

Web site	Distance from West Lafayette	Estimated Latency	Ping
www.ucsd.edu	3442.4 km	11.48 ms	70.73 ms
www.indiana.edu	113.62 km	0.38 ms	3.21 ms
www.mit.edu	1672 km	5.58 ms	7.72 ms
www.brandeis.edu	1654.4 km	5.52 ms	34.02 ms
www.ufl.edu	1622 km	5.41 ms	37.61 ms
www.tsinghua.edu.cn	10783 km	35.97 ms	212.73 ms

Explanation:

From the table, it is easy to tell that as distance increase, latency increases.

Delay = data size / bandwidth + distance / SOL(speed of light)

Router traversal of Purdue to Brandeis:

sslslab01 74 \$ traceroute www.brandeis.edu

traceroute to www.brandeis.edu (129.64.99.200), 30 hops max, 60 byte packets

```
1  switch-lwsn2133-z1r11.cs.purdue.edu (128.10.25.250)  0.181 ms  0.174 ms
0.170 ms
2  lwsn-b143-c6504e-01-po11-tcom.cs.purdue.edu (128.10.127.251)  1.326 ms
1.422 ms 1.232 ms
3  itns-core-vss-01-vlan4094.tcom.purdue.edu (172.28.0.1)  0.740 ms  0.849 ms
0.991 ms
4  tel-210-c9006-01-te0-0-0-2.tcom.purdue.edu (172.28.252.85)  0.875 ms  1.099
ms 0.997 ms
5  indiana-gigapop-ctc-internet2-150.tcom.purdue.edu (192.5.40.86)  10.568 ms
10.567 ms 10.561 ms
6  et-10-0-0.101.rtr.chic.net.internet2.edu (149.165.254.186)  6.828 ms  6.691 ms
6.685 ms
7  et-10-0-0.107.rtr.clev.net.internet2.edu (198.71.45.9)  16.138 ms  16.299 ms
16.292 ms
8  nox1sumgw1-vl-112-nox-i2.nox.org (192.5.89.17)  29.755 ms  29.980 ms  29.956
ms
9  207.210.143.122 (207.210.143.122)  30.867 ms  30.868 ms  30.908 ms
10 ***
11 ***
12 webserv-prod.unet.brandeis.edu (129.64.99.200)  32.317 ms !X  33.097 ms !X
33.033 ms !X
```

Router traversal of Purdue to MIT:

sslslab01 75 \$ traceroute www.mit.edu

traceroute to www.mit.edu (23.194.133.54), 30 hops max, 60 byte packets

```
1  switch-lwsn2133-z1r11.cs.purdue.edu (128.10.25.250)  0.112 ms  0.261 ms
0.130 ms
2  lwsn-b143-c6504e-01-po11-tcom.cs.purdue.edu (128.10.127.251)  0.691 ms
0.566 ms 0.564 ms
3  itns-core-vss-01-vlan4094.tcom.purdue.edu (172.28.0.1)  2.972 ms  3.035 ms
2.829 ms
4  tel-210-c9006-01-te0-0-0-2.tcom.purdue.edu (172.28.252.85)  0.936 ms  1.041
ms 1.184 ms
5  indiana-gigapop-ctc-internet-151.tcom.purdue.edu (192.5.40.82)  2.201 ms
1.984 ms 2.191 ms
6  207-67-55-145.static.twtelecom.net (207.67.55.145)  2.124 ms  2.103 ms  2.093
ms
7  chi2-pr1-xe-0-2-0-0.us.twtelecom.net (66.192.254.70)  7.359 ms  7.536 ms  7.524
ms
8  ix-0-1-2-0.tcore2.CT8-Chicago.as6453.net (206.82.141.97)  7.592 ms  7.355 ms
7.577 ms
9  64.86.79.82 (64.86.79.82)  8.373 ms  8.206 ms  8.148 ms
```

10 a23-194-133-54.deploy.static.akamaitechnologies.com (23.194.133.54) 7.985 ms 7.929 ms 8.861 ms

Explanation:

From the information above, we can see even though Brandeis and MIT has almost same distance to Purdue and there are only 2 more hops from Purdue to Brandeis than to MIT, there are some significant delay when data passed some gateways to Brandeis (traces has already been marked by yellow color).

The main reason is that the headquarter of a cloud services provider - Akamai Technologies, is located in MIT.

Ping to www.indiana.edu with different payload size

500	1000	1500	2000	2500	3000	3500
3.33ms	3.36ms	3.89ms	3.83ms	3.89ms	3.96ms	3.99ms

Explanation:

Large packets of data cause more latency.

Packet size / Bandwidth = delay (per hop)

Even though when sending large size packet, throughput is better and overhead is smaller. But for a 7 hops transfer, small size packet transfer is more efficient.

Ping to www.indiana.edu from a laptop in LWSN.

```
PING www.indiana.edu (129.79.78.192): 1500 data bytes
1508 bytes from 129.79.78.192: icmp_seq=0 ttl=57 time=6.289 ms
1508 bytes from 129.79.78.192: icmp_seq=1 ttl=57 time=7.310 ms
1508 bytes from 129.79.78.192: icmp_seq=2 ttl=57 time=7.995 ms
1508 bytes from 129.79.78.192: icmp_seq=3 ttl=57 time=5.616 ms
1508 bytes from 129.79.78.192: icmp_seq=4 ttl=57 time=5.845 ms
1508 bytes from 129.79.78.192: icmp_seq=5 ttl=57 time=5.373 ms
1508 bytes from 129.79.78.192: icmp_seq=6 ttl=57 time=7.902 ms
1508 bytes from 129.79.78.192: icmp_seq=7 ttl=57 time=7.938 ms
1508 bytes from 129.79.78.192: icmp_seq=8 ttl=57 time=5.392 ms
1508 bytes from 129.79.78.192: icmp_seq=9 ttl=57 time=8.501 ms
1508 bytes from 129.79.78.192: icmp_seq=10 ttl=57 time=5.828 ms
1508 bytes from 129.79.78.192: icmp_seq=11 ttl=57 time=8.534 ms
^C
--- www.indiana.edu ping statistics ---
12 packets transmitted, 12 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 5.373/6.877/8.534/1.210 ms
```

Router traversal of Purdue to www.indiana.edu from a laptop in LWSN.

```
traceroute: Warning: www.indiana.edu has multiple addresses; using 129.79.78.192
traceroute to www.indiana.edu (129.79.78.192), 64 hops max, 1500 byte packets
 1  itns-service-vss-01-vlan982.tcom.purdue.edu (10.184.160.1)  144.221  ms
   39.615 ms  14.980 ms
 2  itns-core-vss-01-vlan2530.tcom.purdue.edu (172.28.253.217)  8.274 ms  11.323
   ms  8.067 ms
 3  tel-210-c9006-01-te0-0-0-2.tcom.purdue.edu (172.28.252.85)  4.966 ms  7.093
   ms  5.585 ms
 4  indiana-gigapop-ctc-internet2-150.tcom.purdue.edu (192.5.40.86)  4.724  ms
   8.116 ms  7.313 ms
 5  149.165.254.230 (149.165.254.230)  4.907 ms  7.115 ms  6.768 ms
 6  ae-0.0.br2.blde.net.uits.iu.edu (134.68.3.35)  7.769 ms  6.811 ms  7.461 ms
```

Ping to www.indiana.edu from the lab machine.

```
PING www.indiana.edu (129.79.78.193) 1500(1528) bytes of data.
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=1 ttl=56 time=3.76
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=2 ttl=56 time=3.72
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=3 ttl=56 time=3.98
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=4 ttl=56 time=4.11
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=5 ttl=56 time=4.09
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=6 ttl=56 time=3.74
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=7 ttl=56 time=3.99
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=8 ttl=56 time=4.20
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=9 ttl=56 time=4.01
ms
1508 bytes from www.indiana.edu (129.79.78.193): icmp_seq=10 ttl=56 time=4.07
ms
^C
--- www.indiana.edu ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9011ms
rtt min/avg/max/mdev = 3.724/3.970/4.203/0.178 ms
```

Router traversal of Purdue to www.indiana.edu from a lab machine.

```
traceroute to www.indiana.edu (129.79.78.192), 30 hops max, 1500 byte packets
 1  switch-lwsn2133-z1r11.cs.purdue.edu (128.10.25.250)  0.236 ms  0.405 ms
    0.401 ms
 2  lwsn-b143-c6504e-01-po11-tcom.cs.purdue.edu (128.10.127.251)  1.269 ms
    1.266 ms  1.296 ms
 3  itns-core-vss-01-vlan4094.tcom.purdue.edu (172.28.0.1)  1.631 ms  1.488 ms
    1.558 ms
 4  tel-210-c9006-01-te0-0-0-2.tcom.purdue.edu (172.28.252.85)  1.508 ms  1.703
    ms  1.744 ms
 5  indiana-gigapop-ctc-internet2-150.tcom.purdue.edu (192.5.40.86)  2.534 ms
    2.532 ms  2.528 ms
 6  149.165.254.230 (149.165.254.230)  2.582 ms  2.471 ms  2.523 ms
 7  ae-0.0.br2.blcd.net.uits.iu.edu (134.68.3.35)  3.700 ms  3.690 ms  3.690 ms
```

Explanation:

From those two sets of data, we can see ping to the same website, from a laptop is two times slower than from a lab machine. The laptop's IP does not directly belong to Purdue network, which takes more time to get to the Purdue gateway.