Melvin Moreno

1.a. A packet switched network would be more appropriate for this application. Packet switching is great for bursty data like this; so it would perform optimally with switching packets instead of circuits.

b. No form of congestion control is necessary because the application sends 5 Mbits at max which is less than the 30Mbs intermediate link capacity.

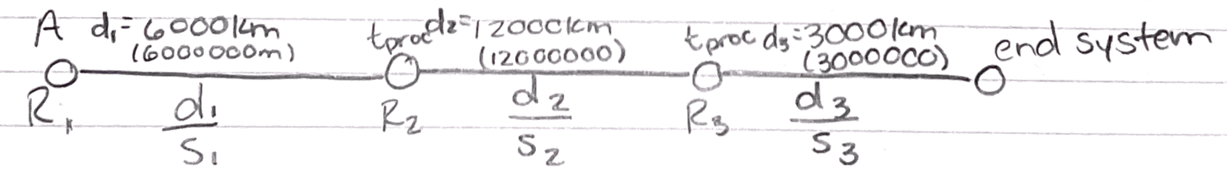
2.a. 150 Mbps link
10 Mbps per user
150 Mbs link / 10 Mbps per user = $\boxed{15 \text{ users}}$

b. 12% probability that a given user is transmitting.

c. $P(X=x) = \binom{n}{x}(p)(1-p)^{n-x}$
$P(X=x) = \binom{60}{x}(0.12)(0.88)^{60-x}$

d. $P(X>15) = 1 - \sum_{x=0}^{15} \binom{60}{x}(0.12)^x(0.88)^{60-x} = \boxed{0.00151}$

3. length L, system A, 3 links, 2 packet switches,
d_i = length, s_i = speed, R_i = transmission rate



L = 10,000 bytes (0.01Mbits) t_{proc} = 0.015s
$s_i = 2.8 \times 10^8 m/s$
R_i = 45 mbps

end-to-end delay $= \frac{L}{R_1} + \frac{L}{R_2} + \frac{L}{R_3} + \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3} + 2(t_{proc})$

$\hookrightarrow \frac{0.01}{45} + \frac{0.01}{45} + \frac{0.01}{45} + \frac{6000000m}{(2.8\times10^8 m/s)} + \frac{12000000m}{(2.8\times10^8 m/s)} + \frac{3000000}{(2.8\times10^8 m/s)} + 2(0.015s)$

$= \boxed{0.1056 \text{ seconds}}$

4. 15 packets waiting to be transmitted.
Size of packets = 4000 bytes
Link rate = 100 mbps
Current transmission of packet = 20%

Queuing delay = $\frac{[nL + (L-x)]}{R}$
$L = 4000$ bytes
$R = 100$ mbps $= 1 \times 10^8$ bps
$x = \frac{4000}{5} = 800$ bytes
$n = 15$

$$\frac{[(15)(4000) + (4000-800)]}{1 \times 10^8} \times 100 \times 15$$
$$= \boxed{0.948 \text{ seconds}}$$

5. For each link, the throughput is the minimum bandwidth of the link among all the links in that path.
The max throughput will be the sum of the minimum transmission rates in all paths S.
max throughput = min $\{R^i_1, R^i_2, R^i_3, \ldots R^i_N\}$.

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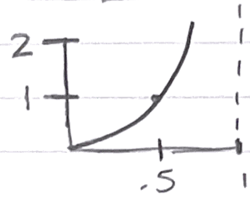
6a. $\frac{TP}{R(1-T)} + \frac{P}{R} = \boxed{\frac{P/R}{1-T}}$

b. $f(x) = \frac{x}{1-x\alpha}$



$\lim_{x \to 1} = \infty$

c. $\frac{1}{p-\alpha}$

7.a. $\frac{60 \times 10^6}{100 \times 10^6}$ = 0.6 seconds from source host to the first switch

0.6 × 3 = 1.8 seconds from source to destination.

b. $\frac{4000 \text{ bits}}{100 \times 10^6}$ = 0.00004 seconds for first packet to first switch

0.00004 × 2 = 0.00008 seconds for second packet

c. (0.00004 × 3) + 0.00004(15000 − 1) =
↳ 0.60008 seconds
Message segmentation only adds 0.00008 seconds, which is insignificant.

d. With message segmentation, the packets have to be put in sequence at the destination.