CS3611 Computer Networks (Spring 2023) Homework 1

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1. The time required for encoding is

$$\frac{8 \times 56\text{bytes}}{64\text{kbps}} = 7\text{msec}$$

The time required for transmission is

$$\frac{8 \times 56\text{bytes}}{5\text{Mbps}} = 89.6\mu\text{sec}$$

The time required for encoding is also 7msec.

Therefore, the total time required is $7\text{msec} + 89.6\mu\text{sec} + 10\text{msec} + 7\text{msec} = 24.0896\text{msec}$.

2. (a) $\frac{20\text{Mbps}}{200\text{kbps}} = 100$ users can be supported.

(b) The probability that a given user is transmitting is $p = 10\% = 0.1$.

(c) Let X denote the number of users that are transmitting simultaneously. Then

$$X \sim B(300, 0.1)$$

Therefore, $P(X = n) = C_{300}^{n} \cdot 0.1^{n} \cdot 0.9^{300-n}$.

(d) The probability that 101 or more users are transmitting simultaneously is

$$P(X \geq 101) = 1 - \sum_{n=0}^{100} C_{300}^{n} \cdot 0.1^{n} \cdot 0.9^{300-n} \approx 0$$

which implies that it is almost impossible.

3. (a) The bandwidth-delay product is $10\text{Mbps} \times \frac{20000\text{km}}{2.5\times 10^{8}\text{m/sec}} = 0.8\text{Mbits}$.

(b) The maximum number of bits in the link is $10\text{Mbps} \times \frac{20000\text{km}}{2.5\times 10^{8}\text{m/sec}} = 0.8\text{Mbits}$.

(c) The bandwidth-delay product is the maximum number of bits that can be in the link.

(d) The width of a bit in the link is $\frac{20000\text{km}}{0.8\text{Mbits}} = 25\text{m}$, which is not longer than a football field (approximately 100m).

(e) The bandwidth-delay product is $R \cdot \frac{m}{s}$. Therefore, the width of a bit is $\frac{m}{R \cdot \frac{m}{s}} = \frac{s}{R}$.

4. (a) The time required to move the message from the sourse host to the first packet switch is $\frac{4\times 10^{6}\text{bits}}{2\text{Mbps}} = 2\text{sec}$. The total time required to move the message from source host to destination host is $3 \times \frac{4\times 10^{6}\text{bits}}{2\text{Mbps}} = 6\text{sec}$.

(b) The time required to move the first packet from the source host to first switch is $\frac{2000\text{bits}}{2\text{Mbps}} = 1\text{msec}$. The time that the second packet is fully received at the first switch is $2 \times \frac{2000\text{bits}}{2\text{Mbps}} = 2\text{msec}$.

(c) Every 1msec, one more packet is fully received by destination host. Considering another 2msec for the first packet, it takes $2000\text{msec} + 2\text{msec} = 2002\text{msec}$ to move the file from source host to destination host. Compared to the result without message segmentation, it only takes about $\frac{1}{3}$ time, which is much faster.

(d) Although message segmentation improves throughput, it brings more difficulty for implementation. Extra header bits are needed for many small packets. Packet switch also requires more time for packet processing, which brings new delay. Hence, message segmentation is not necessarily better in practice.

5. By Shannon Theorem, the maximum data rate is

$$6\text{kHz} \times \log_2(1+100) \approx 39.95\text{kbps} < 56\text{kbps}$$

Therefore, it is impossible to provide 56kbps data rate service.

6. For a circuit-switched network, the total delay is

$$s\text{sec} + k \times d\text{sec} + \frac{x\text{bits}}{b\text{bps}} = \left(s + kd + \frac{x}{b}\right)\text{sec}$$

For a packet-switched network, the total delay is

$$k \times d\text{sec} + \frac{x\text{bits}}{p\text{bits}} \cdot \frac{p\text{bits}}{b\text{bps}} + (k-1)\frac{p\text{bits}}{b\text{bps}} = \left[(k-1)\frac{p}{b} + kd + \frac{x}{b}\right]\text{sec}$$

Let $s + kd + \frac{x}{b} > (k-1)\frac{p}{b} + kd + \frac{x}{b}$, we have

$$b \cdot s > (k-1) \cdot p$$

Therefore, packet-switched network has a lower delay when $b \cdot s > (k-1) \cdot p$.