EECS 863
Homework 4

1) Five servers share a 1 Gb/s link to a server. Each Server generates λ_i = 15,000 packets/sec with an average length of 10,000 bits/packet. Inter-arrival and service times are exponentially distributed.

   Case A: The total 1 Gb/s link is divided equally among the 5 servers, i.e., 200Mb/s links.
   Case B: The 5 servers share the total 1 Gb/s link using a statistical multiplexer.

   For each case find and compare:
   a) The average number of packets in the system.
   b) The average number of packets in the buffer.
   c) The average delay in μs.

2) Design and performance of a Call Center. In a call center there are M customer service representatives. Arriving calls are sent to an idle customer service representative. If all customer service representatives are busy then the customer hears a message that "all customer service representatives are currently busy please wait for the next available customer service representative". These calls are queued up waiting for a free customer service representative. You are to decide how many customer service representatives to hire. Past experience indicates that the customer service representative takes on average 17 min to complete a customer call and calls arrive at a rate of 1 call/min. You need to hire enough customer service representatives (M) to keep the probability of getting the please wait message to less 1% (10^{-2}).

   a) Find M.

   b) For the load used in part a), plot $\log_{10}$[probability of getting the please wait message] vs M for M=20…50. Comment on the shape of this curve.

3) In a DWDM system wavelengths can be assigned on demand. The system sends files with an average length of 2.2TB, file lengths are exponentially distributed. Each wavelength transmits at 100Gb/s. A group of users generates 200 wavelength requests/hr. Time between requests are exponentially distributed.

   a) The group is assigned a set of N wavelengths. How many wavelengths (N) are needed to keep the blocking probability < 2%?

   b) Plot Load = λ*(average holding time) as a function of the number of wavelengths (N=4…21) for a blocking probability 2%. Hint: Use the Erlang B table.

4) Design a statistical multiplexer. Traffic parameters: arrival rate = 1,000 packets/sec & average packet length = 1000 bits/ packet. QoS parameters: E[T]=1ms & $P_B=10^{-4}$. Find the link capacity in Mb/s and system size needed to achieve these QoS specifications.

5) A router has 128 250 Mb/s input ports and one port connected to an ISP. The network connected to each input port generates on average 25 Mb/s of Internet traffic (traffic that exits the output port to the ISP). You need to sign an SLA with the ISP that specifies how much capacity the ISP will provide. To achieve a rate-c congestion probability of 1% how much capacity in Gb/s is needed from the ISP.

   [Reference: Internet and the Erlang Formula, Thomas Bonald and James Roberts, ACM SIGCOMM Computer Communication Review, Volume 42, Number 1, January 2012]

6) Your company makes $(1/300) for every bps of throughput delivered to the customer. However your company has to pay the customer back $2.00 for every second their packets are delayed.
   Assume that the customer's packets are 600 bits long on average and the link capacity is 1200 b/s.

   Find the customer packet arrival rate where your company will just start to make money, i.e., find the breakeven point.

7) Design a statistical multiplexer with a finite system, i.e., specify the output line rate in b/s and system size so the average delay is less than 0.2 ms and the probability of a blocked packet is less than 0.01. Assume the average arrival rate to the multiplexer is 10,000 packets/second with an average size of 1000 bits. Assume the interarrival times and message length p.d.f.'s are exponential.

8) A DWDM system has 15 wavelengths each operating at 100 Gb/s. The average size of a user file is 1 TByte files.
Users generate 1 file transfer request every 400 sec, or the arrival rate per user = λ_i= 1/400 requests/sec.
Find the number of users that can be supported to maintain a blocking probability of about 2%.