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hw2

1.

a. packet size = (F+h) bytes = (F+h) * 8 bits
transmission speed = R bits / sec
N links
time=N*prop delay+N*T
time=D+$N * 0 + N * \left(\frac{(F+h)*8}{\mathrm{R}}\right) = D + N * \left(\frac{(F+h)*8}{\mathrm{R}}\right) seconds$

b. packet size = (P+h) * 8 bits
transmission speed = R bits / sec
N links
M packets
time=N*prop delay+N*t+(n-1)*t
n=number of packets representing each message
t=time to transmit each packet

Assuming that the packets arrive in order $time = D + \mathrm{N} * 0 + \mathrm{N} * \left(\frac{(\mathrm{P+h})*8}{\mathrm{R}}\right) + (M-1) * \left(\frac{(\mathrm{P+h})*8}{\mathrm{R}}\right) = D + \left(\mathrm{N} + (\mathrm{M}-1)\right) * \left(\frac{(\mathrm{P+h})*8}{\mathrm{R}}\right) \text{seconds}$

c. Packet switched network
F bytes are segmented into M packets of P bytes each
Header=h/2 bytes added to each packet
Ts=virtual circuit set up time
Each packet=$\left(\mathrm{P} + \left(\frac{\mathrm{h}}{2}\right)\right) * 8 \text{ bits}$
Time for each packet=$\left(\frac{\left(\mathrm{P}+\left(\frac{\mathrm{h}}{2}\right)\right)*8}{\mathrm{R}}\right)$
Time to send first packet=$N * \left(\frac{\left(\mathrm{P}+\left(\frac{\mathrm{h}}{2}\right)\right)*8}{\mathrm{R}}\right)$
Every $\left(\frac{\left(\mathrm{P}+\left(\frac{\mathrm{h}}{2}\right)\right)*8}{\mathrm{R}}\right)$ seconds a packet from M-1 packets gets to the destination

time=$\mathrm{T_s} + \mathrm{D} + \left(\mathrm{N} + (\mathrm{M}-1)\right) * \left(\frac{\left(\mathrm{P}+\left(\frac{\mathrm{h}}{2}\right)\right)*8}{\mathrm{R}}\right) \text{seconds}$

d. Circuit switched network
R bits/sec after the circuit has been established
Header=h/2 bytes added to entire file
Ts=virtual circuit set up time
Size of packet=$\left(F + (h/2)\right) bytes = \left(F + (h/2)\right) * 8\ bits$

$$\mathrm{T_s} + \mathrm{D} + \left(\frac{\left(\mathrm{F}+\left(\frac{\mathrm{h}}{2}\right)\right)*8}{\mathrm{R}}\right) \text{seconds}$$

e. Packet switching is more efficient with respect to bandwidth and latency compared to circuit switching. Thus, under an increase in those properties, a faster transfer is possible

2.

a. 20 — $20*150kbps = 3000kbps = 3\ mbps$

b. .1 — each user transmits 10% of the time

c. $\binom{120}{n}p^n(1-p)^{120-n} = \binom{120}{n}.1^n(.9)^{120-n}$

d. $1 - \sum_{n=0}^{20}\binom{120}{n}p^n(1-p)^{120-n} = 1 - \sum_{n=0}^{20}\binom{120}{n}.1^n(.9)^{120-n}$

Using central limit theorem $1 - \text{p}(\sum_{n=1}^{120} x <= 20) = 1 - .9920 = .008$

e. $\frac{.7*3000000}{150000} = 14\ people$

3.

a. Source -> first node $= \frac{(8*10^6)}{(2*10^6)} = 4\ seconds,$

altogether the message must traverse 3 nodes mean total time = $4*3 = 12\ seconds$

b. 10000 bits = 1*10^4 -> $\left(\frac{1*10^4}{2*10^6}\right) = .005\ seconds$

2^{nd} packet received at $2*.005 = .01\ seconds$

c. $.005\ (seconds\ per\ node)*3(nodes) = .015\ seconds$

1 packet is received every .005 seconds after this

800^{th} packet received at $time = 799\ (800-1\ packet)*.005\ + .015 =\ 4.01\ seconds$

Message segmentation is faster overall meaning the message arrives 3 times as fast

d. Message segmentation allows for things like movies to move along a network easier because it breaks them down into smaller packets which routers can accommodate a lot better. If it was all one large packet, the movie would likely cause a queuing delay at each switch it passed through. Further, if an entire movie was transmitted in one packet and a bit in that packet got flipped, the entire movie would have to be retransmitted.

e. Headers of each packet altogether make the total amount of bytes needed for headers larger.

With one large packet, you would have to rearrange anything at the destination. With many smaller packets, you need to arrange them sequentially at the destination

4.

a. From book $d_{prop} = m/s\ seconds$

b. From book $d_{trans} = L/R\ seconds$

c. End to end $d_{a->b} = d_{prop} + d_{trans} = \left((\frac{m}{s}) + (\frac{L}{R})\right) seconds$

d. Exiting A and entering the wire

e. On the wire

f. At B

g. $s = 2.5*10^8, L = 120\ bits, R = 56\ kbps$

$m = \left(s*\frac{L}{R}\right) = (2.5*10^8)*\frac{120}{56*10^3} = 535{,}714.286$

5.

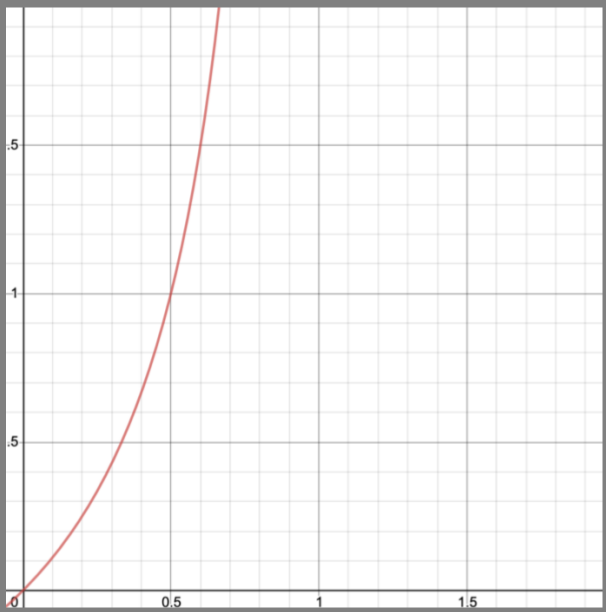
a. $I = traffic\ intensity, I = La/R, Queuing\ delay = IL/(R(1-I))\ for\ I < 1$

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

b. Total delay= $\frac{L}{R(1-I)} = \frac{\frac{L}{R}}{1-I} = \frac{\frac{L}{R}}{1-\frac{La}{R}}$

   set x=L/R and a=1 to plot

   Link to Plot: https://www.desmos.com/calculator/ovr3zcn1jz



6. $a = rate\ of\ packet\ arrival, \mu = transmission\ rate\ packets/sec$
   $I = traffic\ intensity, I = La/\mu, Queuing\ delay = IL/(\mu(1-I))$

   $total\ delay = d_{queue} + d_{trans} = \frac{IL}{\mu(1-I)} + \frac{L}{\mu} = \frac{L}{\mu}(\frac{I}{(1-I)} + 1) = \frac{L}{\mu}(\frac{I}{(1-I)} + \frac{(1-I)}{(1-I)}) = \frac{L}{\mu}(\frac{I+1-I}{(1-I)}) =$
   $\frac{L}{\mu}(\frac{1}{(1-I)})\ seconds$

   Substitute $I = La/\mu$

   $\frac{L}{\mu}(\frac{1}{(1-\frac{La}{\mu})}) = \frac{L}{\mu}(\frac{1}{(\frac{\mu}{\mu}-\frac{La}{\mu})}) = \frac{L}{\mu}(\frac{1}{(\frac{\mu-La}{\mu})}) = \frac{L}{\mu}(\frac{\mu}{\mu-La}) = \frac{L}{\mu-La} packets/second$

7.
   a. Max throughput of the server is the rate of the first path or $\{R_1^k\}$
   b. Max throughput of the server if using all M paths with N links is the link with the lowest transmission rate or min$\{R_1^k, \dots, R_n^k\}$

8.
   a. R*T_{prop}= $1500000 * \left(\frac{5000000}{2.5*10^8}\right) = 1500000 * .02 = 30000$ bits
   b. 30000 is less than 450000 so the max that can be on the link is 30000
   c. One knows the maximum number of bits that the link can support at any given time
   d. Transmission delay + propagation delay

   End to end delay is $\frac{5000000}{250000000} + \frac{450000}{1500000} = .02 + .3 = .32$

e. $\frac{450000}{50} = 9000\ bits\ per\ frame$

Total time=$50 * \left(T_{frame} + 2 * T_{prop}\right) = 50 * \left(\frac{9000}{1500000} + 2 * \frac{5000000}{250000000}\right) = 2.3\ seconds$

f. Largest value of m is $floor(\ 2 * (\frac{5000000}{250000000})/\frac{9000}{1500000}) = floor(\frac{.04}{.006}) = floor(6.\overline{6}) = 6\ frames$

Total time=$50 * \frac{9000}{1500000} + 2 * T_{prop} = \frac{450000}{1500000} + 2 * \frac{5000000}{250000000} = .34$

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