EEL 703(Computer Networks) Tutorial Sheet No.1

1. We consider a buffer that receives messages to be sent. The transmission is made by means of two modern lines that operate at the same speed. We know that:

   (a) The message arrival process is Poisson process with parameter λ

   (b) The message transmission time is exponentially distributed with mean value $E[X]$

   It is requested to determine the following quantities

   (i) The traffic intensity in Erlangs that is offered to the buffer,

   (ii) the mean number of messages in the buffer,

   (iii) The mean delay for a message from its arrival to the buffer till it is completely transmitted

   (iv) Could the buffer support an input traffic characterized by $\lambda = 10\ msg/s$ and $E[X] = 2\ s$?

2. An *Internet Service Provider* (ISP) must design the number of access lines to a *Point-of-Presence* (POP), S, in order to guarantee a blocking probability (circuit-switched traffic) lower than or equal to 2%. The follow ing data are available:

   (a) The served users produce a mean total arrival rate of calls in the rush hour equal to 6 calls/min.

   (b) Each call (Internet dial-up connection) has a duration modeled by an exponentially distributed variable with mean value of 3 minutes.

   It is requested to derive the analytical model of the system to express the blocking probability and to derive the value of S according to the Erlang-B table.
   It is requested to solve the same exercise as above under the assignment that the duration of an internet connection in Pareto distributed with mean value of 3 minutes.

3. We consider a traffic regulator that manages the message arrivals at a buffer of a transmission line. Messages arrive according to exponentially distributed interarrival times with parameter l. The message transmission time can be modeled as an exponential distribution with parameter μ. The traffic regulator acts so that the arriving messages are sent to the transmission buffer with probability q, whereas messages are blocked with probability $1 - q$. It is requested to determine:

   (i) A suitable model for the buffer,

   (ii) The stability condition for the buffer,

   (iii) The mean message delay from the arrival to the buffer to the completion of its transmission.

4. We have to buffer for the the transmission of messages that arrive according to exponentially distributed interarrivals with mean value $E[X]$. The transmission time of a message can be modeled by means of an exponential distribution with mean value $E[T]$. The buffer employs an auto-regulation technique, so that when the number of messages in the buffer is greater than or equal to S, any new arrival can be rejected with probability 1-p (queue management according to the *Random Early Discard*, RED, policy). It is requested to model this system, to identify the stability condition for the buffer and to evaluate the probability that a new arrival is blocked and refused.

5. A telecommunication operator has two (parallel) transmitters at 5 Mbit/s. A switch at the input of the link divides the messages with equal probability among the two transmitters. Each transmitter has a buffer with infinite capacity to store messages. The messages arrive to the link according to a Poisson process with mean rate $\lambda = 20$ msgs/s and have a mean length of 100 kbit.

   (i) It is required to evaluate the mean delay from the message arrival to the input of the radio link to when it's transmission has been completed.

   (ii) We assume that the operator substitutes the two transmitters with a single one with a rate of 10 Mbit/s; we have to evaluate the mean message delay in this case and to compare this result to the previous point.

6. A radio link adopts four equivalent parallel transmitters for redundancy reasons. The operational characteristics of the transmitters require that each of them be switched off (for maintenance or recovery actions) according to the Poisson Process with a mean interarrival time of 1 month. The technician that performs maintenance and recovery actions requires a time exponentially distributed with mean duration of 12 hours in order to fix the problem. We consider that two technicians are available. The exercise requires:

   (i) To define a suitable model for the system;

   (ii) To determine the probability distribution of the number of down transmitters at a generic instant;

   (iii) To express the probability that no transmitter is operational on this radio link.

7. We have an ISDN private branch exchange with two output lines (i.e. ISDN basic access) and no waiting room that can receive two different type of calls:

   Type ♯1 phone call that requires one output line. The arrival process is Poisson with mean rate λ_1 and the call length is exponentially distributed with mean rate μ_1.

   Type ♯2 phone call that requires two output lines. The arrival process is Poisson with mean rate λ_2 and the call length is exponentially distributed with mean rate μ_2

   If an arriving call to the private branch exchange needs a number of output lines greater than those available, it is blocked and lost. It is requested to model the system and to determine the blocking probability for both type ♯1 and type ♯2 calls.

8. We consider a switch with a single output line. Calls arrive according to interarrival times exponentially distributed with parameter α. Each call has a length with exponential distribution and parameter γ. We have to analyze two different cases.

   Case ♯1 : The switch can put in a waiting list the calls that find a busy output line. It is requested to model this system and to express the probability that an arriving call is put in the waiting list since the output line is busy, P_C.

   Case ♯2 : The switch has no waiting list: If an arriving call finds a busy output line, the call is blocked and lost. It is requested to model this system and to express the call blocking probability P_B. Which is the maximum input load in Erlang in order to have a blocking probability lower than 1% ?

   Finally, we have to compare the system stability aspects in these two different cases.

9. We have m independent Poisson arrival processes of messages, each with parameter λ. Messages arrive to a transmission system that has a whole transmission capacity C. Each message requires a service time exponentially distributed. It is requested to compare the mean delay experienced by a message in two different cases to share capacity C:
   (i) We use a distinct queue for each traffic flow (*deterministic multiplexing*), each queue having a transmission capacity C/m that corresponds to a mean message transmission time equal to $1/\mu$.
   (ii) We use a single queue that collects all the traffic flows (*statistical multiplexing*), with a transmission capacity equal to C and a corresponding mean message transmission time equal to $1/(m\mu)$.

10. We have to consider an ATM traffic source that injects cells into the network according to a token bucket regulator. ATM cells arrive to the buffer of the regulator according to a Poisson process with parameter λ. The effect of the regulator on the transmission of the cells is modeled as follows: an ATM arriving at the head of the buffer finds an available token for the immediate transmission with probability p; otherwise the cell has to wait for an exponentially distributed time with parameter μ with probability $1 - p$.
    For the sake of simplicity, once a cell has received its token, we neglect its transmission time. We have to evaluate the mean delay according to which cell is injected in the network owing to the regulator.