

## Ceren Dinç 28220

### CS408 HOMEWORK1

#### Q1-a) From Sabancı University to Purdue University:

##### Ping at **noon**:

```
cerendinc@Ceren MacBook Pro:~  
$ ping www.purdue.edu  
PING www.purdue.edu (128.210.7.200): 56 data bytes  
64 bytes from 128.210.7.200: icmp_seq=0 ttl=237 time=156.862 ms  
64 bytes from 128.210.7.200: icmp_seq=1 ttl=237 time=155.654 ms  
64 bytes from 128.210.7.200: icmp_seq=2 ttl=237 time=156.067 ms  
64 bytes from 128.210.7.200: icmp_seq=3 ttl=237 time=157.046 ms  
64 bytes from 128.210.7.200: icmp_seq=4 ttl=237 time=157.952 ms  
64 bytes from 128.210.7.200: icmp_seq=5 ttl=237 time=157.073 ms  
64 bytes from 128.210.7.200: icmp_seq=6 ttl=237 time=172.108 ms  
64 bytes from 128.210.7.200: icmp_seq=7 ttl=237 time=155.660 ms  
64 bytes from 128.210.7.200: icmp_seq=8 ttl=237 time=157.458 ms  
64 bytes from 128.210.7.200: icmp_seq=9 ttl=237 time=158.211 ms  
64 bytes from 128.210.7.200: icmp_seq=10 ttl=237 time=156.963 ms  
64 bytes from 128.210.7.200: icmp_seq=11 ttl=237 time=160.834 ms  
64 bytes from 128.210.7.200: icmp_seq=12 ttl=237 time=157.987 ms  
64 bytes from 128.210.7.200: icmp_seq=13 ttl=237 time=155.708 ms  
64 bytes from 128.210.7.200: icmp_seq=14 ttl=237 time=156.469 ms  
64 bytes from 128.210.7.200: icmp_seq=15 ttl=237 time=159.462 ms  
64 bytes from 128.210.7.200: icmp_seq=16 ttl=237 time=159.699 ms  
64 bytes from 128.210.7.200: icmp_seq=17 ttl=237 time=157.737 ms  
64 bytes from 128.210.7.200: icmp_seq=18 ttl=237 time=159.735 ms  
64 bytes from 128.210.7.200: icmp_seq=19 ttl=237 time=158.753 ms  
64 bytes from 128.210.7.200: icmp_seq=20 ttl=237 time=155.852 ms  
64 bytes from 128.210.7.200: icmp_seq=21 ttl=237 time=156.116 ms  
64 bytes from 128.210.7.200: icmp_seq=22 ttl=237 time=158.532 ms  
64 bytes from 128.210.7.200: icmp_seq=23 ttl=237 time=156.918 ms  
64 bytes from 128.210.7.200: icmp_seq=24 ttl=237 time=157.510 ms  
^C  
--- www.purdue.edu ping statistics ---  
25 packets transmitted, 25 packets received, 0.0% packet loss  
round-trip min/avg/max/stddev = 155.654/158.094/172.108/3.176 ms  
(base)
```

##### Ping at **midnight**:

```
cerendinc@Ceren MacBook Pro:~  
$ ping www.purdue.edu  
PING www.purdue.edu (128.210.7.200): 56 data bytes  
64 bytes from 128.210.7.200: icmp_seq=0 ttl=238 time=182.360 ms  
64 bytes from 128.210.7.200: icmp_seq=1 ttl=238 time=171.811 ms  
64 bytes from 128.210.7.200: icmp_seq=2 ttl=238 time=180.566 ms  
64 bytes from 128.210.7.200: icmp_seq=3 ttl=238 time=177.789 ms  
64 bytes from 128.210.7.200: icmp_seq=4 ttl=238 time=230.491 ms  
64 bytes from 128.210.7.200: icmp_seq=5 ttl=238 time=252.813 ms  
64 bytes from 128.210.7.200: icmp_seq=6 ttl=238 time=196.232 ms  
64 bytes from 128.210.7.200: icmp_seq=7 ttl=238 time=171.462 ms  
64 bytes from 128.210.7.200: icmp_seq=8 ttl=238 time=215.315 ms  
64 bytes from 128.210.7.200: icmp_seq=9 ttl=238 time=177.925 ms  
64 bytes from 128.210.7.200: icmp_seq=10 ttl=238 time=180.071 ms  
64 bytes from 128.210.7.200: icmp_seq=11 ttl=238 time=173.840 ms  
64 bytes from 128.210.7.200: icmp_seq=12 ttl=238 time=174.552 ms  
64 bytes from 128.210.7.200: icmp_seq=13 ttl=238 time=170.159 ms  
64 bytes from 128.210.7.200: icmp_seq=14 ttl=238 time=181.467 ms  
64 bytes from 128.210.7.200: icmp_seq=15 ttl=238 time=169.776 ms  
64 bytes from 128.210.7.200: icmp_seq=16 ttl=238 time=221.640 ms  
64 bytes from 128.210.7.200: icmp_seq=17 ttl=238 time=173.540 ms  
64 bytes from 128.210.7.200: icmp_seq=18 ttl=238 time=185.093 ms  
64 bytes from 128.210.7.200: icmp_seq=19 ttl=238 time=190.853 ms  
64 bytes from 128.210.7.200: icmp_seq=20 ttl=238 time=200.542 ms  
64 bytes from 128.210.7.200: icmp_seq=21 ttl=238 time=183.650 ms  
64 bytes from 128.210.7.200: icmp_seq=22 ttl=238 time=423.711 ms  
64 bytes from 128.210.7.200: icmp_seq=23 ttl=238 time=390.367 ms  
64 bytes from 128.210.7.200: icmp_seq=24 ttl=238 time=270.164 ms  
64 bytes from 128.210.7.200: icmp_seq=25 ttl=238 time=323.535 ms  
64 bytes from 128.210.7.200: icmp_seq=26 ttl=238 time=177.525 ms  
^C  
--- www.purdue.edu ping statistics ---  
27 packets transmitted, 27 packets received, 0.0% packet loss  
round-trip min/avg/max/stddev = 169.776/213.565/423.711/65.449 ms  
(base)
```

Based on the ping statistics part at the end, round-trip times show some variation between 2 ping outputs. Output command shows number of packets which are transmitted and received, percentage of the packet loss, round-trip time statistics (min, avg, max, stddev). Average round-trip time during noon was 158.094 ms and during midnight was 213.565 ms. The average round-trip delay is higher at midnight compared to noon. So, this indicates that the delay in network connectivity is higher at midnight than the noon. The reason behind this difference could be increased network traffic at midnight. Average RTT of noon & midnight: 185.8295 ms

## Q1-b) From Sabancı University to Purdue University:

### Traceroute at noon:

```
cerendino@Ceren MacBook Pro:~$ traceroute www.purdue.edu
traceroute to www.purdue.edu (128.210.7.200), 64 hops max, 52 byte packets
 1 10.51.0.1 (10.51.0.1) 8.076 ms 6.430 ms 7.629 ms
 2 10.200.15.2 (10.200.15.2) 7.682 ms
   10.200.14.2 (10.200.14.2) 6.890 ms 4.758 ms
 3 10.201.9.1 (10.201.9.1) 4.492 ms 5.614 ms
   10.201.8.1 (10.201.8.1) 5.226 ms
 4 10.201.0.254 (10.201.0.254) 7.448 ms 5.507 ms 5.586 ms
 5 193.255.135.2 (193.255.135.2) 7.445 ms 6.038 ms 5.596 ms
 6 host-85-29-49-13.reverse.superonline.net (85.29.49.13) 7.337 ms 6.329 ms 7.511 ms
 7 10.40.178.209 (10.40.178.209) 9.917 ms 8.990 ms 8.424 ms
 8 * * 10.40.168.240 (10.40.168.240) 7.500 ms
 9 * 10.38.210.62 (10.38.210.62) 7.289 ms *
10 10.38.211.242 (10.38.211.242) 9.026 ms 7.139 ms 9.588 ms
11 * * *
12 10.40.169.200 (10.40.169.200) 7.942 ms * *
13 * * *
14 * 100ge0-35.core2.bts1.he.net (72.52.92.206) 56.602 ms 58.280 ms
15 100ge0-61.core2.vie1.he.net (184.105.65.109) 55.684 ms 49.261 ms *
16 * * *
17 100ge0-77.core1.cmh1.he.net (72.52.92.249) 144.684 ms * *
18 * port-channel4.core2.ind1.he.net (184.104.196.50) 153.501 ms 150.938 ms
19 100ge0-77.core1.cmh1.he.net (72.52.92.249) 143.898 ms * *
20 port-channel4.core2.ind1.he.net (184.104.196.50) 152.825 ms *
   38.101.160.251 (38.101.160.251) 196.849 ms
21 184.105.35.194 (184.105.35.194) 150.653 ms * 150.457 ms
22 * * 38.101.160.251 (38.101.160.251) 162.224 ms
23 * * *
24 * * *
25 * * *
26 * * *
27 128.210.7.200 (128.210.7.200) 156.398 ms 156.283 ms *
(base)
```

### Traceroute at midnight:

```
$ traceroute www.purdue.edu
traceroute to www.purdue.edu (128.210.7.200), 64 hops max, 52 byte packets
 1 192.168.1.1 (192.168.1.1) 6.071 ms 7.537 ms 4.245 ms
 2 * * *
 3 172.19.6.1 (172.19.6.1) 151.851 ms 33.625 ms 45.341 ms
 4 172.16.193.125 (172.16.193.125) 40.812 ms 39.490 ms 60.443 ms
 5 172.16.68.94 (172.16.68.94) 26.623 ms 42.948 ms
   172.16.68.142 (172.16.68.142) 22.070 ms
 6 172.16.68.109 (172.16.68.109) 166.634 ms
   172.16.68.157 (172.16.68.157) 47.467 ms 51.334 ms
 7 172.16.198.7 (172.16.198.7) 40.600 ms 53.976 ms 40.330 ms
 8 10.40.168.240 (10.40.168.240) 30.202 ms * *
 9 * * *
10 * * *
11 10.36.6.38 (10.36.6.38) 83.105 ms 28.209 ms 97.270 ms
12 * * *
13 100ge0-75.core1.cmh1.he.net (184.104.193.93) 199.242 ms * 176.754 ms
14 * 100ge0-75.core1.cmh1.he.net (184.104.193.93) 169.869 ms * *
   hurricane-svc08043-lag003148.ip.twelve99-cust.net (62.115.189.114) 169.769 ms * *
15 * 100ge0-75.core1.cmh1.he.net (184.104.193.93) 169.869 ms
   indiana-university-co-indiana-gigapop.10gigabitethernet12-5.core1.ind1.he.net (184.105.35.194) 175.702 ms
16 * 38.101.160.251 (38.101.160.251) 191.460 ms 170.591 ms
17 indiana-university-co-indiana-gigapop.10gigabitethernet12-5.core1.ind1.he.net (184.105.35.194) 161.741 ms
   1amb-20-c7710-01-ptp-pol83-091.tcom.purdue.edu (192.5.40.185) 166.797 ms
   indiana-university-co-indiana-gigapop.10gigabitethernet12-5.core1.ind1.he.net (184.105.35.194) 170.597 ms
18 38.101.160.251 (38.101.160.251) 167.461 ms * *
19 1amb-20-c7710-01-ptp-pol83-091.tcom.purdue.edu (192.5.40.185) 172.653 ms 168.752 ms *
20 * * *
21 * * *
22 * 128.210.7.200 (128.210.7.200) 182.735 ms *
(base)
```

Output of the traceroute command gives information about network paths by sending packets to given destination and waits response from routers. Packets goes through different routers and networks and then reaching the final destination. Also, output shows IP addresses of those routers and RTT of packet between routers.

There can be **potential bottlenecks** at routers which indicated by \*\*\* symbols. Those routers are not responding to packets. Those can be seen from the hops: **At noon** 11,13,16,23,24,25,26 and **at midnight** 2,9,10,12,20,21. Also, at each hop if packet transmission times differ a lot, it also can be potential bottleneck. For example at midnight, 3<sup>rd</sup> hop has transmission times in which 1<sup>st</sup> one is a lot lower than 2<sup>nd</sup> and 3<sup>rd</sup>. At 8<sup>th</sup> hop first transmission is completed but other 2 are not.

There are different IP addresses for hops, so this shows that **network topology** has multiple hops between routers and networks.

At noon routers have private IP addresses which shows it is following local network. At midnight again we see private IP addresses from the hops at the beginning. However from the remaining hops, we see routers that have public IPs. This shows that the traffic is no longer following local network, but it is router over the internet.

Also, while analyzing network topology it can be seen that at midnight RTT values are higher than the noon. When RTT values are high, it may indicate potential bottlenecks.

### Q1-c)

I counted distinct IP addresses in the traceroute outputs which indicates routers between the source and destination. However there might be routers that are not shown in the output, so total number of routers could be higher compared to my results.

**At noon I got 18 and at midnight 14** different IP addresses.

As I explained in Q1b, paths show difference between noon and midnight. At noon, IPs with 10.x.x.x shows that it is local network. However at midnight we see more public IPs that are globally routable.

### Q2-a)

Bird fly distance from Sabancı University to Purdue University: **8,922.10 km (5,543.94 mil)**

Propagation Delay:  $8922.1 \times 10^3 / 2 \times 10^5 = 44.6105 \text{ ms}$

### Q2-b)

Approximate fiber optic cable distance from Sabancı to Purdue: **12,485.51 km (7,758.13 mil)**

Propagation Delay:  $12485.51 \times 10^3 / 2 \times 10^5 = 62.42755 \text{ ms}$

RTT:  $62.42755 \times 2 = 124.8551 \text{ ms}$

### Q2-c)

Average RTT that I found in Q1a for noon: 158.094 and for midnight: 213.565. Average of those are: 185.8295.

RTT in Q2b was 124.8551.

I think this difference is due to my measurement. I used Google Maps to measure fiber optic cable distance so I think my measurement is less than the real value.