

Chapter 1

P6a) The propagation delay, d_{prop} , in terms of m and s :

$$d_{\text{prop}} = m/s \text{ seconds}$$

b) The transmission time of the packet, d_{trans} , in terms of L and R :

$$d_{\text{trans}} = L/R \text{ seconds.}$$

c) Expression for the end-to-end delay:

$$d_{\text{end-to-end}} = (m/s + L/R) \text{ seconds.}$$

d) The bit is just leaving Host A.

e) The first bit is in the link and has not reached Host B.

f) The first bit has reached Host B.

g) The distance m so that d_{prop} equals d_{trans} :

$$m = \frac{L}{R} s$$

$$m = \frac{L}{R} s = \frac{12000}{10 \times 10^6} (2.5 \times 10^8)$$

we know that 1 byte = 8 bits
 1500 bytes = 1500×8
 = 12000 bits

$$= \frac{12}{10 \times 10^3} (2.5 \times 10^8)$$

$$= \boxed{300 \text{ km}}$$

a) The total of users can be supported, when circuit switching is used.

$$\begin{aligned} \text{The number of users} &= \frac{\text{Transmission rate of the link used by the user}}{\text{Transmission rate required by each user}} \\ &= \frac{10 \text{ Mbps}}{200 \text{ Kbps}} \end{aligned}$$

We know that $1 \text{ Mbps} = 10^3 \text{ Kbps}$

$$= \frac{10000 \text{ Kbps}}{200 \text{ Kbps}}$$

$$= 50 \text{ users}$$

So the total number of users = 50

b)

Transmission rate = 10%

$$\text{Probability} = \frac{1}{10} = 0.1$$

c)

$$P(n) = {}^N C_n (P)^n (1-P)^{N-n}$$

$$P(n) = {}^{120} C_n \left(\frac{1}{10}\right)^n \left(\frac{9}{10}\right)^{120-n}$$

Recall: Binomial distribution

$$P(n) = \binom{120}{n} \times p^n \times (1-p)^{120-n}$$

$\binom{120}{n}$: Different ways of choosing n users from 120 users

p^n : probability of choosing these n users

$(1-p)^{120-n}$: Probability of $n-k$ users not being chosen.

d) The probability that there are 51 or more users transmitting simultaneously.

$$\text{Probability} = 1 - \sum_{n=0}^{50} \binom{120}{n} p^n (1-p)^{120-n}$$

$$= 1 - \sum_{n=0}^{50} \binom{120}{n} 0.10^n \cdot 0.90^{120-n}$$

P.13

calculate the average queuing delay:

a)

The first packet queuing delay = 0

The second packet queuing delay = $\frac{L}{R}$

The third packet queuing delay = $2 \frac{L}{R}$ and so on

The Nth packet queuing delay = $(N-1) \frac{L}{R}$

Therefore, the average queuing delay of Nth packet =

$$= \frac{\left(\frac{L}{R} + 2 \frac{L}{R} + 3 \frac{L}{R} + \dots + (N-1) \frac{L}{R} \right)}{N}$$

$$= \frac{L}{RN} \sum_{i=1}^{N-1} i$$

$$= \left(\frac{L}{RN} \right) \frac{N(N-1)}{2}$$

$$= (N-1) \frac{L}{(2R)}$$

b) To transmit such batches, it takes LN/R seconds. Therefore, a new batch arrives then the queue is empty each time. Thus, the average delay of a packet across all batches is the average delay within one batch.

Hence the average queuing delay of a packet = $(N-1) \frac{L}{(2R)}$

P.14

a) The transmission delay is L/R . The total delay is
 $\text{Total delay} = \text{queuing delay} + \text{transmission delay}.$

$$\frac{IL}{R(1-I)} + \frac{L}{R} = \boxed{\frac{L/R}{1-I}}$$

b) Let $x = L/R$ be the transmission delay, Traffic intensity $I = \frac{La}{R} = xa$
 Hence the total delay $= \boxed{\frac{x}{1-xa}}$

For $x=0$, the total delay $= 0$; as we increase x , total delay increases, approaching infinity as x approaches $1/a$.

Chapter 2

P.4

- a) The document request was `http://gaia.cs.umass.edu/cs453/index.html`. The `Host:` field indicates the server's name and `/cs453/index.html` indicates the file name.
- b) The browser is running HTTP version 1.1, as indicated just before the first pair.
- c) The browser is requesting a persistent connection, as indicated by the `Connection: Keep-alive`.
- d) This is a trick question. This information is not contained in an HTTP message anywhere. So there is no way to tell this from looking at the exchange of HTTP messages alone. One would need information from the IP datagrams (that carried the TCP segment that carried the HTTP GET request) to answer this question.
- e) Mozilla/5.0. The browser type information is needed by the server to send different versions of the same object to different types of browsers.

Chapter 2

P.6

a) Overall operation stated that for HTTP 1.1, persistent connections are the default behavior of any HTTP connection. That is, unless otherwise indicated, the client should assume that the server will maintain a persistent connection, even after error responses from the server.

The closing of a connection can be initiated by either the client or the server using the connection header must include the connection token, "close" in the request. If the server wishes to close the connection, it must include the same "close" token in connection header along with its response. This connection header is the last request for that connection. Both the client and server can close a connection.

b) There are no encryption services provided by HTTP.

c) Yes, a client can open three or more simultaneous connections with a given server, although the suggested number of concurrent persistent connections is two.

d) Closing the connection by one side is possible while the other side is transmitting. This is because HTTP is stateless and therefore neither party knows the other's state.

Ch1.

P.18

Traceroutes between NYCU and ptt.cc

a)

The average(mean) of the round-trip delays at each of the three hours is 7.901 ms, 9.018 ms, and 8.209 ms, respectively. The standard deviations are 1.51 ms, 1.73 ms, and 1.35 ms, respectively.

```
ralphkedywillensbureau — zsh — 80x24
(base) ralphkedywillensbureau@Ralphs-MacBook-Pro ~ % traceroute ptt.cc
traceroute: Warning: ptt.cc has multiple addresses; using 140.112.172.3
traceroute to ptt.cc (140.112.172.3), 64 hops max, 52 byte packets
 1 172.17.47.254 (172.17.47.254) 5.925 ms 6.365 ms 6.370 ms
 2 140.113.136.222 (140.113.136.222) 5.250 ms 6.470 ms 6.490 ms
 3 not-a-legal-address (140.113.0.74) 7.310 ms 6.358 ms 6.315 ms
 4 not-a-legal-address (140.113.0.105) 7.367 ms 6.858 ms 8.794 ms
 5 192.192.61.118 (192.192.61.118) 6.889 ms 7.914 ms 7.762 ms
 6 192.192.61.18 (192.192.61.18) 7.203 ms
   192.192.61.4 (192.192.61.4) 7.383 ms
   192.192.61.18 (192.192.61.18) 8.426 ms
 7 192.192.61.0 (192.192.61.0) 8.538 ms
   192.192.61.16 (192.192.61.16) 7.792 ms
   192.192.61.0 (192.192.61.0) 8.720 ms
 8 192.192.61.81 (192.192.61.81) 9.248 ms 13.445 ms 9.381 ms
 9 140.112.0.69 (140.112.0.69) 9.701 ms 7.462 ms 8.608 ms
10 140.112.0.201 (140.112.0.201) 8.356 ms 7.492 ms 7.547 ms
11 140.112.0.213 (140.112.0.213) 9.613 ms
   140.112.0.173 (140.112.0.173) 8.153 ms
   140.112.0.213 (140.112.0.213) 9.076 ms
12 c.ptt.cc (140.112.172.3) 9.271 ms 9.075 ms 7.518 ms
(base) ralphkedywillensbureau@Ralphs-MacBook-Pro ~ %
```

```
ralphkedywillensbureau — zsh — 80x24
(base) ralphkedywillensbureau@Ralphs-MacBook-Pro ~ % traceroute ptt.cc
traceroute: Warning: ptt.cc has multiple addresses; using 140.112.172.11
traceroute to ptt.cc (140.112.172.11), 64 hops max, 52 byte packets
 1 172.17.47.254 (172.17.47.254) 16.881 ms 7.042 ms 6.224 ms
 2 140.113.136.222 (140.113.136.222) 9.774 ms 6.752 ms 5.342 ms
 3 not-a-legal-address (140.113.0.74) 5.378 ms 5.548 ms 5.212 ms
 4 not-a-legal-address (140.113.0.105) 6.768 ms 6.750 ms 7.454 ms
 5 192.192.61.118 (192.192.61.118) 7.547 ms 7.433 ms 9.587 ms
 6 192.192.61.4 (192.192.61.4) 8.023 ms 7.308 ms 12.543 ms
 7 192.192.61.16 (192.192.61.16) 8.063 ms
   192.192.61.0 (192.192.61.0) 9.332 ms 8.925 ms
 8 192.192.61.81 (192.192.61.81) 11.584 ms 11.253 ms 8.708 ms
 9 140.112.0.69 (140.112.0.69) 9.290 ms 9.461 ms 9.737 ms
10 140.112.0.201 (140.112.0.201) 9.174 ms 9.196 ms 13.446 ms
11 140.112.0.173 (140.112.0.173) 17.083 ms
   140.112.0.213 (140.112.0.213) 10.608 ms
   140.112.0.173 (140.112.0.173) 7.993 ms
12 ptt.cc (140.112.172.11) 11.476 ms 8.307 ms 9.481 ms
(base) ralphkedywillensbureau@Ralphs-MacBook-Pro ~ %
```



```
tracert to ptt.cc (140.112.172.5) 64 hops max, 52 byte packets
ralphkedywillensbuteau — -zsh — 80x24
Last login: Wed Oct 19 19:12:02 on ttys000
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ % traceroute ptt.cc
traceroute: Warning: ptt.cc has multiple addresses; using 140.112.172.5
traceroute to ptt.cc (140.112.172.5), 64 hops max, 52 byte packets
 1 172.17.47.254 (172.17.47.254) 6.807 ms 5.389 ms 9.613 ms
 2 140.113.136.222 (140.113.136.222) 5.686 ms 6.370 ms 6.773 ms
 3 not-a-legal-address (140.113.0.74) 5.148 ms 8.790 ms 7.456 ms
 4 not-a-legal-address (140.113.0.105) 8.229 ms 8.941 ms 7.431 ms
 5 192.192.61.118 (192.192.61.118) 7.847 ms 7.489 ms 7.494 ms
 6 192.192.61.18 (192.192.61.18) 8.528 ms 7.546 ms
   192.192.61.4 (192.192.61.4) 6.379 ms
 7 192.192.61.16 (192.192.61.16) 7.145 ms
   192.192.61.0 (192.192.61.0) 7.445 ms 8.429 ms
 8 192.192.61.81 (192.192.61.81) 8.546 ms 8.579 ms 10.710 ms
 9 140.112.0.69 (140.112.0.69) 10.770 ms 9.138 ms 9.712 ms
10 140.112.0.201 (140.112.0.201) 8.307 ms 8.925 ms 8.525 ms
11 140.112.0.173 (140.112.0.173) 9.637 ms 8.671 ms
   140.112.0.213 (140.112.0.213) 12.223 ms
12 e.ptt.cc (140.112.172.5) 10.001 ms 8.261 ms 8.623 ms
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ %
```

b) In this example, the traceroutes have 12 routers in the path at each of the three hours. Yes, the paths changed during the hours. the IPs of the destination are different between hours. It is probably for server load balance.

c)Traceroute packets passed through 3 ISP networks from Source to destination. Yes, in this experiment the largest delays occurred at peering interfaces between adjacent ISPs.

d)
traceroutes from dorm9.nctu.edu.tw to www.umass.edu

The average(mean) of the round-trip delays at each of the three hours is 51.59 ms, 53.75 ms, and 79.97 ms, respectively. The standard deviations are 74.98 ms, 87.31 ms, and 139.36 ms, respectively. the traceroutes have 12 routers in the path at each of the three hours. No, the paths didn't change during any of the hours. Traceroute packets passed through 4 ISP networks from Source to destination. Yes, in this experiment the largest delays occurred at peering interfaces between adjacent ISPs.

```
ralphkedywillensbuteau — zsh — 80x24
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ % traceroute www.umass.edu
traceroute: Warning: www.umass.edu has multiple addresses; using 23.46.63.73
traceroute to e28010.dscb.akamaiedge.net (23.46.63.73), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  7.218 ms  3.801 ms  8.638 ms
 2  gateway-140-113-89-0.dorm9.nctu.edu.tw (140.113.89.254)  9.804 ms  7.669 ms  5.558 ms
 3  172.16.79.2 (172.16.79.2)  7.353 ms  4.683 ms  6.967 ms
 4  not-a-legal-address (140.113.0.170)  5.426 ms  18.143 ms  5.881 ms
 5  not-a-legal-address (140.113.0.74)  13.736 ms  9.261 ms  4.874 ms
 6  not-a-legal-address (140.113.0.105)  10.606 ms  11.029 ms  4.869 ms
 7  192.192.61.118 (192.192.61.118)  8.229 ms  13.500 ms  11.267 ms
 8  192.192.61.54 (192.192.61.54)  12.143 ms  8.638 ms  12.932 ms
 9  192.192.61.58 (192.192.61.58)  14.610 ms  12.486 ms  7.662 ms
10  192.192.68.62 (192.192.68.62)  165.169 ms  150.409 ms  157.023 ms
11  48-222-163-203-static.tpix.net.tw (203.163.222.48)  245.427 ms  194.246 ms  221.441 ms
12  a23-46-63-73.deploy.static.akamaitechnologies.com (23.46.63.73)  177.015 ms  149.426 ms  150.291 ms
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ %
```

```
ralphkedywillensbuteau — zsh — 80x24
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ % traceroute www.umass.edu
traceroute: Warning: www.umass.edu has multiple addresses; using 23.199.34.145
traceroute to e28010.dscb.akamaiedge.net (23.199.34.145), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  5.558 ms  3.160 ms  3.542 ms
 2  gateway-140-113-89-0.dorm9.nctu.edu.tw (140.113.89.254)  5.327 ms  5.105 ms  6.957 ms
 3  172.16.79.2 (172.16.79.2)  5.392 ms  4.520 ms  8.436 ms
 4  not-a-legal-address (140.113.0.170)  6.619 ms  4.934 ms  9.914 ms
 5  not-a-legal-address (140.113.0.74)  9.911 ms  9.971 ms  5.504 ms
 6  not-a-legal-address (140.113.0.105)  6.573 ms  6.253 ms  4.711 ms
 7  192.192.61.118 (192.192.61.118)  5.466 ms  6.745 ms  5.696 ms
 8  192.192.61.54 (192.192.61.54)  16.786 ms  9.568 ms  9.435 ms
 9  192.192.61.58 (192.192.61.58)  8.415 ms  11.342 ms  9.630 ms
10  192.192.68.62 (192.192.68.62)  143.672 ms  152.674 ms  145.867 ms
11  48-222-163-203-static.tpix.net.tw (203.163.222.48)  191.081 ms  288.742 ms  385.143 ms
12  a23-199-34-145.deploy.static.akamaitechnologies.com (23.199.34.145)  145.864 ms  144.540 ms  142.071 ms
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ %
```


815.7 MB Disk Image Oct 12, 2022 at 6:08 AM
ralphkedywillensbuteau — zsh — 80x24

```
((base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ % traceroute www.umass.edu
traceroute: Warning: www.umass.edu has multiple addresses; using 104.116.243.48
traceroute to e28010.dscb.akamaiedge.net (104.116.243.48), 64 hops max, 52 byte
packets
 1 192.168.0.1 (192.168.0.1)  4.260 ms  44.984 ms  9.926 ms
 2 gateway-140-113-89-0.dorm9.nctu.edu.tw (140.113.89.254)  5.309 ms  8.710 ms
 27.549 ms
 3 172.16.79.2 (172.16.79.2)  6.157 ms  4.903 ms  3.313 ms
 4 not-a-legal-address (140.113.0.170)  5.227 ms  4.692 ms  24.777 ms
 5 not-a-legal-address (140.113.0.74)  16.546 ms  25.815 ms  34.890 ms
 6 not-a-legal-address (140.113.0.105)  12.113 ms  23.593 ms  4.717 ms
 7 192.192.61.118 (192.192.61.118)  24.060 ms  15.394 ms  7.504 ms
 8 192.192.61.54 (192.192.61.54)  24.973 ms  17.918 ms  7.053 ms
 9 192.192.61.58 (192.192.61.58)  11.023 ms  13.916 ms  20.777 ms
10 192.192.68.62 (192.192.68.62)  150.311 ms  143.415 ms  148.601 ms
11 48-222-163-203-static.tpix.net.tw (203.163.222.48)  484.343 ms  460.378 ms
595.287 ms
12 a104-116-243-48.deploy.static.akamaitechnologies.com (104.116.243.48)  158.3
67 ms  178.774 ms  149.642 ms
(base) ralphkedywillensbuteau@Ralphs-MacBook-Pro ~ %
```