ELIZADE UNIVERSITY

ILARA-MOKIN

FACULTY: BASIC AND APPLIED SCIENCES
DEPARTMENT: MATHEMATICS AND COMPUTER SCIENCE
2nd **SEMESTER EXAMINATION**
2015 / 2016 **ACADEMIC SESSION**

COURSE CODE: CSC 408

COURSE TITLE: Queuing Systems

COURSE LEADER: Dr. Vincent Akpan

DURATION: 2 ½ Hours

HOD's SIGNATURE

INSTRUCTION:

The paper will contain SIX Questions. You should answer FOUR Questions.

Students are warned that possession of any unauthorized materials in an examination is a serious offence

1. (a) What is queuing theory?

(b) On the basis of **Figure 1** which depicts the elements of a basic queuing system, briefly discuss the following terms as they relate to queuing systems:

(i) Arrival (ii) Queue
(iii) System capacity (iv) Queuing discipline
(v) Service (iv) Output

(c) Using suitable diagrams, briefly distinguish between open and closed queuing system with emphasis on which is limited and unlimited population.

(d). Consider the timesharing system with a memory constraint shown in **Figure 2** where swapping may occur between interaction, so that a request may be forced to queue for a memory partition prior to competing for the resources of the central subsystem. The following actual measurement date was obtained by observing the timesharing workload on a system with several distinct workloads:

Average number of timesharing user: 23 ($N = 23$)
Average response time perceived by a user: 30 seconds ($R = 30$)
Timesharing throughput: 0.45 interactions/second ($X = 0.45$)
Average number of timesharing requests occupying memory: 1.9 ($N_{in\_memory} = 1.9$)
Average CPU service requirement per iteration: 0.63 second ($D_{CPU} = 0.63$)

(i) Compute the average think time of a timesharing user?
(ii) On the average, how many users were attempting to obtain service (i.e. how many users were not think at their terminals)?
(iii) On the average, how many much time elapsed between the acquisition of memory and the completion of an interaction?
(iv) What is the contribution to CPU utilization of the timesharing workload?

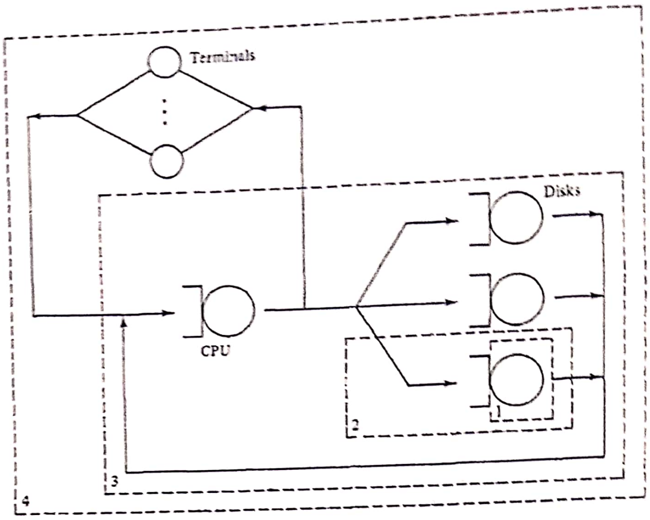

Figure 1: Elements of queuing systems for

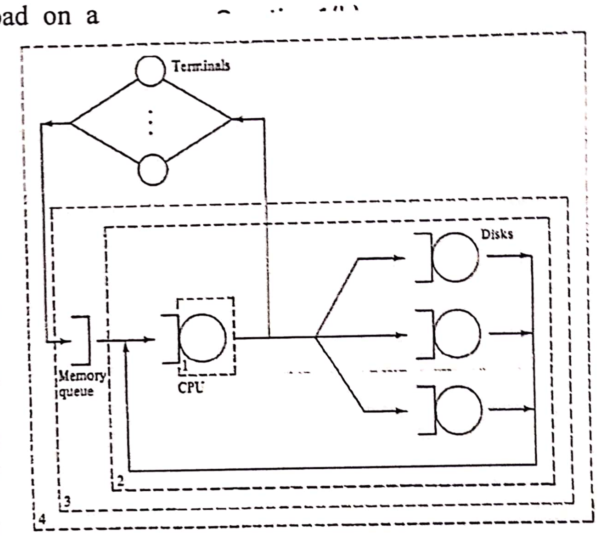

Figure 2: Little's law applied to memory constrained

2. (a) (i) State the utilization law.

(ii) Starting from any known principle, show that the utilization law is $U = X \cdot S$ (where all symbols have their usual meaning).

(b) If we observe 8 arrivals during an observation interval of 4 minutes for which 8 completions were equally observed and the resource was busy for 2 minutes during that interval. Compute:

(i) Arrival rate (ii) Throughput
(iii) Utilization, (iv) Average service requirement per request

3. (a) (i) State the Little's law.

(ii) Starting from any known principle, show that the Little's law is $N = X \cdot R$ (where all symbols have their usual meaning).

(b) If a total of 2 request – minutes of residence time are accumulated during a 4 minute observation interval in which 8 requests complete. Compute:

(i) Average number of requests, and
(ii) Average system residence time per request.

4. (a) (i) State three reasons why Little's law is considered an important law in queuing theory and queuing systems.
   (ii) Briefly describe how the Little's law applies to the hypothetical timesharing system at the four different levels indicated by the four boxes in **Figure 3**.
   (b) Suppose that the resource is a disk and that the disk drive is serving 40 requests/second and that the average request requires 0.0225 seconds of disk service. Using the Little's law, compute the utilization of the disk.

5. (a) Suppose that the average number of requests present is 4 and that the disk is serving 40 requests/second. Using the Little's law, compute:
   (i) The average time spent at the disk by a request.
   (ii) The average queuing time of a request.
   (iii) The average number of requests in the queue.
   (b) Suppose that a system throughput is ½ interactions per second and that, on the average, there are 7.5 "*ready*" users. Using the Little's law, compute the average response time.
   (c)(i) State the response time law.
   (ii) Suppose that there are 10 users where the average think time is 5 seconds and the average response time is 15 seconds. Using the Little's law, compute the system throughput.
   (iii) Suppose that a system has 64 interactive users where the average think time is 30 seconds and that the system throughput is 2 interactions/second. Compute the response time.

6. The server in a single server queue is modeled using three stages as shown in **Figure 4.** Note that once service finishes at *Stage 1*, the job is equally likely to go either to *Stage 2* or to *Stage 3*. The three stages are identical and independent of each other with each providing an exponentially distributed service time with mean $1/\mu$. Assume that this server model is used for both parts (a) and (b) below.
   (a) Consider a M/-/1/2 queue at equilibrium with average job arrival rate λ.
      (i) Obtain the probability *pi* of there being *i* jobs in the system (including the one currently in service) for *i=0,1,2*.
      (ii) What is the average departure rate of jobs from the system?
   (b) Consider a $M^{[X]}$/-/1/2 queue at equilibrium where the batches arrive with average arrival rate λ. The generating function of the batch sizes is $(0.25+0.5z+0.25z^2)$ and the queue is assumed to follow a *Partial Batch Acceptance Strategy.*
      (i) Obtain the probability *pi* of there being *i* jobs in the system (including the one currently in service) for *i=0,1,2*.
      (ii) What is the average departure rate of jobs from the system?

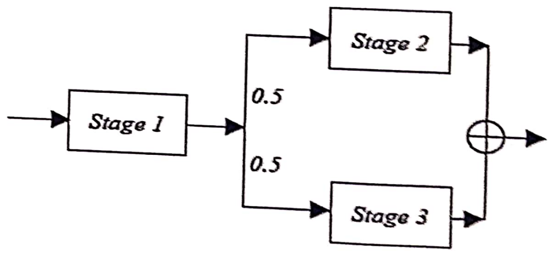

Figure 4: Queuing system for Question 6.