CS 6210: Perf. Evaluation of Comp. Systems
Quiz II: Oct. 22, 2011, 9:30 AM - 10.45AM, Prof. Krishna Sivalingam
Closed Book and Closed Notes; No Cell Phone; ONLY Scientific Calculator; No Sharing of Calculator; No discussions with students enrolled in class.

Answer the following **SIX** questions. Include all calculations and mathematical expression derivations in your answer sheets, for complete credit. Please write legibly. **If you use additional sheets, please write your name and roll number on the additional sheets.**

If you do not present your IIT Madras ID during the Quiz, you have to present it to me within ONE hour of the Quiz; else, the Quiz will not be considered for grading.

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1. (4) Define the notion of "reachability graph" of a given Petri Net model.

   Show the Petri Net model for an M/M/1/4 system.

2. (7) Consider a cluster computer which can hold at most B batch jobs in memory. The job execution time is exponentially distributed with average of 8 milliseconds. If the number of arrivals is 90 jobs/second (with Poisson distribution) and the blocking probability should be less than 0.001, what should be the minimum value of B?

   For a general M/M/1/B queue with arrival rate of λ and service rate of μ, derive $E[r]$ for $\lambda \to \infty$.

3. (13) Answer the following questions:

   (a) (3) For an M/G/1 system with Poisson arrival parameter of λ, average service time of $E[s]$, determine the probability that the server is idle using the residual time analysis.

   (b) (4) Consider a channel with bandwidth of 100 Mbps that has to be shared among 8 users. Let the packet arrival process be Poisson with rate of 800 packets-per-second per user; the packet lengths are fixed at 1000 bytes. What is the average total per-packet delay with FDM?

   (c) (6) Derive the Average Waiting Time ($E[w]$) for an M/G/1 system with vacations, where arrival/departure parameters are as listed above and $E[V]$ and $E[V^2]$ denote the first and second moments of the vacation time.

4. (10) Answer the following questions:

   (a) (6) Show that the departure process of an M/M/1 queue is Poisson with rate λ.

   (b) (4) Consider a system with three M/M/1 queues in tandem defined by the parameters: $\lambda = 2; \mu_1 = 3; \mu_2 = 4; \mu_3 = 6$. Determine: (i) the probability that the system is idle; and (ii) the average total delay between entering and departing the system.

5. (8) Answer the following questions:

(a) (4) Given the following set of observations from a simulation experiment, determine the observation at which the system might have entered steady state using the "Truncation" method:

13, 14, 15, 17, 19, 21, 18, 20, 21, 18

(b) (4) Consider a simulation run that is being terminated using the "Independent Replications" method. The ratio of the 99% confidence interval width to the mean value of the computed metric should be less than 0.05. Given that six replications have been completed and the respective mean values of the metric are: **45, 56, 49, 61, 37, 52** should the simulation stop or continue further?

Some of the relevant values needed are: $z_{0.99} = 2.326; z_{0.995} = 2.576; t_{0.995,5} = 4.032; t_{0.995,6} = 3.707; t_{0.9995,5} = 6.869; t_{0.9995,6} = 5.959$.

6. (8) Consider a closed queuing network with a CPU and 2 storage disks (A and B) and a set of N terminals. The user think time is 3 s; the disk service times per request were 25 and 30 milliseconds respectively for A and B; the average service time per CPU visit was 12 milliseconds. Each job requested disk A four times and disk B five times. Disk A was utilized 60% of the time. (The average queue lengths at CPU, A and B were respectively: 2.57, 1.5, and 9.) Determine the system throughput (X), N, system response time (R), and the per-device throughputs.