.mancrh-rbr1.ja.net [146.97.38.42]
 18  142 ms  *        *      universityofmanchester.ja.net [146.97.169.2]
 19  133 ms  131 ms  131 ms  130.88.249.194
 20    *      *        *      Request timed out.
 21  131 ms  131 ms  136 ms  gw-jh.its.manchester.ac.uk [130.88.250.32]
 22  131 ms  132 ms  132 ms  eps.its.man.ac.uk [130.88.101.49]

Trace complete.
```

Route 2:

```
D:\>tracert cs.manchester.ac.uk

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

  1    1 ms    1 ms    1 ms  192.168.0.1
  2    2 ms    3 ms    2 ms  6.244.189.203.in-addr.arpa [203.189.244.6]
  3    3 ms    2 ms    2 ms  203.189.244.5
  4    3 ms    3 ms    4 ms  124.155.242.121
  5    2 ms    4 ms    2 ms  dhcp-192-196-101.in2cable.com [203.192.196.101]
  6    *        *        6 ms  dhcp-192-196-29.in2cable.com [203.192.196.29]
  7    3 ms    3 ms    3 ms  115.113.165.121.static-mumbai.vsnl.net.in [115.113.165.121]
  8    5 ms    5 ms    3 ms  172.23.78.237
  9    4 ms    4 ms    3 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
 10  127 ms  127 ms  127 ms  if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 11  117 ms  *        *      if-ae-21-2.tcore1.pye-paris.as6453.net [80.231.154.208]
 12  146 ms  134 ms  149 ms  if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 13    *        *      127 ms  66.153.231.80.in-addr.arpa [80.231.153.66]
 14    *        *      125 ms  ae-1-9.bear1.Manchesteruk1.Level3.net [4.69.167.38]
 15  134 ms  134 ms  133 ms  JANET.bear1.Manchester1.Level3.net [212.187.174.238]
 16  131 ms  130 ms  130 ms  ae22.manckh-sbr2.ja.net [146.97.35.189]
 17  132 ms  131 ms  130 ms  ae23.mancrh-rbr1.ja.net [146.97.38.42]
 18    *      131 ms  *      universityofmanchester.ja.net [146.97.169.2]
 19  161 ms  142 ms  131 ms  194.249.88.130.in-addr.arpa [130.88.249.194]
 20    *        *        *      Request timed out.
 21  131 ms  133 ms  152 ms  gw-jh.its.manchester.ac.uk [130.88.250.32]
 22  131 ms  131 ms  130 ms  eps.its.man.ac.uk [130.88.101.49]

Trace complete.
```

In the above pictures, route 1 takes different route in step 3 and step 19. Cases like these seem to come once in 2-3 trace routes, so seem highly likely.

This shows that packets can travel through different paths for long physical distances depending on the path chosen by the routing metric for choosing the best path.