Fall 2024, CS 3953: Computer Networks

Homework 1 Solution

Problem 1 (15 points)

Each packet contains 80 bytes (640bits)

$$Packetization\ delay = \frac{640\ bits}{128\ kbps} = 5\ ms$$

$$Transmission\ delay = \frac{640\ bits}{6000000\ bps} \approx 0.11\ ms$$

$$Propagation\ delay = 15\ ms$$

$$Total\ delay = 5ms + 0.11ms + 15ms + 5ms = 25.11\ ms$$

Problem 2 (20 points)

1. Number of users supported $= \frac{10000kbps}{200kbps} = 50$
2. $p = 0.2$
3. $p(exactly\ n\ users\ transmitting) = \binom{50}{n}(0.2)^n(0.8)^{50-n}$
4. $p(n \geq 12) = 1 - \sum_{n=0}^{11}\binom{50}{n}(0.2)^n(0.8)^{50-n}$

Problem 3 (25 points)

1.

$$d_{drop} = \frac{d}{s} = \frac{30000000m}{2 \times 10^8 m/s} = 150ms$$

$$Bandwidth - delay\ product = R \times d_{drop} = 6000000bps \times 0.15s = 900000\ bits$$

2. The maximum number of bits in the link at any time is equal to the bandwidth-delay product 900000 bits.
3. The bandwidth-delay product of a link is the maximum number of bits that can be in the link.
4. The width of a bit $= \frac{s}{R} = \frac{2\times10^8 m/s}{6000000bps} \approx 33.33m$, which is shorter than a football field.
5. $\frac{s}{R}$

Problem 4 (20 points)

1. Time to send message from source host to first packet switch $= \frac{6\times10^6}{2\times10^6} = 3sec$ With store-and-

forward switching, the total time to move message from source host to destination host $3sec \times 3 = 9sec$.

2. Time to send 1st packet from source host to first packet switch = $\frac{1000}{2\times10^6} = 0.5msec$. Time at which 2nd packet is received at the first switch = time at which 1st packet is received at the second switch $2 \times 0.5msec = 1msec$..
3. Time at which 1st packet is received at the destination host $= 3 \times 0.5msec = 1.5msec$. After this, every 0.5msec one packet will be received; thus time at which last (2000th) packet is received= $1.5msec + 1999 \times 0.5msec = 1.001sec$. It can be seen that delay in using message segmentation is significantly less.
4. 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.

Problem 5 (5 points)

According to Shannon theorem, the maximum data rate of this channel = 4k × log2 (1 +S/N) = 4k × log2 (1 + 1000) ≈ 39.88kbps. So it's impossible to provide 40kbps data rate service on this channel.

Problem 6 (15 points)

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.