

# CS536 Lab 2

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October 1, 2025

we don't make mistakes, we have happy accidents

*Bob Ross*

## Problem 3

I have checked my UDP ping app using lab machines in HAAS G50 during different times in the day. I checked once around 11 am and another time at 8 pm. The results didn't vary much but the ping was faster in the evening. This might be because the lab was crowded in the morning and more people were using the computers. Below are my results:

```
amber17 60 $ ping 10.168.53.27 -c 100 -i 0.3
64 bytes from 10.168.53.27: icmp_seq=85 ttl=64 time=0.396 ms
64 bytes from 10.168.53.27: icmp_seq=86 ttl=64 time=0.585 ms
64 bytes from 10.168.53.27: icmp_seq=87 ttl=64 time=0.661 ms
64 bytes from 10.168.53.27: icmp_seq=88 ttl=64 time=0.664 ms
64 bytes from 10.168.53.27: icmp_seq=89 ttl=64 time=0.681 ms
64 bytes from 10.168.53.27: icmp_seq=90 ttl=64 time=0.712 ms
64 bytes from 10.168.53.27: icmp_seq=91 ttl=64 time=0.568 ms
64 bytes from 10.168.53.27: icmp_seq=92 ttl=64 time=0.769 ms
64 bytes from 10.168.53.27: icmp_seq=93 ttl=64 time=0.444 ms
64 bytes from 10.168.53.27: icmp_seq=94 ttl=64 time=0.642 ms
64 bytes from 10.168.53.27: icmp_seq=95 ttl=64 time=0.667 ms
64 bytes from 10.168.53.27: icmp_seq=96 ttl=64 time=0.460 ms
64 bytes from 10.168.53.27: icmp_seq=97 ttl=64 time=0.456 ms
64 bytes from 10.168.53.27: icmp_seq=98 ttl=64 time=0.443 ms
64 bytes from 10.168.53.27: icmp_seq=99 ttl=64 time=0.499 ms
64 bytes from 10.168.53.27: icmp_seq=100 ttl=64 time=0.551 ms

--- 10.168.53.27 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 31673ms
rtt min/avg/max/mdev = 0.242/0.519/0.824/0.156 ms
amber17 61 $
```

Figure 1: Legacy Ping Result in the Morning

```
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS
amber25 54 $ ping 10.168.53.35 -c 100 -i 0.2
64 bytes from 10.168.53.35: icmp_seq=79 ttl=64 time=0.714 ms
64 bytes from 10.168.53.35: icmp_seq=80 ttl=64 time=0.827 ms
64 bytes from 10.168.53.35: icmp_seq=81 ttl=64 time=0.851 ms
64 bytes from 10.168.53.35: icmp_seq=82 ttl=64 time=0.687 ms
64 bytes from 10.168.53.35: icmp_seq=83 ttl=64 time=0.677 ms
64 bytes from 10.168.53.35: icmp_seq=84 ttl=64 time=0.738 ms
64 bytes from 10.168.53.35: icmp_seq=85 ttl=64 time=0.808 ms
64 bytes from 10.168.53.35: icmp_seq=86 ttl=64 time=0.591 ms
64 bytes from 10.168.53.35: icmp_seq=87 ttl=64 time=0.668 ms
64 bytes from 10.168.53.35: icmp_seq=88 ttl=64 time=0.589 ms
64 bytes from 10.168.53.35: icmp_seq=89 ttl=64 time=0.657 ms
64 bytes from 10.168.53.35: icmp_seq=90 ttl=64 time=0.672 ms
64 bytes from 10.168.53.35: icmp_seq=91 ttl=64 time=0.590 ms
64 bytes from 10.168.53.35: icmp_seq=92 ttl=64 time=0.629 ms
64 bytes from 10.168.53.35: icmp_seq=93 ttl=64 time=0.836 ms
64 bytes from 10.168.53.35: icmp_seq=94 ttl=64 time=0.446 ms
64 bytes from 10.168.53.35: icmp_seq=95 ttl=64 time=0.577 ms
64 bytes from 10.168.53.35: icmp_seq=96 ttl=64 time=0.494 ms
64 bytes from 10.168.53.35: icmp_seq=97 ttl=64 time=0.591 ms
64 bytes from 10.168.53.35: icmp_seq=98 ttl=64 time=0.592 ms
64 bytes from 10.168.53.35: icmp_seq=99 ttl=64 time=0.666 ms
64 bytes from 10.168.53.35: icmp_seq=100 ttl=64 time=0.761 ms

--- 10.168.53.35 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 20195ms
rtt min/avg/max/mdev = 0.325/0.622/0.851/0.120 ms
amber25 55 $
```

Figure 2: Legacy Ping Result in the Afternoon

```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS
amber17 54 $ ./udppingc 10.168.53.27 8080 123456 80801 10
Starting UDP ping to 10.168.53.27:8080
Ping 1: seq=339, RTT=781.00 us
Ping 2: seq=340, RTT=334.00 us
Ping 3: seq=341, RTT=325.00 us
Ping 4: seq=342, RTT=260.00 us
Ping 5: seq=343, RTT=381.00 us
Ping 6: seq=344, RTT=388.00 us
Ping 7: seq=345, RTT=284.00 us
Ping 8: seq=346, RTT=389.00 us
Ping 9: seq=347, RTT=157.00 us
Ping 10: seq=348, RTT=238.00 us

--- UDP Ping Statistics ---
Packets sent: 10
Packets received: 10
Packet loss: 0.0%
RTT Avg = 329.70 us
RTT Min = 157.00 us
RTT Max = 781.00 us
RTT STD = 158.31 us
--- UDP Ping Statistics ---
amber17 55 $

```

Figure 3: Client Ping Result in the Morning (pcount = 10)

```

amber17 57 $ ./udppingc 10.168.53.27 8080 123456 80801 100
Ping 90: seq=341, RTT=283.00 us
Ping 91: seq=342, RTT=269.00 us
Ping 92: seq=343, RTT=288.00 us
Ping 93: seq=344, RTT=243.00 us
Ping 94: seq=345, RTT=220.00 us
Ping 95: seq=346, RTT=167.00 us
Ping 96: seq=347, RTT=162.00 us
Ping 97: seq=348, RTT=161.00 us
Ping 98: seq=349, RTT=158.00 us
Ping 99: seq=350, RTT=238.00 us
Ping 100: seq=351, RTT=192.00 us

--- UDP Ping Statistics ---
Packets sent: 100
Packets received: 100
Packet loss: 0.0%
RTT Avg = 288.10 us
RTT Min = 155.00 us
RTT Max = 518.00 us
RTT STD = 87.00 us
--- UDP Ping Statistics ---
amber17 58 $

```

Figure 4: Client Ping Result in the Morning (pcount = 100)

```

PROBLEMS 3 OUTPUT DEBUG CONSOLE TERMINAL PORTS
amber25 53 $ ./udppingc 10.168.53.35 8080 123456 80801 100
Ping 85: seq=706, RTT=233.00 us
Ping 86: seq=707, RTT=182.00 us
Ping 87: seq=708, RTT=249.00 us
Ping 88: seq=709, RTT=231.00 us
Ping 89: seq=710, RTT=286.00 us
Ping 90: seq=711, RTT=238.00 us
Ping 91: seq=712, RTT=248.00 us
Ping 92: seq=713, RTT=220.00 us
Ping 93: seq=714, RTT=208.00 us
Ping 94: seq=715, RTT=152.00 us
Ping 95: seq=716, RTT=199.00 us
Ping 96: seq=717, RTT=208.00 us
Ping 97: seq=718, RTT=140.00 us
Ping 98: seq=719, RTT=263.00 us
Ping 99: seq=720, RTT=234.00 us
Ping 100: seq=721, RTT=164.00 us

--- UDP Ping Statistics ---
Packets sent: 100
Packets received: 100
Packet loss: 0.0%
RTT Avg = 221.33 us
RTT Min = 140.00 us
RTT Max = 882.00 us
RTT STD = 84.86 us
--- UDP Ping Statistics ---
amber25 54 $

```

Figure 5: Client Ping Result in the Afternoon (pcount = 100)

Note: I used `ifconfig` to get the ip of the server computer. It is also interesting to note that our app had faster ping than the legacy ping app.

## Bonus

We want to measure round-trip times (RTTs) between Purdue University and selected remote hosts using the `ping` utility, and to compare the observed RTTs with theoretical lower bounds derived from the speed of light. We also use `traceroute`, `dig`, and `whois` to investigate routing paths and to determine whether target servers are located on campus or proxied through content delivery networks (CDNs).

### Ping to `www.upenn.edu`

The ping result is as follows:

```
PING www.upenn.edu (23.185.0.4): 56 data bytes
64 bytes from 23.185.0.4: icmp_seq=0 ttl=59 time=12.085 ms
...
64 bytes from 23.185.0.4: icmp_seq=19 ttl=59 time=13.008 ms

--- www.upenn.edu ping statistics ---
20 packets transmitted, 20 received, 0.0% packet loss
round-trip min/avg/max/stddev = 9.312/12.569/16.414/2.147 ms
```

Observed average RTT:  $\approx 12.6$  ms.

We also run Traceroute:

```
traceroute to www.upenn.edu (23.185.0.4), 64 hops max, 40 byte packets
 1  192.168.4.1  6.336 ms  3.723 ms  3.944 ms
 2  * * *
 3  * * *
 4  10.192.208.213  13.351 ms  9.489 ms  9.519 ms
    (remaining hops did not return responses)
```

The traceroute did not reveal intermediate hops after the 4th hop, suggesting filtering or ICMP suppression by providers. We `dig +short www.upenn.edu A` which returned `23.185.0.4`. Now if we lookup this ip:

```
IP: 23.185.0.4
NetName: PANTHEON-IP4
Organization: Pantheon (San Francisco, CA, US)
```

This indicates that `www.upenn.edu` is hosted on Pantheon's infrastructure (a web hosting/CDN provider) rather than directly on UPenn's campus servers.

**Distance and Lower Bound Calculation:** Approximate great-circle distance between Purdue (West Lafayette, IN) and Philadelphia, PA (UPenn) is  $\approx 996$  km. Assuming  $c \approx 3 \times 10^8$  m/s:

$$\text{RTT}_{\min, \text{vacuum}} = 2d/c \approx 6.64\text{ms}$$

The observed RTT (12.6 ms) is consistent with either a lightly circuitous path through regional Points of Presence (PoPs) or Pantheon edge servers located in the eastern U.S. I checked the distance of Pantheon () to Purdue and it was about 1900 miles. It seems that this particular ip is located at (37.7749, -122.4194) which is about 3057 kilometers away from Purdue University. The lower bound for this location would be around 20.38 ms which is theoretically impossible!

### Ping to `www.stanford.edu`

#### DNS/Whois Results

```
dig +short www.stanford.edu
pantheon-systems.map.fastly.net.
151.101.66.133
151.101.130.133
151.101.194.133
151.101.2.133
```

```
Whois 151.101.66.133
Organization: Fastly, Inc. (San Francisco, CA, US)
```

Stanford's web presence is served by Fastly, a CDN provider. This implies that RTT measurements may reflect the distance to the nearest Fastly edge node rather than to Stanford's campus in California.

**Theoretical Calculation (if hosted on-campus)** Great-circle distance from Purdue to Stanford (Palo Alto, CA) is  $\approx 3300$  km:

$$\text{RTT}_{\text{min,vacuum}} \approx 22\text{ms}$$

However, due to CDN hosting, measured RTTs are likely far lower and correspond to geographically closer Fastly PoPs (e.g., Chicago or New York). We can verify this by running ping:

```
PING pantheon-systems.map.fastly.net (151.101.194.133): 56 data bytes
64 bytes from 151.101.194.133: icmp_seq=0 ttl=59 time=9.416 ms
64 bytes from 151.101.194.133: icmp_seq=1 ttl=59 time=13.092 ms
64 bytes from 151.101.194.133: icmp_seq=2 ttl=59 time=9.386 ms
...
64 bytes from 151.101.194.133: icmp_seq=19 ttl=59 time=10.285 ms

--- pantheon-systems.map.fastly.net ping statistics ---
20 packets transmitted, 20 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 9.124/12.574/16.291/2.208 ms
```

This average is lower than the theoretical guarantee so stanford servers are definitely using a CDN.

For the sake of completeness, we find a distant site with a significantly bigger ping as well. Below is the ping result for Hong Kong University of Science and Technology:

```
PING hkust.edu.hk (143.89.209.9): 56 data bytes
64 bytes from 143.89.209.9: icmp_seq=0 ttl=36 time=206.218 ms
64 bytes from 143.89.209.9: icmp_seq=1 ttl=36 time=207.843 ms
...
64 bytes from 143.89.209.9: icmp_seq=19 ttl=36 time=210.996 ms

--- hkust.edu.hk ping statistics ---
20 packets transmitted, 20 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 205.724/208.341/210.996/1.692 ms
```

We can see the average is now 208.25 ms. The distance between Purdue University and HKUST is approximately 12699.33 kilometers, so the theoretical RTT lower bound is 84.66 ms. Therefore, this server could actually be located in Hong Kong (or somewhere nearby!).