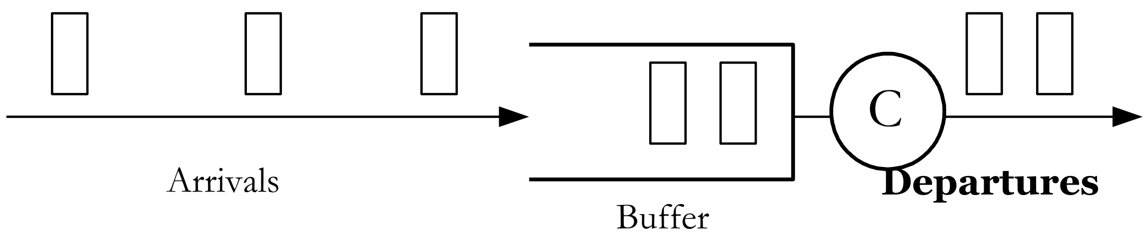
Problem set-5

Traffic modeling

Q1

Suppose we want to predict the delay and throughput at a buffer of a network link that operates at link capacity C Mbps. The situation is illustrated in the figure, where packets are represented as rectangular boxes.



To conduct an analysis of this link, we need to make assumptions on the traffic that arrives to the link. The traffic description must specify the spacing between packets and the size of packets that arrive to the buffer.

A very popular model to represent the number of packet arrivals in a time interval is the Poisson Process. In a **Poisson process** with rate λ, the number of (arrival) events in a time interval (t, t+τ], denoted by N(t+τ) – N(t), is given by

$$P[N(t+\tau)-N(t)=k]=\frac{(\lambda\tau)^k}{k!}e^{-\lambda\tau} \qquad ,k=0,1,\ldots,$$

A Poisson process has some interesting and useful properties:

- In a Poisson process, the time between two (arrival) events follows an exponential distribution, i.e.,

$$P[\text{Time between two events} \leq X] = 1 - e^{-\lambda X}$$

- If we add the arrivals of two Poisson processes with rate λ and μ, we obtain a Poisson process with rate λ + μ.

In this problem we generate Poisson traffic and study its properties. Consider a packet arrival pattern of a flow, where all packets have a constant size of 100 Bytes and where packet arrivals follow a Poisson process. The average traffic rate of the flow is 1 MBps (Mega Byte per second). The file poisson1.data contains a traffic trace of the data. The file has three columns:

Column 1	Column 2	Column 3
Packet number	Timestamp (in microseconds)	Packet size (in bytes).

You can read the file in Matlab by

```
[packet_no_p, time_p, packetsize_p] = textread('poisson1.data', '%f %f %f');
```

A) Verify the measured mean bit rate of the flow with the target rate, by calculating the mean and the variance of the times between consecutive arrival events. Compare the values with the theoretically expected values.

B) Create three graphs that plot the data generated by the trace, viewed at different time scales. Each graph has 100 data points.

C) Generate a vector with 100 elements. Each element stores the number of bytes from the Poisson trace (i.e. `poisson1.data)` that arrive in a time period of 1 second.

   - 1st element: # bytes arriving in time period [0, 1 s];
   - 2nd element: # bytes arriving in time period [1, 2 s];
   - …

D) Generate a vector with 100 elements. Each element stores the number of bytes from the Poisson trace that arrive in a time period of 100 milliseconds, beginning at a randomly selected start time.

   - Pick a random starting point, e.g., time 30 s.
   - 1st element: # bytes arriving in time period [30, 30.1 s];
   - 2nd element: # bytes arriving in time period [30.1, 30.2 s];
   - ….

E) Generate a vector with 100 elements. Each element stores the number of bytes from the Poisson trace that arrive in a time period of 10 milliseconds, beginning at a randomly selected start time.

   - Pick a random starting point, e.g., time 50.2 s.
   - 1st element: # bytes arriving in time period [50.2, 50.21 s];
   - 2nd element: # bytes arriving in time period [50.21, 50.22 s];
   - ….

For C, D and E sub-questions, plot the content of the vectors in three separate graphs, with the time intervals on the x-axis, and the number of bytes on the y-axis. The data points should be depicted as vertical bars (e.g., using the MATLAB function `bar()'). Describe your observations of the graphs.

Q2

Consider a packet arrival pattern of a flow, where packets arrive with an equal spacing of 800 μsec (microseconds), and with an exponentially distributed packet size with parameter with average size $1/\mu = 100$ Bytes. The file poisson2.data contains a traffic trace of the data. The file has 3 columns as Q1. You can read the data in the same way as Q1.

A) Verify the measured mean bit rate of the flow with the target rate, by calculating the mean and the variance of the times between consecutive arrival events. Compare the values with the theoretically expected values.

B) Plot the histogram of traffic rate in which you should use the scott's rule (as discussed in the lecture).

C) Estimate a model for the traffic rate from your observation from B. Show comparison of your model and the histogram of traffic rate (i.e. from B).

D) Use chi-squared test to evaluate your mode of traffic rate in C. You can use the function chi2gof in Matlab.