# HW1 Solutions

### Problem 6

a)  seconds.

b)  seconds.

c)  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

km.

### Problem 8

a) 20 users can be supported.

b) .

c) .

d) .

Option 1: Direct calculation (here produced by Matlab binocdf()): 0.0079.

Option 2: We use the central limit theorem to approximate this probability. Let  be independent random variables such that .

“21 or more users”







when  is a standard normal r.v. Thus “21 or more users”.

### Problem 16

The total number of packets in the system includes those in the buffer and the packet that is being transmitted. So, N=10+1.

Because , so (10+1)=a\*(queuing delay + transmission delay). That is,

11=a\*(0.01+1/100)=a\*(0.01+0.01). Thus, a=550 packets/sec.

### Problem 23

Let’s call the first packet A and call the second packet B.

1. If the bottleneck link is the first link, then packet B is queued at the first link waiting for the transmission of packet A. So the packet inter-arrival time at the destination is simply *L/Rs*.
2. If the second link is the bottleneck link and both packets are sent back to back, it must be true that the second packet arrives at the input queue of the second link before the second link finishes the transmission of the first packet. That is,

*L/Rs + L/Rs + dprop < L/Rs + dprop + L/Rc*

The left hand side of the above inequality represents the time needed by the second packet to *arrive at* the input queue of the second link (the second link has not started transmitting the second packet yet). The right hand side represents the time needed by the first packet to finish its transmission onto the second link.

If we send the second packet *T* seconds later, we will ensure that there is no queuing delay for the second packet at the second link if we have:

*L/Rs + L/Rs + dprop + T >= L/Rs + dprop + L/Rc*

Thus, the minimum value of T is *L/Rc* − *L/Rs* .

### Problem 31

1. Time to send message from source host to first packet switch = With store-and-forward switching, the total time to move message from source host to destination host = 
2. Time to send 1st packet from source host to first packet switch = . . Time at which 2nd packet is received at the first switch = time at which 1st packet is received at the second switch = 
3. Time at which 1st packet is received at the destination host = . After this, every 5msec one packet will be received; thus time at which last (800th) packet is received = . It can be seen that delay in using message segmentation is significantly less (almost 1/3rd).
4. 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).
5. 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.
6. Packets have to be put in sequence at the destination.
7. 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.

### Problem 32

The propagation delays affect the overall end-to-end delays both for packet switching and message switching equally.

* For message switching, the end-to-end delay with propagation delay becomes 12.3 sec.
* For packet switching, the end-to-end delay with propagation delay becomes 4.31 sec.

Both delays are 0.3 sec more compared to P31. a and P31.c.

### Problem 33

There are *F*/*S* packets. Each packet is S=80 bits. Time at which the last packet is received at the first router is sec. At this time, the first F/S-2 packets are at the destination, and the F/S-1 packet is at the second router. The last packet must then be transmitted by the first router and the second router, with each transmission taking sec. Thus delay in sending the whole file is

To calculate the value of S which leads to the minimum delay,

