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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

1

(a) 3Mbps / 150kbps = 3000 kbps / 150 kbps = 20 users

(b) Since each users transmit 20 percent of a time, then probability that the given user is transmitting is p = 0.2

(c) ${}^{100}C_n\,(0.2)^n\,(0.8)^{100-n}$

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

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

2a queueing delay 1^{st} package = 0

↳ no package in front means no queue

delay 2^{nd} package = $\frac{L}{R}$

3^{rd} package = $\frac{2L}{R}$

⋮

N^{th} package = $\frac{(N-1)L}{R}$

$$\text{Average queueing delay} = \frac{\left(\frac{L + 2L + \ldots (N-1)L}{R}\right)}{N}$$

$$= \frac{L}{R}\frac{(1+2+\ldots(N-1))}{N}$$

$$= \frac{L}{R} \cdot \frac{(\cancel{N}(N-1))}{2\cancel{N}} = \frac{L(N-1)}{2R}$$

b Because of each trasmission takes LN/R seconds, there will be no queue, or the buffer will be empty when each set of N packets arrive

Thus, the answer will be same with part one.

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

Problem 3

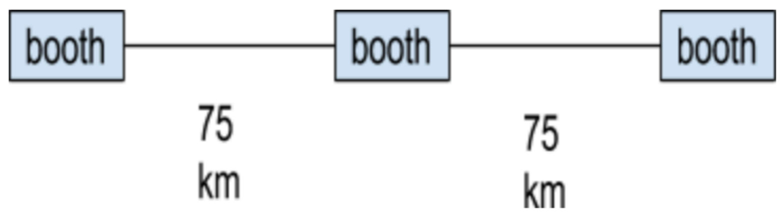
Review the car-caravan analogy in lecture #1 slides 49–50 (for Chapter 1). Assume a propagation speed of 100 km/h.

(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

3



(a) Each booth serve = 10 cars x 12 second = 120 seconds = 2 minutes
From 1 booth to another booth = $\frac{75\ km}{100\ km/hour}$ = 0.75 hour = 45 minutes
Since there is 3 booths, and every car need to travel 75 km twice, thus
(3 x 2 minutes) + (2 x 45 minutes) = 96 minutes
Thus, end-to-end delay is 96 minutes

(b) Each booth serve = 8 cars x 12 second = 96 seconds = 1.6 minutes
From 1 booth to another booth = $\frac{75\ km}{100\ km/hour}$ = 0.75 hour = 45 minutes
Since there is 3 booths, and every car need to travel 75 km twice, thus
(3 x 1.6 minutes) + (2 x 45 minutes) = 94.8 minutes
Thus, end-to-end delay is 94.8 minutes

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

4. We need to know, how fast the transfer time via this link or FedEx overnight delivery

Via link:

$$\frac{50\text{ TB} \times (8 * 10^{12}\text{ bits/TB})}{10^{9}\text{ bits/second}} = 4 * 10^{5}\text{ seconds}$$

$$= 111.11\text{ hours}$$

Via FedEx overnight < 24 hours

Since using the 1Gbps link will take around 111.11 hours, which may take up to 4 to 5 days, using FedEx overnight is still better since it will only take 1 day or 24 hours to deliver the data.