CS536 Lab 2

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> 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:

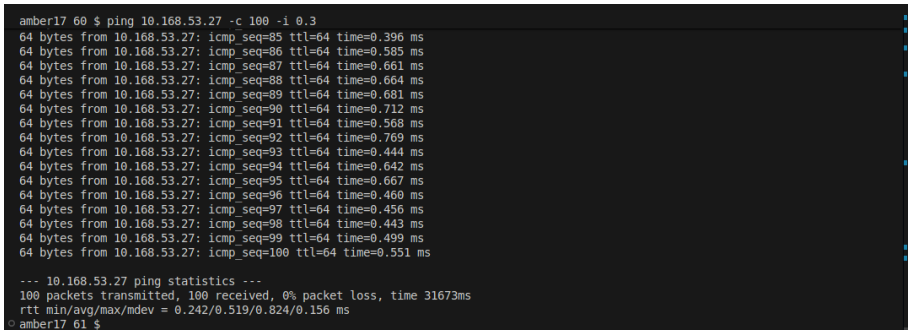

Figure 1: Legacy Ping Result in the Morning

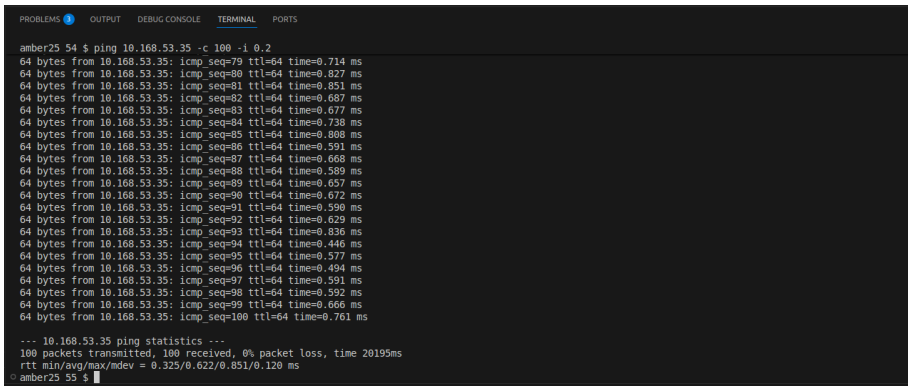

Figure 2: Legacy Ping Result in the Afternoon

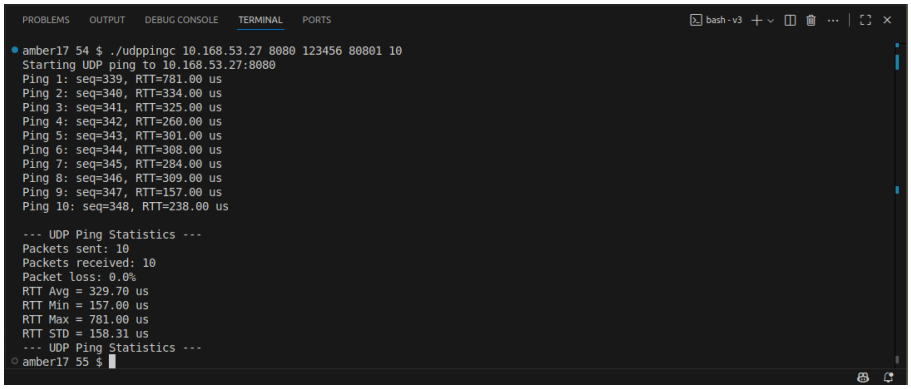

Figure 3: Client Ping Result in the Morning (pcount = 10)

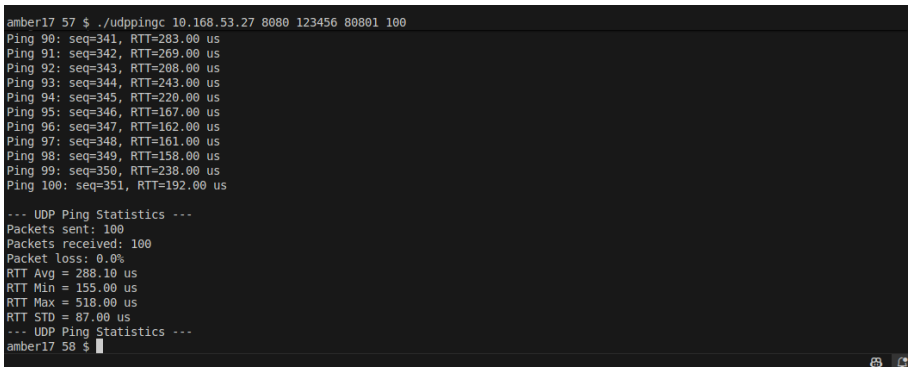

Figure 4: Client Ping Result in the Morning (pcount = 100)

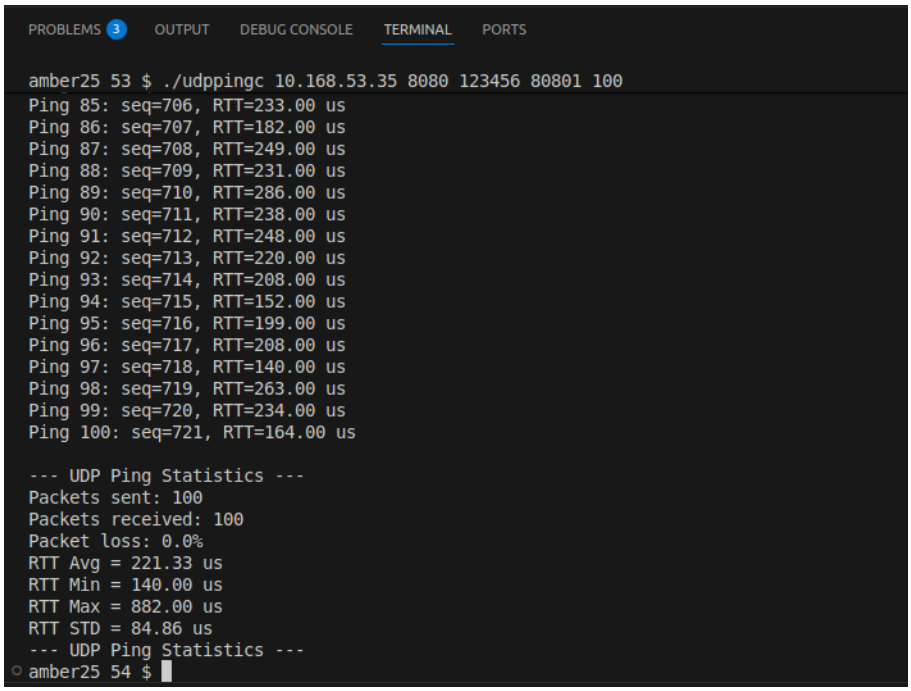

Figure 5: Client Ping Result in the Afternoon (pcount = 100)

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: ≈ 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 ≈ 996 km. Assuming $c \approx 3 \times 10^8$ m/s:

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

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 ≈ 3300 km:

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

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!).