EECS-863 Analysis of Communication Networks

Spring Semester 2008
Project #1, Due 25 March 2008
Reading: Lecture Notes and Sections 9.1.1 – 9.1.5, 9.3

This project will help to familiarize you with simulation in general and the Extend® simulation tool in particular. Turn in a written report. There is no specific format for the report, but it must be computer-generated (not hand-written), well-organized, and complete, yet concise. Calculations for part 1 may be hand-written and included in an appendix. Your discussions of results obtained are quite important.

1. Consider a simple statistical multiplexer with a first-in, first-out (FIFO) queue. The packet arrivals are Poisson (exponential interarrival times) and the packet lengths are exponentially distributed with a mean of 500 bytes. The link transmission speed is 64 kb/s (64,000 bits per second). Calculate the necessary mean arrival rate (in packets per second) to produce a normalized link load of 0.90, then calculate the mean packet delay (queuing plus service) through this statistical multiplexer.
2. Construct an Extend simulation model for the simple statistical multiplexer described in the previous part. You *must* associate at least one attribute with each packet (you can use more attributes if you like), and you must make use of this attribute in the simulation. All simulation parameters (which are: mean packet arrival rate, mean packet length, link transmission speed) should be constants that can easily be set (and changed) from the top-level simulation model. Your model should have the capability of measuring the mean and standard deviation of the packet delays (queuing plus service time). You should also include the capability to plot the running (accumulated-average) mean packet delay as a function of time. Make your model neat, organized, and well-documented. Include a printout of your simulation block diagram in your report.
3. We would not usually simulate a system for which know the "true" performance values, but we will do so here to illustrate how simulation can only provide estimates of the "true" values. Conduct the following experiments with your simulation model. These are designed to illustrate and compare different ways of getting results from a simulation model.
   (a) Calculate the amount of time required for the source to generate approximately 4000 packets and use a run-in period corresponding to approximately 2000 packets. That is, clear the statistics block after approximately 2000 packets so that the final statistics are based on approximately 2000 packet delays, even though the simulation will generate approximately 4000 packets. Conduct 100 simulation runs for this amount of time. Note that you will be simulating a grand total of 400,000 packet generations, a figure that will be held constant in parts (b) through (d). Use a File Out block to write the following information to a file: mean packet delay for each of the 100 runs as well as the *actual* number of simulated packet delays used to calculate the mean for each run. The simulations will run significantly faster if you do not have any display blocks (e.g., for packet counts or plots) in the top level of your simulation. Import the data into a spreadsheet and calculate the mean and variance of the 100 mean packet delays and of the 100 numbers of simulated packets. Include a table entry for the analytical result for mean packet delay from part 1. *Note*: do not be alarmed if there is not particularly good agreement between the result of any *one* of these simulation runs and the analytic result

from part 1. However, if there is more than a 5% discrepancy between the *average* of the 100 runs and the analytic result from part 1, you are probably doing something wrong. In this case, stop and try to figure out what is wrong; contact me for assistance if necessary. Include a copy of the spreadsheet in your report. If you like, you may also use the spreadsheet to graph the results of these 100 simulation runs (but this is not required).

(b) Repeat all of part (a), but this time calculate the amount of time needed for the source to generate approximately 2000 packets, do *not* use a run-in period, and conduct 200 simulation runs.

(c) Calculate the amount of simulation time required for the source to generate approximately 10,000 packets. Conduct 40 simulation runs for this amount of time, using a run-in period corresponding to approximately 2000 packets. Create a spreadsheet similar to the ones in parts (a) and (b) for these results. Compare the mean of the 40 mean delays with your previous results. Also compare the variance of these 40 mean values with the variance of the 100 mean delays from part (a). After conducting the block of 40 simulation runs, conduct one more, using a plotter block in Extend to plot the running (accumulated-average) mean packet delay as a function of time. Include this plot in your project report.

(d) Optional (small extra credit may be awarded): conduct some additional investigations of your own choosing that may help you learn how to properly conduct simulations and interpret results.

(e) Summarize and discuss what you have learned from this part about the interpretation of simulation results, based on the results obtained in parts (a)-(c) or (a)-(d) compared with the analytical results of part 1. This discussion is an important part of this project; spend some time on it.

4. Now you will conduct some simulation experiments for situations that you cannot (yet) analyze ahead of time. This is a more realistic and typical use for simulation – to obtain performance estimates for situations that cannot be analyzed mathematically. Your *goal* is to determine the effect that the second-order statistics (that is, standard deviation, variance, and/or second moment) of packet length have on mean packet delay (queuing plus service) and/or on mean waiting time (queuing only). Using the previous simulation model, change the distribution of packet lengths to LogNormal. In addition to the mean of the distribution (which you should not change), you will now have to specify a standard deviation. Conduct trials (a trial is a set of simulation runs) for several different values of standard deviation of packet length. You choose the values for standard deviation, but two of your choices must be 0 and standard deviation equal to the mean packet length. Each trial should be identical: same number of simulation runs, same simulation time in each run, same run-in period for each run. Select values for each of these based on what you learned in the previous part. Briefly discuss your reasons for choosing your particular values. Summarize your results in two sets of three plots (graphs) each, first showing mean packet delay in the system as a function of standard deviation, variance, and second moment of packet length, then showing mean waiting time as a function of the same three quantities. Briefly discuss what your results seem to indicate. Be as specific as you can.