EECS 863
Spring 2022
Project 2

Provide your results in the form of a technical report using the provided format.
See: **[Technical Report Format](http://www.ittc.ku.edu/~frost/EECS_563/Technical%20Report%20Format-2019.pdf)**
http://www.ittc.ku.edu/~frost/EECS_563/Technical%20Report%20Format-2019.pdf
Also see this paper for advice on writing technical reports.
See: **[Paper on writing technical reports](http://www.ittc.ku.edu/~frost/EECS_563/Writing%20Technical%20Reports.pdf)**
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Do not pad your reports, all figures and tables must be discussed in the text.

The purpose of this simulation study is to evaluate the performance of FIFO (First-In-First-Out) queues with various input traffic characteristics. Estimate and plot the normalized delay vs. the offered load for the following 6 cases. Change the offered load by changing the average interarrival time or message length as required. Consider loads of 0.25, 0.5, 0.75, 0.9, and 0.95. For each load run enough replications to achieve a relative error of 0.1. For each load report the computational resources needed to achieve a relative error of 0.1; computational resources can be measured by the total number of packets processed. That is, plot the total packets processed vs. load. Compare your results to theory where possible. Also discuss how your simulation models were verified and validated.

Case 1:
An exponential message length pdf with an average of 1 and an exponential interarrival time pdf.

Case 2:
A fixed message length of length 1 and an exponential interarrival time pdf.

Case 3:
A fixed message length of length 1 and an uniform interarrival time (T_a) pdf, use $T_a \sim U(0, 2E[T_a])$, i.e., T_a is uniformly distributed between 0 and $2E[T_a]$.
Note Arrival rate $=1/E[T_a]$.

Case 4:
The input traffic to the FIFO is the combination of 10 sources with the characteristics given in Case 3. In this case the load per source=total load/10. Approximate the average delay characteristic using an M/M/1 model and compare the approximation to the simulation results. Relate these results to the assumption that merging (superposing) several independent non-Poisson processes results in an approximate Poisson process.

Case 5

Use a Pareto message length pdf with an average of 1 ($E[L]=\alpha x_{min}/(\alpha-1)$, so in the Pareto model in extendsim set Minimum =0.25, α=1.33, location=0; this results in an E[L]=1). Note for $\alpha<2$ the variance is infinite. Discuss any problems you have obtaining statistically significant results for this case.

Examine the delay as a function of time and compare to Cases 1-5

Discuss the impact of different traffic models on the average delay; also consider the impact as the load changes.

Case 6 (for 10% extra credit)

The input traffic is a Markov Modulated Poisson Process (MMPP). In a MMPP process the arrival rate changes according to a continuous time Markov chain. That is, the arrival process is Poisson with arrival rate λ_i while the arrival rate process in is state i. The time the arrival rate process is in state i is exponentially distributed. Use a fixed message length and MMPP arrival process with 3 states. The arrival rate while in state 1 is 0, i.e., state 1 is an off state. The arrival rate in state 3 is five times that of state 2. The average time in each state is the same. Set the average time in state i to 10. Set λ_2=1. What is the average arrival rate? In this case change the load by changing the message length. You can use MMPP model at: http://www.ittc.ku.edu/~frost/EECS_563/LOCAL/Extend_Models_2019-v10/MMPP_Model-3-states-ES10.mox