UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, DECEMBER 2001

CSC 470H1 – COMPUTER SYSTEMS MODELLING AND ANALYSIS

EXAM TYPE: D

Examiner – J. Lee

Examination Aids : [Non-Programmable Calculators and Two 8.5" by 11" double-sided, self-prepared fact sheets.]

I. SHORT PROBLEMS [25 MARKS] Write all answers in the exam booklet:

1. [5] What does TCP stand for?

2. [5] When analyzing switch service disciplines, we consider the scenario where many connections are trying to share the same outgoing link. However, in an actual switch, there are many physical outgoing links. Explain why we only focus on one of the outgoing links.

3. [5] Suppose the additive congruential method is used to generate pseudo random numbers. Pseudo random number n_{i+1} is generated as a function of the previous three numbers. That is, $n_{i+1} = (\Sigma_{j=1..k} a_j n_{i+1-j}) \bmod m$, where $a_1=5$, $a_2=2$, $a_3=9$, $k=3$, and m=7. The first three numbers are generated using the linear congruential method with the formula $n_{i+1} = (an_i + c) \bmod m$, where $a=2$, $c=5$ and $m=7$. What is n_7 if the seed is 3? SHOW YOUR WORK!

4. [5] How are transmission delay and propagation delay related?

5. [5] Who is R. L. Cruz?

II. PROBLEMS - SHOW ALL WORK! [75 MARKS] Write all answers in the exam booklet:

1. [15] We had to address Burke's theorem for the work done in CSC470.

a. State Burke's theorem.
b. Prove Burke's theorem.

2. [15] Consider a queueing system where interarrival and service times are integer valued, so customer arrivals and departures occur at integer times. Let p_a be the probability that an arrival occurs at any time k, and assume that at most one arrival can occur. Also, let p_c be the probability that a customer who was in service at time k will complete service at time $k+1$. What is the probability that n customers are in the system in terms of p_a and p_c?

3. [15] Suppose n connections in a network traverse the same path to ultimately reach the same destination. Each connection i implements TCP and follows the (σ,ρ) traffic model with parameters σ_i and ρ_i. The switches along the path guarantee a service capacity of $g_i > \rho_i$ for connection i. C_m is the maximum service capacity for switch m. The total number of hops to the destination is h, l_i is max packet length for connection i, and L is max packet length in the network. What is the worst-case end-to-end queueing delay for this scenario?

4. [15] In an event-driven simulation more than one event may have the same time of occurrence.

a. How is this handled?
b. Regardless of how you answer part a, all events in a simulation must be handled one after another (assuming that the computer you are using to run the simulation has 1 CPU). However, in a real-life scenario, events may occur at the same time. Justify why and how our simulations can still accurately model the real-life systems.

5. [15] Consider a server – called server "S" – that receives Poisson packet traffic from two sources, 1 and 2, at rates λ_1 and λ_2, respectively. Server S transmits the packets to another server, on a FCFS basis, and S's service capacity is C bits/sec. The two input streams are assumed to be independent, and their packet lengths are identically and exponentially distributed with mean L bits. A packet from node 1 is always accepted by S. A packet from node 2 is only accepted if the number of packets in S is less than a given number $K > 0$. Otherwise, it is assumed lost.

a. What is the range of values of λ_1 and λ_2 for which the expected number of packets in S will stay bounded as time increases?
b. For λ_1 and λ_2 in the range of part a, find the steady-state probability of having n packets in server S ($n \geq 0$).
c. Find the average time needed by a packet from source 1 to clear S once it enters S, and the average number of packets in S from source 1.
d. Find the average time needed by a packet from source 2 to clear S once it enters S, and the average number of packets in S from source 2.

III. BONUS QUESTIONS [10 MARKS] Write all answers in the exam booklet:

1. [2] What are my two favorite sports?
2. [2] Who is the author CSC470's textbook?
3. [2] What was mysterious about the rental vehicle that I had for a week?
4. [2] What is *your* favorite sport?
5. [2] Well, it's finally over. Enjoy the rest of the term and thanks for all your effort! I wish you all the best in the future and most importantly, take care. (Yes, you'll get 2 free marks for just reading this.)

Total Marks = 100
Total Pages = 3