COMP-4320

Introduction to Computer Networks

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LAB SECTION: 001

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Homework #1

Exercise 1 (60 points)

The ping program allows you to send a test packet to a given location and see how long it takes to get there and back. Try using ping to see how long it takes to get from your location to several known locations. From these data, plot the one-way transit time over the Internet as a function of distance. The ping provides the round trip time. Half the minimum round trip time is *in general* a reasonable estimate of the one-way transit time. It is best to use universities since the location of their servers is in general known very accurately. For example, yale.edu is in New Haven, Connecticut; harvard.edu is in Cambridge, Massachusetts; scu.edu.au (Southern Cross University, Australia); une.edu.au (University of New England, Australia); and www.zju.edu.cn (Zhejian University, China).

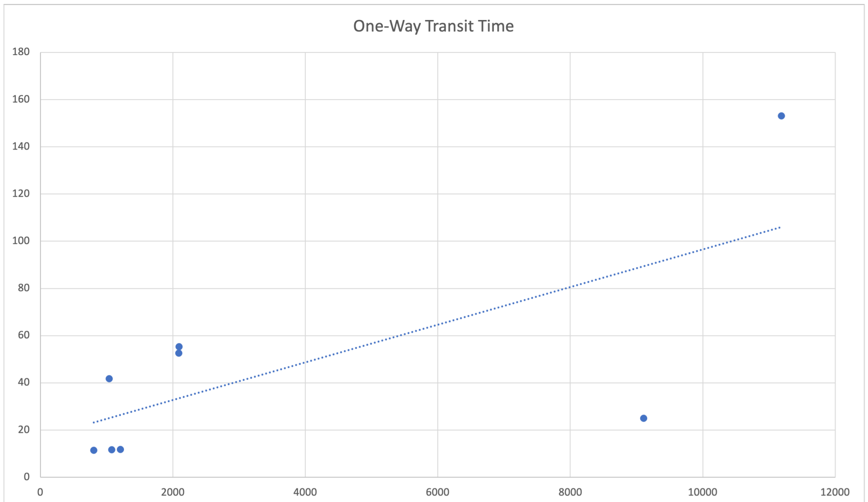
Add three other universities of your choice (must respond to your pings).
(10 points) Provide **one screenshot** (document) of ONE ping to any of the above destinations. Insert the screenshot in this document

Below is a table consisting of the ping results as well as the distances. The average one-way transit time was obtained by taking half of the average round tip time.

UNIVERSITY	LOCATION	URL	AVG ROUND TRIP TIME (ms)	AVG ONE-WAY TRANSIT TIME (ms)	DISTANCE (mi)
Yale	New Haven, Connecticut	yale.edu	23.324	11.662	1078
Harvard	Cambridge, Massachusetts	harvard.edu	23.636	11.818	1206
Southern Cross University	Australia	scu.edu.au	306.247	153.1235	11189
University of New England	Australia	une.edu.au	49.909	24.9545	9109
UC Berkeley	California	berkeley.edu	110.776	55.388	2092
Princeton	New Jersey	princeton.edu	22.943	11.4715	805
Stanford	California	stanford.edu	105.170	52.585	2089
M.I.T.	Cambridge, Massachusetts	mit.edu	83.601	41.8005	1036

Figure 1: Data representing the average one-way transit time from Auburn University to respective schools

(30 points) Sort on the x-axis the locations (all universities provided and the three universities you provide) in increasing distance from Auburn and plot the one-way transit time.



(20 points) Discuss the plot. Does the one-way transit correlate with the distance? If not, why?

→ The graph doesn't necessarily follow a linear pattern; although time does vary with distance. There seems to be several outliers presented here which seems to be the University of New England with a distance of 9,109 miles and a one-way transit time of 25 milliseconds. Also Southern Cross University with a distance of approximately 11,000 miles and a one-way transit time of 153 milliseconds; both being located in Australia.

```
PING yale.edu (151.101.194.133): 56 data bytes
64 bytes from 151.101.194.133: icmp_seq=0 ttl=56 time=24.042 ms
^C
--- yale.edu ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 24.042/24.042/24.042/0.000 ms
→ ~
→ ~
→ ~ ping harvard.edu
PING harvard.edu (23.185.0.1): 56 data bytes
64 bytes from 23.185.0.1: icmp_seq=0 ttl=56 time=45.150 ms
^C
--- harvard.edu ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 45.150/45.150/45.150/0.000 ms
→ ~
→ ~
→ ~ ping scu.edu.au
PING scu.edu.au (203.2.41.31): 56 data bytes
^C
--- scu.edu.au ping statistics ---
1 packets transmitted, 0 packets received, 100.0% packet loss
→ ~ ping www.scu.edu.au
PING www.scu.edu.au (203.2.40.162): 56 data bytes
64 bytes from 203.2.40.162: icmp_seq=0 ttl=232 time=318.021 ms
^C
--- www.scu.edu.au ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 318.021/318.021/318.021/0.000 ms
→ ~
→ ~
→ ~ ping une.edu.au
PING une.edu.au (43.245.43.58): 56 data bytes
64 bytes from 43.245.43.58: icmp_seq=0 ttl=47 time=65.539 ms
^C
--- une.edu.au ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 65.539/65.539/65.539/0.000 ms
→ ~
→ ~
→ ~ ping berkeley.edu
PING berkeley.edu (35.163.72.93): 56 data bytes
64 bytes from 35.163.72.93: icmp_seq=0 ttl=24 time=128.581 ms
^C
--- berkeley.edu ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 128.581/128.581/128.581/0.000 ms
→ ~
→ ~
→ ~ ping www.princeton.edu
PING www.princeton.edu.cdn.cloudflare.net (104.18.5.101): 56 data bytes
64 bytes from 104.18.5.101: icmp_seq=0 ttl=56 time=21.315 ms
^C
--- www.princeton.edu.cdn.cloudflare.net ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 21.315/21.315/21.315/0.000 ms
→ ~
→ ~
→ ~ ping stanford.edu
PING stanford.edu (171.67.215.200): 56 data bytes
64 bytes from 171.67.215.200: icmp_seq=0 ttl=235 time=92.941 ms
^C
--- stanford.edu ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 92.941/92.941/92.941/0.000 ms
→ ~
→ ~
→ ~ ping mit.edu
PING mit.edu (23.56.211.213): 56 data bytes
64 bytes from 23.56.211.213: icmp_seq=0 ttl=55 time=31.632 ms
^C
--- mit.edu ping statistics ---
1 packets transmitted, 1 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 31.632/31.632/31.632/0.000 ms
```

Figure 2: Transcript of Ping Session

Exercise 2 (40 points)

a) **(25 points)** A system has a 6 layer protocol hierarchy. The upper layer (Applications) generates messages of length 100 bytes. At **each** of the 6 layers, a 30 byte header is added. What fraction of the network bandwidth is filled with headers? The fraction **f** is equal the total number of bytes of all headers over the total number of bytes sent out by a sender at the application layer. We assume that there are no trailers and that the application layer also has a header.

i. **(15 points) Draw** the full message with all headers assuming there are no trailers. Refer to the Slide 12 about encapsulation. Draw similarly to that slide the messages/headers as rectangles.

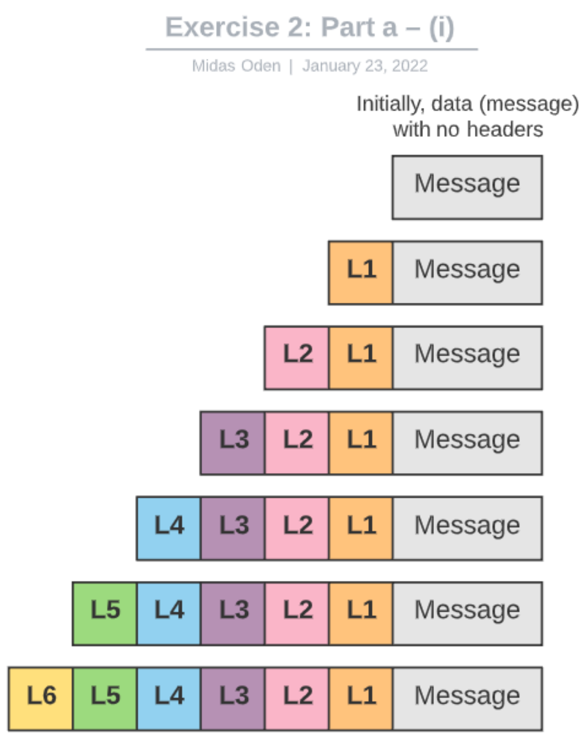


Figure 3: Final message with all headers

ii. **(5 points) Derive** the fraction f.

→ To begin deriving the fraction f, we start with the length in bytes for how much the upper layer (Applications) generate messages...

$$Messages\ of\ length = 100\ bytes \tag{1}$$

Since we are dealing with a system that has a 6-layer protocol hierarchy, 30 bytes will be added at **each** of the 6 layers. So...

$$Total\ header\ bytes = 30 * 6 = 180 \tag{2}$$

$$Total\ bytes\ sent\ through\ sender = 100 + 180 = 280 \tag{3}$$

Now, we are able to derive the fraction f...

$$fraction(f) =$$

$$\frac{Total\ header\ bytes}{Total\ bytes\ sent\ through\ sender}$$

$$fraction(f) =$$

$$\frac{180}{280}$$

$$fraction(f) =$$

$$\frac{9}{14}$$

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b) **(15 points)** Consider a DNS request on the Internet. The DNS request (application layer) is a message of about 125 bytes. The UDP header is 8 bytes long. The IP header is in general 20 bytes long. An IEEE 802.3 Ethernet frame may have up to a 26 bytes header and a 16 bytes trailer. What fraction f of the network bandwidth is filled with headers/trailer?

i. **(10 points) Draw** the full message with all headers/trailer. Draw similarly to the slide about encapsulation.

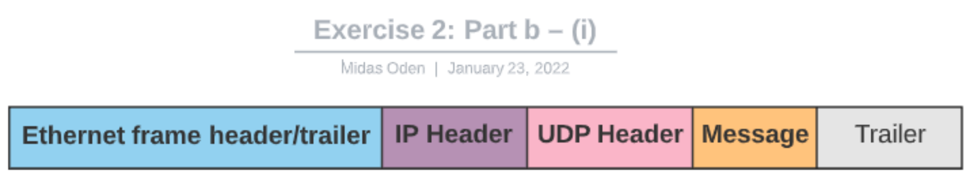

Figure 4: Full message with headers/trailer

ii. **(5 points) Derive** the fraction f.

→ To begin deriving the fraction f, we start with the number of bytes for the given message representing the DNS request...

$$DNS\ request = 125\ bytes \tag{4}$$

The following equation is used to derive the fraction f by...

$$fraction(f) =$$

$$\frac{Total\ header\ and\ trailer\ bytes}{Total\ bytes\ sent\ through\ sender}$$

The total header and trailer bytes will simply be the sum of the given headers and trailers...which are the UDP header (8 bytes), IP header (20 bytes), and an IEEE 802.3 Ethernet frame (26 bytes header and 16 bytes trailer)...

$$Total\ header\ and\ Trailer\ bytes = 8 + 20 + 26 + 16 = 70\ bytes \tag{5}$$

The total bytes sent through the sender will represent the given message length + the header and trailer bytes...

$$Total\ bytes\ sent\ through\ sender = 125 + 70 = 195\ bytes \tag{6}$$

Now, we are able to derive the fraction f...

$$fraction(f) =$$

$$\frac{Total\ header\ and\ trailer\ bytes}{Total\ bytes\ sent\ through\ sender}$$

$$fraction(f) =$$

$$\frac{70}{195}$$

$$fraction(f) =$$

$$\frac{14}{39}$$

$$\therefore\ fraction(f) = 38.9\% \tag{7}$$

Appendix (100 points)

Grading: What is OBVIOUS and CLEAR LINK?

Alice travels from Auburn to Atlanta in her car at a speed of 60 mph. Leaving at 8am, at what time will Alice reach Atlanta assuming that she had a flat tire that delayed her 30 minutes.

$\longrightarrow$ The time t to travel a distance d at speed v is equal to...

$$d/v = d/60 \; mph \tag{8}$$

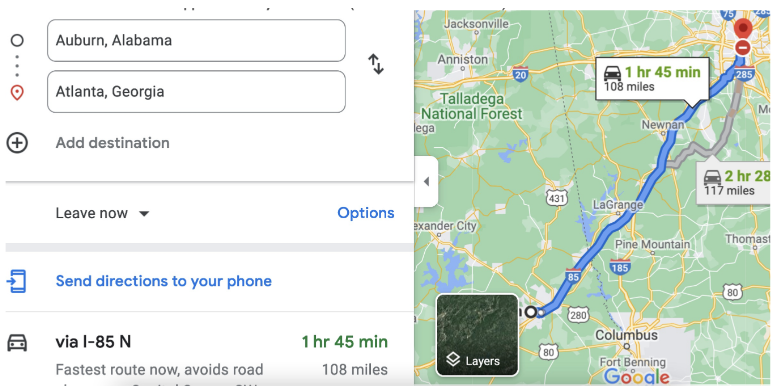

Figure 5: Based on GoogleMaps, the distance from Auburn to Atlanta is approximately 108 miles.

$\longrightarrow$ Therefore, the time t = 108 miles / 60 mph * 60 minutes/hour = 108 minutes. Alice leaves Auburn at 8AM but encounters a flat tire that delayed her arrival by 30 minutes.

$$8AM + 108 \; minutes + 30 \; minutes = \tag{9}$$

$$8AM + 120 \; minutes + 18 \; minutes = 10{:}18AM \tag{10}$$

$\longrightarrow$ **ANSWER:** So, by factoring in the 30 minute delay, she will then reach Atlanta at approximately 10:18AM.