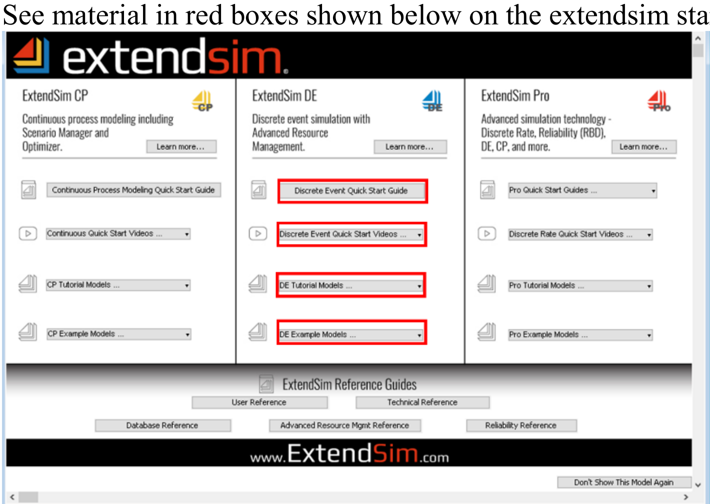
EECS 863
Spring 2022
Project 1

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)**
http://www.ittc.ku.edu/~frost/EECS_563/Writing%20Technical%20Reports.pdf
Do not pad your reports, all figures and tables must be discussed in the text.

The objective of this project is to build, verify and validate a simulation model of an M/M/1 system. The simulation model will be constructed in extendsim; in the process of building this model features of the tool will be employed, e.g., setting attributes, sensitizing parameters, cloning, replication, deleting initial transients, applying stopping rules, and hierarchical modeling. For every case studied in this project discuss how the simulation model was verified and validated.

Resources:
Discrete Event Simulation Quick Start Guide (QSG) see https://extendsim.com/learning/learnstarted
See material in red boxes shown below on the extendsim start-up screen.



Extendsim is available on the EECS computers located in Eaton Hall.
You can also access extendsim through virtualdesktop.ku.edu and then selecting the Engineering Desktop. Remember to use use onedrive to store data and to NOT store it on the desktop or anywhere else.

System Paramters

Traffic Parameters:

Message length = 1000 bits
Exponentially distributed message lengths
Exponentially distributed interarrival times
Arrival rate adjusted to achieve specified loads.

System parameters:

Link capacity = 1Mb/s
Infinite capacity

Performance metrics of interest:

Average queue length
Average queue wait time.
Average number in the system
Average delay through the system

1) Build a basic extendsim model (using a small number of blocks) of an M/M/1 given the objective of estimating the average queue length and average queue wait time for loads of 0.1, 0.5, and 0.9. Manually execute the model once for each load. Select the simulation end time such that about 10,000 packets are observed for a load of 0.1. Report how you confirmed the simulated load matched expectations. Compare the simulated results to theoretical predictions.

2) In communications networks packets include a header containing overhead information, e.g., source and destination addresses; CRC for error checking; and sequence numbers. In simulation the data structure associated with the packet is also augmented with simulation specific information, e.g., time created. Modify the extendsim model built in 1). by add attributes to each created packet using the *set* and *get* blocks. Include the message length in bits as an attribute. Use value blocks to transform the message length onto a service time and the arrival rate into an average interval time. Use the clone tool to make it easy to set the simulation parameters. Manually estimate the average delay through the system for loads of 0.1, 0.5, and 0.9. Also determine the normalized delay through the system, (average delay/average service time)

3) Investigation into the removal the initial transient. For a load of 0.9 set use these combination of the run-in time t_p and stopping time. Estimate the average delay using 10 replications.

Run-in time t_p	Stopping time
0	10
0.05	10.05
0.1	10.1
1	11

Discuss the impact of removing the initial transient, did the removal significantly change the estimate the average delay.

4) In the simulation model created in part 2) sensitize the arrival rate parameter to estimate average delay through the system for loads 0.1 to 0.9 in steps of 0.05. Extract the data from extendsim and plot the average delay and normalized delay vs load (you can use Excel for plotting).

5) Modify the simulation model created in part 2) to have the simulation stop when a relative error specification is reached. Set the load to 0.9 and end time such that about 9000 packets are observed per run. Use multiple runs and replicate until the relative error < 0.05. How many replications was required to achieve a relative error < 0.05. Repeat for a load of 0.5; compare the required number of required replications and explain.

6) Hierarchical modeling is used to control the complexity of simulation models. Create a hierarchical traffic source block based on simulation model created in part 2. The hierarchical traffic source block must have the arrival rate and average message length as inputs (assume exponentially distributed message lengths). Using the model with the hierarchical traffic source block repeat part 4). The hierarchical traffic source block must be fully documented. Discuss the use of libraries of hierarchical blocks.