

March 18, 2002

Midterm Exam

EE 6340: Introduction to Telecommunications Networks

NOTE: Please, complete the following table and keep record of your assignment number.

First Name	
Last Name	
Student ID	
Assignment #	0

Exercise 1. Suppose that string 1010 is used as the bit string to indicate the end of a frame and the bit stuffing rule is to insert a 1 after each appearance of 101 in the original data. For example, 101010 would be modified by stuffing to 10110110. In addition, if the data frame ends in 10, a 1 would be stuffed after the first 1 in the actual terminating string 1010.

- A) How is the following data string encoded after bit stuffing including the terminating string [pt. 5]?
00100101101010100010
- B) Determine destuffing rule and rule to detect the string end [pt. 5].
- C) How following string(s) is decoded [pt. 5]? (If multiple strings are decoded, clearly indicate how many strings are decoded and the original bit sequence in each string.)
0010111011011001101010110110001011010

Exercise 2. Consider a system in which customers are served in two cascaded stages. Service time of stage 1 is exponentially distributed with mean $1/\mu_1$. Service time of stage 2 is exponentially distributed with mean $1/\mu_2$. Customers arrive at the first stage at a Poisson rate of λ , and the system buffering capacity is unbounded.

- A) Choose the appropriate queue(s) to model the system and determine stability conditions [pt. 5].
- B) Compute T : the expected time a generic customer spends in the system including service time [pt. 5].
- C) Assume that $\mu_1 = \mu_2 = \mu$. What is the average time spent in the system by a customer that, while entering the system, finds $k_1 = 0$ customers in the first stage, and $k_2 = 1$ customer in the second stage [pt. 5]. (Note that the distribution of the minimum of two random variables that are exponentially distributed with mean $1/\mu$, is a random variable exponentially distributed with mean $1/2\mu$.)
- D) Generalize the previous result to $k_1 = 0$ and k_2 any value [pt. 10].

Exercise 3. Consider a single-server system with two queues that works as follows. Server is idle only when both queues are empty. Server starts serving the queue in which the first arrival occurs. For example, let's assume that the first arrival occurs in queue 1. Server serves queue 1 until no customers are left in that queue. At that point, server either becomes idle if both queues are empty, or starts serving the other queue (queue 2) if one or more customers are awaiting service there. Once again, server will not leave queue 2 until all customers in that queue are served. At this point, server either becomes idle if both queues are empty, or starts serving the other queue (queue 1) if one or more customers are awaiting service there. This behavior will continue indefinitely.

Assume Poisson arrivals with rate λ_1 at queue 1. Assume Poisson arrivals with rate λ_2 at queue 2. Service time is the same for both queues, and is represented by a generic random variable X , whose distribution is known, e.g., $\bar{X} = 1/\mu$. Assume that the switching time of the server (e.g., time required by the server to move from one queue to the other) is negligible.

- A) Determine the stability conditions [pt. 5].

- B) Derive $p_0 = P\{\text{system is empty}\}$ [pt. 5].
- C) Derive the average length of a busy period (a busy period starts when server switches from idle to busy and ends when the server switches back to idle) [pt. 10]. Notice that during the same busy period, server may switch back and forth several times between the two queues.
- D) Derive W , the expected waiting time (service time is not included) for a generic customer [pt. 10].