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EECS 325

Homework 1

1. a is the average arrival rate of packets, L is the average packet length, R is the transmission rate.
   (a) $a = \frac{R}{L} = \frac{1\ Mbps}{12000\frac{bits}{packet}} = 83.3\overline{3}\,\frac{packets}{s}$, $I = \frac{La}{R} = \frac{83.33\frac{packets}{s} * 12000\ bits}{3\ Mbps} = \mathbf{\frac{1}{3}}$
   (b) If one packet arrives every L/R seconds, then the packet will arrive at an empty queue and there will be no queuing delay.
   (c) If one packet arrives at a rate greater than ten times L/R, then the packet will queue for over 10 seconds.
   (d) N is the number of users, $P(T)$ is the probability of transmission
   The probability that no users are transmitting can be expressed by:
$$\left(1 - P(T)\right)^N = \left(\frac{2}{3}\right)^3 = \mathbf{\frac{8}{27}}$$
   The probability that any one user is transmitting can be expressed by:
$$\binom{N}{1} * P(T) * \left(1 - P(T)\right)^{N-1} = \binom{3}{1} * \frac{1}{3} * \left(\frac{2}{3}\right)^2 = \mathbf{\frac{4}{9}}$$
   The probability that any two users are transmitting can be expressed by:
$$\binom{N}{2} * P(T) * \left(1 - P(T)\right)^{N-2} = \binom{3}{2} * \frac{1}{3} * \frac{2}{3} = \mathbf{\frac{2}{3}}$$
   The probability that all three users are transmitting can be expressed by:
$$\binom{N}{3} * P(T) * \left(1 - P(T)\right)^{N-3} = \binom{3}{3} * \frac{1}{3} * 1 = \mathbf{\frac{1}{3}}$$
   (e) There are four possible loads: one, two, three, or no users transmitting. When none are transmitting, the intensity is zero and the router queue shrinks. When one is transmitting, the intensity is 0.5 and the queue also shrinks. When two are transmitting, the intensity is 1 and the queue is roughly stable. When three are transmitting, the intensity is 1.5 and the queue grows. Therefore, the queue is typically in a shrinking mode.

2. If the bandwidth of the incoming link is much greater than that of the incoming link, a time gap would form on the outgoing link because the router would not be able to release packets at the rate at which it receives them.

3.
   (a) $d_{prop} = \frac{m}{s} sec$
   (b) $d_{trans} = \frac{L}{R} sec$

(c) $d_{total} = d_{prop} + d_{trans} = \frac{m}{s} + \frac{L}{R}\ sec$

(d) At time $t = d_{trans}$ the last bit of the packet leaves Host A.

(e) If d_{prop} is greater than d_{trans}, at time $t = d_{trans}$, the first bit of the packet is on the link between the two hosts.

(f) If d_{prop} is less than d_{trans}, at time $t = d_{trans}$, the first bit of the packet reaches Host B.

(g) The distance that causes d_{prop} and d_{trans} to be equal can be expressed by:

$$m = \frac{L * s}{R} = \frac{\left(120\ bits * \left(2.5 * 10^8 \frac{meters}{sec}\right)\right)}{56\ kbps * 1000} = 535714\ meters = \mathbf{536\ km}$$

4.

(a) The time the message takes to arrive at its destination without message segmentation can be expressed by:

$\frac{8*10^6\ bits}{2*10^6\ bps} = 4\ seconds\ per\ link,\ 4\ sec * 3\ links = \mathbf{12\ sec}\ total$

(b) The time the first packet takes to move over one link can be expressed by:

$$\frac{2 * 10^3}{2 * 10^6} sec = 0.001\ sec = \mathbf{1\ msec}$$

Because the first packet arrives at the second packet switch at the same time the second packet arrives at the first packet switch, the above time is doubled (**2 msec**).

(c) The first packet arrives after crossing three links. The remaining packets arrive after taking the time it takes to cross the last link. Thus, the time it takes all packets to arrive can be expressed by:

$$3\ msec + 799\ packets * 1\ msec = \mathbf{8.02\ sec}$$

which is almost 4 seconds shorter than it takes without message segmentation.

(e) Some drawbacks of message segmentation: increased overhead for individual packets, time taken to reassemble the message at its destination

Some advantages of message segmentation: Packets can be resent if corrupted, less time is taken.

5. $total = message + overhead + retransmission$

Packet size 1000 bytes:

$\frac{1*10^6 bytes}{1*10^3\ bytes/packet} = 1000\ packets;$

$$1 * 10^6\ bytes + 100\ bytes * 1000\ packets + 1100\ bytes = \mathbf{1101100\ bytes}$$

Packet size 5000 bytes:

$\frac{1*10^6 bytes}{5*10^3\ bytes/packet} = 200\ packets;$

$$1 * 10^6\ bytes + 100\ bytes * 200\ packets + 5100\ bytes = \mathbf{1025100\ bytes}$$

Packet size 10000 bytes:

$\frac{1*10^6 bytes}{1*10^4\ bytes/packet} = 100\ packets;$

$$1*10^6\ bytes + 100\ bytes * 100\ packets + 10100\ bytes = \mathbf{1020100\ bytes}$$

Packet size 20000 bytes:

$\frac{1*10^6 bytes}{2*10^4\ bytes/packet} = 50\ packets;$

$$1*10^6\ bytes + 100\ bytes * 50\ packets + 20100\ bytes = \mathbf{1025100\ bytes}$$

We can see that a packet size of 10000 will cause the fewest number of bytes to be transmitted.

6. DNS
   `91 4.769329000 172.19.87.29 129.22.104.132 DNS 70 Standard query 0xdf63 A www.bw.edu`
   HTTP
   `243 5.039113000 172.19.87.29 192.150.115.232 HTTP 415 GET /web_resources/themes/www-bw-edu/css/bw_main_css.css HTTP/1.1`
   TCP
   `1143 5.416322000 94.31.29.53 172.19.87.29 TCP 1434 80→62524 [ACK] Seq=57961 Ack=317 Win=36864 Len=1380`
   TLSv1.2
   `352 5.097234000 198.41.215.8 172.19.87.29 TLSv1.2 1434 Server Hello`
   UDP
   `17 1.356135000 172.19.87.29 208.78.164.12 UDP 126 Source port: 60215 Destination port: 27018`

7. My Lat/Long: 41.501134 / -81.600123

   RTT www.case.edu: 59ms
   Lat/Long: 41.5074 / -81.6053
   Distance: 0.8193 km
   Theoretical min: 2.73 microseconds
   RTT www.cam.ac.uk: 115ms
   Lat/Long: 52.2 / 0.1167
   Distance: 5989
   Theoretical min: 20ms
   RTT: www.tsinghua.edu.cn: 235ms
   Lat/Long: 39.35 / 99.3
   Distance: 10960 km
   Theoretical min: 36.6ms

   As distance increases, so does RTT. The difference is due to nodal delay and the inherent speed of the medium (fiber optic cable, etc.).