Problem 1

Suppose users share a 3 Mbps link. Also suppose each user requires 150 Kbps when transmitting, but each user transmits only 20 percent of the time.

(a) When circuit switching is used, how many users can be supported?

(b) For the remainder of the problem, suppose packet switching is used. Find the probability that a given user is transmitting.

(c) Suppose there are 100 users. Find the probability that at any given time, exactly n users are transmitting simultaneously. (Hint: Use the binomial distribution)

(d) Find the probability that there are 21 or more users transmitting simultaneously.

Write your solution to Problem 1 in this box

(a) 3 Mbps = 3000 kbps

$$\frac{3000 \text{ kbps}}{150 \text{ Kbps}} = 20$$

20 users can be supported at the same time

(b) $p = 20\% = 0.2$

(c) $\binom{100}{n} \cdot (0.2)^n \cdot (0.8)^{100-n}$

[$\binom{100}{n}$ means choose n out of 100]

(d) $1 - \sum_{n=0}^{20} \binom{100}{n} \cdot 0.2^n \cdot 0.8^{100-n}$

$= 1 - 0.559$

$= 0.441$

Problem 2

Queuing delay.

(a) Suppose N packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length L and the link has transmission rate R. What is the average queuing delay for the N packets?

(b) Now suppose that N such packets arrive to the link every $\frac{LN}{R}$ seconds. What is the average queuing delay of a packet?

Write your solution to Problem 2 in this box

(a) The first packet doesn't wait

$d_1 = 0$

The second packet waits for the first packet to transmit

$d_2 = L/R$

For the i^{th} packet: $d_i = (N-1) \cdot L/R$

Therefore, on averge, the delay is:

$d_{av} = (N-1)\frac{L}{2R}$

(b) Within a batch of N packets, the link never stops transmitting.

Therefore, the time to transmitt all N packets is

$N \cdot \frac{L}{R} = \frac{LN}{R}$

That is to say, the next batch of N packets arrives right after the link finishes transmitting the last batch.

Therefore average queuing delay for all batches are the same.

It is $d_{av} = (N-1)\frac{L}{2R}$

Problem 3

Review the car-caravan analogy in lecture #1 slides 49–50 (for Chapter 1). Assume a propagation speed of 100 km/h.

(a) Suppose the caravan (10 cars) travels 150 km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just after a third tollbooth. Each car takes 12 sec to serve. What is the end-to-end delay?

(b) Repeat (a), now assuming that there are 8 cars in the caravan instead of 10.

Write your solution to Problem 3 in this box

(a) propagation time of the first half for each car is

$t_p = \frac{75km}{100km/h} = 0.75h = 45min$

For the whole caravan to pass the tollbooth, it takes

$t_W = 10 \cdot 12 sec = 120 sec = 2 min$

The first car won't pass the second tollbooth until the last car arrives.

Therefore, for the whole caravan to arrive at the second tollbooth, it takes $t_1 = t_p + t_w = 47 min$.

Similarly, to arrive at the final tollbooth $t_2 = t_p + t_w = 47 min$

Finally, passing the final tollbooth $t_3 = 2 min$

in total, $t = 47 + 47 + 2 = 96 min$.

(b) Similarly

$t_p = 45 min$, $t_w = 8 \cdot 12 = 96 sec$

$t_1 = 45 min\ 96 sec$

$t_2 = 45 min\ 96 sec$

$t_3 = 96 sec$

$t = t_1 + t_2 + t_3 = 94 min\ 48 sec$

Problem 4

Suppose you would like to urgently deliver 50 terabytes data from Boston to Los Angeles. You have available a 1 Gbps dedicated link for date transfer. Would you prefer to transmit the data via this link or to use FedEx overnight delivery instead? Explain your choice.

Write your solution to Problem 4 in this box

50 terabyte $= 50 \times 10^3$ GB $= 50 \times 10^3 \times 8$ "Giga bit"

$$\frac{50 \times 10^3 \times 8}{1} = 4 \times 10^5 \text{ sec}$$

$$= 4.63 \text{ days}$$

Therefore, overnight FedEx delivery is better