KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES & ENGINEERING

COMPUTER ENGINEERING DEPARTMENT

COE 402 – Computer Systems Performance Evaluation
Assignment 3

On the subject of "Introduction to Simulation" and "Analysis of Simulation Results"

In this assignment you are required to execute an OPNET tutorial and attempt to analyze the obtained simulation results.

(a) **(50 points)** Launch the OPNET software from your UNIX account on the CCSE network and from OPNET modeler "Help" drop down-menu select "Tutorials". Select the first tutorial "M/M/1 Queue (30 min)" from the Modeler Lessons subsection. Go through the tutorial and build the required model for the M/M/1 queue. *Make sure you following the naming convention suggested in this project. I.e. All modules will start with your initials and then the name of module.*

After you run your code and get the same specified results in the tutorial, you are required to submit your code. To do that, follow the following steps to create an archived version of your project:

- Open your completed project in the Project Editor.
- Click on the "running man" icon to open the Configure/Run Discrete Event Simulation (DES) dialog box.
- In the Configure/Run DES dialog box, click the Advanced: Files tab.
- Select the "Generate list of Component File Dependencies" checkbox.
- Run the simulation for a short duration (400 simulated seconds is usually sufficient). During the simulation, OPNET creates a list of each file accessed and displays it in the Dependencies page of the Simulation Sequence dialog box.
- When the simulation is complete, use the checkboxes in the Dependencies tab of the Simulation Sequence dialog box to exclude any file types you do not want in the component file archive. It is recommended that you exclude object files, Standard Models (unless you have modified them).
- Click on the "Package..." button to create an archive of the listed files. A file browser window opens, allowing you to specify the name and location for saving the file. Modeler will automatically add a .opcfa extension to the file name you specify.
- After specifying the name and save location, click on "Save" button. The component file archive is saved.

(a.1) Send the resulting file to the TA's email for marking.

(a.2) Calculate the offered traffic intensity, $\rho=\lambda/\mu$, for the simulation configuration used in the tutorial? Is the system stable or unstable? If the system is stable, is it lightly or heavily loaded?

(b) Having completed part (a), you will find a ".OV" (OPNET vector data) file in the project directory. This file contains the simulation's record in the form of results-versus-time. It is required to apply the methods we learned in Chapter 25 in terms of analyzing simulation results on the data obtained from this simulation exercise. In specific, we would like to do two things: eliminating transient output points, and determining when to stop simulation. For these purposes we need the original untruncated simulation packet delay output (ignore the queue-size statistics).

Export the simulation data you obtained in part (a) into a text file that can be processed using Matlab (highly recommended), Microsoft Excel, or any other tool of your choice.

(b.1) **(100 points)** Eliminating transient output: Apply the following 4 methods to eliminate transient output: (1) Truncation, (2) Initial data deletion, (3) Moving average, and (4) Batch means.

For each of the specified methods, submit the code, the corresponding graphs and your conclusion regarding the length of the transient period. The required graphs are as follows. For method (1), a graph similar to Figure 25.7 and for method (2), a graph similar to Figure 25.8a, b, c, and d. For method (3), the required graph is similar to Figure 25.9 (at least two different values for the window width k) and for method (4), a graph similar to that in Figure 25.10.

Note that for methods (2) and (3) you are required to have more than one replication of the packet-delay figures. It is suggested to use m = 10 equal-length independent replications. Those can be obtained by executing the original OPNET code using 10 different seeds and collecting the packet delay figures after each run.

(b.2) **(50 points)** In this part we would like to determine the appropriate length of time (or number of samples) for terminating the simulation. Apply the following two methods to determine the appropriate number of samples of packet delay required: (1) Independent replications, and (2) Batch means.

For each of the specified methods, submit the code, the corresponding results and your conclusion regarding the required number of samples. For method (2), produce a table showing the variance and the autocovariance for the output data as a function of the number of samples, n (similar to that found in the textbook or in the classroom slides).

Note that for method (1), you required to use more than one replication. Use the replications you generated for part (b.1).

(c) **(50 points)** It is required to run the simulation from part (a) for different values of the packet interarrival times, a parameter specified in the src node in the Node Model Editor. Run the simulation for the following interarrival times (all in seconds):

9.3750, 4.6875, 3.1250, 2.3438, 1.8750, 1.5625, 1.3393, 1.1719, and 1.0417.

Collect the average packet delay and mean queue size statistics from OPNET. Plot these results versus the offered traffic intensity, $\rho=\lambda/\mu$.

For this part, run all simulations for 14 hours, and instruct OPNET to start collecting results after the passage of 3 hours of simulation time in order to eliminate transient response.