Spring 2023, CS 3611: Computer Networks

Homework 1

Solution to problem 1

Consider the first bit in a packet. Before this bit can be transmitted, all of the bits in the packet must be generated. This requires

$$\frac{56 \times 8}{64 \times 10^3}\text{sec} = 7\text{msec}. \tag{1}$$

If we consider the last bit, it will be transmitted as soon as it is created, but will also wait for 7msec before the preceding bits are decoded when the packet has arrived at B. Actually, the time for encoding and decoding for every bit is 7msec.

The time required to transmit the packet is

$$\frac{56 \times 8}{5 \times 10^6}\text{sec} = 89.6\mu\text{sec}. \tag{2}$$

Propagation delay = 10 msec.

So the delay until decoding is

$$7\text{msec} + 89.6\mu\text{sec} + 10\text{msec} = 17.0896\text{msec} \tag{3}$$

Solution to problem 2

a) 100 users can be supported

b) $p = 0.1$

c) $\binom{300}{n} p^n (1-p)^{300-n}$

d) $1 - \sum_{n=0}^{100} \binom{300}{n} p^n (1-p)^{300-n}$

Solution to problem 3

a) $(10^7 \times 20000 \times 10^3)/(2.5 \times 10^8) = 800000$ bits

b) 800000 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 the link / bandwidth-delay product, so 1 bit is 25 meters long, which is shorter than a football field.

e) s/R

Solution to problem 4

a) Time to send message from source host to first packet switch = $\frac{4\times10^6}{2\times10^6}$sec = 2sec. With store-and-forward switching, the total time to move message from source host to destination host 2sec $\times$ 3 = 6sec.

b) Time to send 1^{st} packet from source host to first packet switch = $\frac{2\times10^3}{2\times10^6}$sec = 1msec. Time at which 2^{nd} packet is received at the first switch = time at which 1^{st} packet is received at the second switch 2 $\times$ 1msec = 2msec.

c) Time at which 1^{st} packet is received at the destination host = 1msec $\times$ 3 = 3msec. After this, every 1msec one packet will be received; thus time at which last (2000^{th}) packet is received = 3msec + 1999 $\times$ 1msec = 2.002sec. It can be seen that delay in using message segmentation is significantly less (almost $\frac{1}{3}$).

d) Drawbacks:

- Packets have to be put in sequence at the destination.
- 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.

Solution to problem 5

According to Shannon theorem, the maximum data rate of this channel = $6k \times \log_2(1 + S/N) = 6k \times \log_2(1 + 100) \approx 6k \times 7 = 42$kbps. So it's impossible to provide 56kbps data rate service on this channel.

Solution to problem 6

The total delay of the circuit-switched network= circuit setup time + transmission delay + propagation delay = $s + x/b + k \times d$.

For the packet-switched network, the total delay of the packet-switched network = the end-to-end delay of the first packet + transmission delay of all the packets except the first one = $x/b + (k-1)p/b + k \times d$

So compare these two delays, we can conclude that if $(k-1)p < b \times s$, then the packet network has a lower delay.