第一次作业参考答案:

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 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

$$m = \frac{L}{R}s = \frac{120}{56\times 10^3}\left(2.5\times 10^8\right) = 536\text{km}.$$

Problem 8

a) 20 users can be supported.
b) $p = 0.1$.
c) $\binom{120}{n} p^n (1-p)^{120-n}$.
d) $1 - \sum_{n=0}^{20} \binom{120}{n} p^n (1-p)^{120-n}$.

We use the central limit theorem to approximate this probability. Let X_j be independent random variables such that $P(X_j = 1) = p$.

$$P(\text{ “21 or more users” }) = 1 - P\left(\sum_{j=1}^{120} X_j \le 21\right)$$

$$P\left(\sum_{j=1}^{120} X_j \le 21\right) = P\left(\frac{\sum_{j=1}^{120} X_j - 12}{\sqrt{120\cdot 0.1\cdot 0.9}} \le \frac{9}{\sqrt{120\cdot 0.1\cdot 0.9}}\right)$$

$$\approx P\left(Z \le \frac{9}{3.286}\right) = P(Z \le 2.74)$$

$$= 0.997$$

when Z is a standard normal r.v. Thus $P(\text{ “21 or more users” }) \approx 0.003$.

Problem 9

a) 10,000
b) $\sum_{n=N+1}^{M} \binom{M}{n} p^n (1-p)^{M-n}$

Problem 13

a) The queuing delay is 0 for the first transmitted packet, L/R for the second transmitted packet, and generally, $(n-1)L/R$ for the n^{th} transmitted packet. Thus, the average delay for the N packets is:

$(L/R + 2L/R + ... + (N-1)L/R)/N$
$= L/(RN) * (1 + 2 + ... + (N-1))$
$= L/(RN) * N(N-1)/2$
$= LN(N-1)/(2RN)$
$= (N-1)L/(2R)$

Note that here we used the well-known fact:

$1 + 2 + ... + N = N(N+1)/2$

b) It takes LN / R seconds to transmit the N packets. Thus, the buffer is empty when a each batch of N packets arrive. Thus, the average delay of a packet across all batches is the average delay within one batch, i.e., $(N-1)L/2R$.

Problem 20

Throughput = $min\{R_s, R_c, R/M\}$

Problem 25

a) 160,000 bits
b) 160,000 bits
c) The bandwidth-delay product of a link is the maximum number of bits that can be in the link.
d) the width of a bit = length of link / bandwidth-delay product, so 1 bit is 125 meters long, which is longer than a football field
e) s/R

Problem 27

a) 80,000,000 bits
b) 800,000 bits, this is because that the maximum number of bits that will be in the link at any given time = min(bandwidth delay product, packet size) = 800,000 bits.
c) .25 meters

Problem 31

a) Time to send message from source host to first packet switch = $\frac{8\times10^6}{2\times10^6}\sec = 4\sec$
With store-and-forward switching, the total time to move message from source host to destination host = $4\sec\times 3\ hops = 12\sec$
b) Time to send 1st packet from source host to first packet switch = . $\frac{1\times10^4}{2\times10^6}\sec = 5\ m\sec$. Time at which 2nd packet is received at the first switch = time at which 1st packet is received at the second switch = $2\times 5m\sec = 10\ m\sec$

d)

i. Without message segmentation, if bit errors are not tolerated, if there is a single bit error, the whole message has to be retransmitted (rather than a single packet).
ii. Without message segmentation, huge packets (containing HD videos, for example) are sent into the network. Routers have to accommodate these huge packets. Smaller packets have to queue behind enormous packets and suffer unfair delays.

e)

i. Packets have to be put in sequence at the destination.
ii. Message segmentation results in many smaller packets. Since header size is usually the same for all packets regardless of their size, with message segmentation the total amount of header bytes is more.