KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES & ENGINEERING

COMPUTER ENGINEERING DEPARTMENT

COE 540 – Computer Networks
Assignment 3 – Due Date May 25th, 2008 - Solution Key

<u>Problem 1 (40 points): On the subject of Random Variables and Probability Theory</u>

Let N be a geometric random variable with range 1, 2, 3, … (i.e. N is defined as the number of trials until success in a series of IID Bernoulli trails with parameter p).

a) Compute the quantity Prob[$N > k$].

b) Compute Prob[N is an even number].

c) Evaluate the corresponding probability generating function $G_N(z)$.

d) Use $G_N(z)$.to compute $E[N]$ and $E[N^2]$.

Hint: Though this question is similar to that of last term, the range for the r.v. is different!

<u>Problem 2 (50 points): On the subject of Markov Chains</u>

Data in the form of fixed-length packets arrive in slots on the TWO input lines of a multiplexer. A slot contains a packet with probability p, independent of the arrivals during other slots or on the other line. The multiplexer transmits one packet per time slot and has the capacity to store THREE packets only. If no room for a packet is found, the packet is dropped.

a) COMPUTE the probability of j (for all possible j values) packets arriving on the four input lines during any given time slot.
b) DRAW the state transition diagram and SPECIFY the transition matrix **P** – The state is taken to be the number of packets in the multiplexer.
c) If p is equal to 0.4, what is the probability that the MUX will contain 3 packets after 10 time slot (i.e. at the start of the 11th time slot)? Assume that we start with an empty MUX.
d) Let the load be defined as the mean number of arriving packets per time slot while throughput be defined as the mean number of transmitted packets per time slot. Use Matlab and show the code for:
    1) Plot the throughput versus the input load.
    2) Evaluate and plot the mean number of dropped packets per time slot.

<u>Problem 3 (50 points) Global Balance Equations:</u>

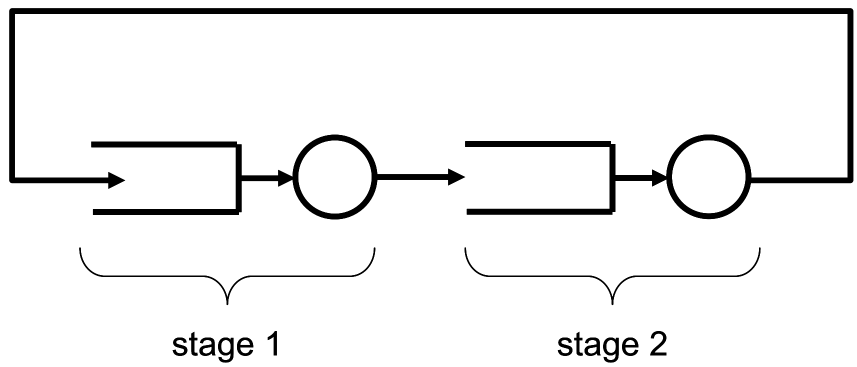
Consider a "cyclic queue" in which M customers circulate around through two queueing facilities as shown below. Both servers are of the exponential type with rates μ1 and μ2, respectively. Let p_k be defined as the probability of k customers in stage 1 and M-k in stage 2.

a) Draw the state-transition-rate diagram.

b) Write down the relationship among $\{p_k\}$ (i.e. global balance equations).

c) Find $N(z) = \sum_{k=0}^{M} p_k z^k$

d) Find p_k.

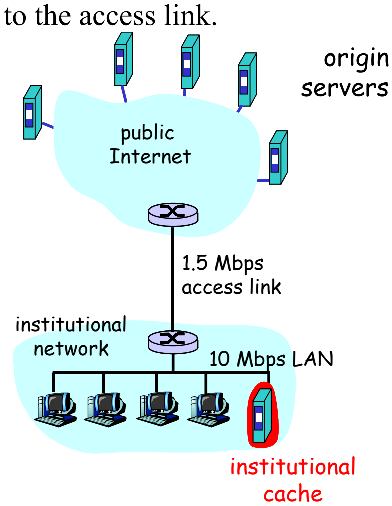


<u>Problem 4 (40 points):Internet Applications (1)</u>

SuppConsider the network layout shown in figure where an institutional network is connected to the Internet. Suppose that the average object size is 900,000 bits and that the average request rate is from the institution's browsers to the origin servers is 1.5 requests per second. Also suppose that the amount of time it take from when the router on the Internet side of the access link forwards an HTTP request until it receives the response is two seconds on average. Model the total average response time as the sum of the average access delay (that is the delay from the Internet router to institution router), and the average Internet delay. For the average access delay, use $\Delta/(1-\Delta\beta)$, where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link.

a. Find the total average response time.

b. Now suppose a cache is installed in the institutional LAN. Suppose the hit rate is 0.4. Find the total response time.



<u>Problem 5 (40 points): On the subject of Internet Applications (2)</u>

Suppose within your Web browser you click on a link to obtain a Web page. Suppose that the IP adderss for the associated URL is not cached in your local host, so that a DNS look-up is necessary to obtain the IP address. Suppose that *n* DNS servers are visited before your local host receives the IP address from DNS; the successive visits incur an RTT of RTT1, …, RTT*n*. Furthermore, suppose that the Web page associated with the link contains exactly one object, a small amount of HTML text. Let RTT0 denote the RTT between the local host and the server containing the object. Assume zero transmission time of the object.

(a) How much time elapses from when the client clicks on the link until the client receives the object.

(b) Suppose the HTML file indexes three very small objects on the same server. Neglecting transmission times, how much time elapses with (1) nonpersistent HTTP with no parallel TCP connections, (2) nonpersistent HTTP with parallel connections, (3) persistant HTTP with piplelining.