Review Question 13.

a) 2 users can be supported because each user requires half of the link bandwidth.

b) Since each user requires *1 Mbps* when transmitting, if two or fewer users transmit simultaneously, a maximum of *2 Mbps* will be required. Since the available bandwidth of the shared link is *2 Mbps*, there will be no queuing delay before the link. Whereas, if three users transmit simultaneously, the bandwidth required will be *3 Mbps* which is more than the available bandwidth of the shared link. In this case, there will be queuing delay before the link.

c) Probability that a given user is transmitting = *0.2*

d) Probability that all three users are transmitting simultaneously = $\binom{3}{3} p^3 (1-p)^{3-3}$

= $(0.2)^3 = 0.008$. Since the queue grows when all the users are transmitting, the fraction of time during which the queue grows (which is equal to the probability that all three users are transmitting simultaneously) is 0.008.

Review Question 16.

The delay components are processing delays, transmission delays, propagation delays, and queuing delays. All of these delays are fixed, except for the queuing delays, which are variable.

Review Question 19.

a) The slowest rate amongst all 3 links: 500 kbps
b) (4000 000 * 8) / 500 000 = 64 seconds
c) Slowest link = 100kbps; (4000 000 * 8) / 100 000 = 320 seconds

Problem 6

a) $d_{prop} = m / s$ seconds.

b) $d_{trans} = L / R$ seconds.

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

d) The last 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) Want *m/s* = *L/R* = $m = \frac{L}{R} s = \frac{120}{56 \times 10^3} \left(2.5 \times 10^8\right) = 536\,\text{km}.$