CSE/ECE 6730 Project 1: Road Traffic Simulation

Due Dates:
- Project Checkpoint: due: 11:59 PM, Friday, January 30, 2015
- Final Report: 11:59 PM, Friday February 20, 2015
- Poster Presentation: in class, Friday, February 20, 2015

1   Problem Statement

The goal of this simulation study is to compare the average travel time for vehicles to traverse a portion of Peachtree Street in midtown Atlanta when using synchronized compared to unsynchronized traffic signals. In both scenarios, each traffic signal will utilize a common timing pattern (i.e., the light remains red for R seconds, yellow for Y seconds, and green for G seconds, and repeats). In one case each of the lights operates independent of the others. In the second case, you will need to define a strategy so the lights are synchronized with each other to improve traffic flow (but use the same R-Y-G timing as the unsynchronized case).

To complete this project you must develop a simulation of a section (from 10th to 14th street) of Peachtree Street during the afternoon commute. This analysis will be focused on predicting the distribution of vehicle travel times as they traverse this stretch of Peachtree Street. You will need to implement all steps of the modeling and simulation life cycle discussed in class, including the development of the conceptual model, development of the simulation model, data collection (some data will be provided that you may optionally use), verification, validation and calibration of the simulation program, input analysis, output analysis, and reporting your results.

The project is, by design, somewhat open-ended. There is no one way to complete it correctly, but you will need to be able to justify the assumptions and decisions you make throughout the study. You may wish to devote more effort to certain aspects of the project rather than others, depending on the interests of members of your team. When it comes to grading, you will score points by going "above and beyond" for specific parts of the project while doing a reasonable job based on material covered in class on all aspects.

2   Simulation Model

The simulation model must be a discrete event simulation program based on a *queueing network* conceptual model. You must identify and review the relevant literature applicable to developing such a model; this literature survey should be described in the project plan and final report. You will need to implement an event-driven (as opposed to a time stepped) time advance mechanism.

The simulation must be stochastic, i.e., use random numbers to model unpredictable or unknown elements of the system such as vehicle inter-arrival times. You will need to identify the places where randomness is appropriate to use in the model, and denote where you used them in your implementation in the final report.

You will need to determine what data you need, and collect and incorporate these data in the simulation model. Much of this data, e.g., the topology of the road network and the capacity, must be stored in a data file and read by the simulation program when it begins to execute. How you store and structure this data is up to you.

You may use any programming language to implement your simulator, however we recommend your team use a single common language for the simulation model to avoid dealing with issues related to interfacing programming languages. Each team must develop their own simulator using a high-level programming language; you may *not* use a discrete event simulation packages such as

Arena nor a transportation simulation package such as VISSIM in this project. However, you may utilize pre-existing (e.g., from other classes) or publically available software for parts of your simulator, e.g., random number generators or priority queue implementations. Any such software you utilize must be documented and properly cited in the final report. Keep in mind if you choose to use existing rather than develop your own implementation you will be expected to devote more effort to other portions of the project relative to teams that develop their simulator entirely from scratch.

The simulator and associated software tools used for the project must be developed by the entire team, with all team members developing a significant part of the code. Each team includes a mix of individuals with different amounts of experience in software development. Members with more experience are expected to help those with less (but not write the code for other team members!).

The software must be developed in a modular fashion, with well-defined, documented application program interfaces (APIs). For example, the software must include a priority queue for the future event list and random number generator for the required probability distributions. You will likely also want to include a library of model objects, e.g., queues. Your software may also include test "driver" programs as needed to verify correct operation of library modules. The validity of random number generators must be verified using appropriate statistical tests.

3 Resources

Several resources are available to you to help you implement this project. These include:

- Baseline Simulation Results. A traffic simulation study of the area in question is described in [1]. You may use this paper as a guide in developing your simulation model. You may also use the data reported in this paper for verification purposes if you wish. There are other publically available reports describing studies of this area that you may wish to refer to in your project.

- Traffic Data. The NGSIM data set is available that provides trace data for vehicles traveling through the area modeled in the simulation study. You may utilize this data to develop input distributions for your model, as well as for validation purposes. Note you are not required to use the NGSIM data set (for example, you may wish to collect your own data), but you should make a credible effort in data collection and analysis to properly model the study area.

- Other Information Resources. You will need additional data to develop your simulation model. Geographic data concerning the area being modeled may be obtained from the web (e.g., google maps). You may wish to collect measurement data yourself (e.g., signal timing or traffic flow data) to complete the project, especially if you decide not to use the NGSIM data set.

It should be emphasized there is not one "correct" way to construct the simulation model and define the data used by the model. It is up to you to decide what makes sense, and what can be justified when arguing the validity of your simulation model.

4 Teams and Statement of Work

You will work in teams of three or four students. The teams will be defined for you. You will need to develop a plan to divide up this task among team players. One person in your team must be designated as the lead who will have the responsibility for organizing the team, scheduling meetings, etc.

You must implement the major steps in the modeling and simulation life cycle. Specifically, you should develop your own version of the problem statement and document any assumptions you are making. You must document the conceptual model to give a clear explanation of what your model does and what is included. We are looking into having a SysML editor available for documenting the conceptual model – more on this will be worked out later in the next week or two. The simulation software must be well documented. You should define all data you collect and use to complete the project, especially any data you collect yourselves. You will need to document what input distributions you used and how to determined and selected parameters for them. You will need to verify and validate your model to the extent possible, and calibrate the models you developed. The experimental design must be described to compare travel times for synchronized and unsynchronized light timing, and approaches you used for signal timing should be documented and justified. While the emphasis of this project is simulation methodology rather than signal timing, you should explain the rationale for the synchronized timing that you used. Finally all results from the simulation study should be well documented and explained.

5   Deliverables

Your grade will be determined largely by the quality of the work you completed in each of the steps of the M&S life cycle, in addition to the quality of the simulation software you developed. The following items that must be completed and turned in on t-square:

- *Project checkpoint*. By the time of the checkpoint you should have completed the problem description (a more detailed version of the described here), conceptual model, and simulation model steps of the simulation project life cycle. You should have a more-or-less completed simulation model running. These should be written up, and turned in. The project checkpoint represents a large portion of the final report. You will add upon this document to complete the final report, described below.

- *Software implementation*. Source code and documentation for all software in your simulation must be turned in with the project checkpoint and final report. In addition to the actual code, the software deliverable must include documentation that you have verified the validity of your random number generator. Be sure to document and cite the source of any pre-existing software you used in your simulation model.

- *Poster session*. You will present your project in a poster session conducted in class, at which time you should be prepared to give a concise (5 minute) presentation of your project, and be prepared to answer questions.

- *Final report*. The final report includes all documentation for the software and simulation study. It should describe the work you completed for all steps of the M&S life cycle in sufficient detail that the reader could reproduce your results. All work you completed for the project must be documented in this report. The final version of the source code for your simulator must also be provided. The final report should be self-contained.

6   Grading

The project is relatively open-ended, so there is much latitude for you to vary your scope of effort in completing the project. In general terms, our grading standards are as follows. If you do an acceptable job completing all of the steps of the M&S life cycle based on material covered in class or provided to you, that will earn a "B" for the project. To get an "A", we'll be looking for you to complete some special aspect(s) "above and beyond." Each of the steps of the life cycle offers opportunities to excel and impress, e.g., by demonstrating strong knowledge of an area through your

own investigations (e.g., well beyond assigned readings), or particularly careful and well-thought out execution of the life-cycle. Part of your work on the project is to identify areas where you feel you can excel, and document your efforts in the project deliverables. We suggest you and other members of your team identify aspects that are of particular interest to you, and devote special attention to that area. Impress us, and shows us what you can do!

Each person will be assigned a grade based on the project as a whole as well as your specific contribution. Thus it is in your best interest both to do whatever is necessary to ensure the overall effort is successful, as well as to make sure you have specific contributions that you can call your own. Note it is mandatory that all team members develop a significant amount of software for the project.

7   Distance Learning Students

Distance learning (DL) students may work in a team with other DL students, or complete the project on their own. In either case, the scope of the project will be scaled to match the size of your team. We will collect your preferences once the registrations for the class are completed, and form teams as needed. More on this once the course roster has been finalized.

8   Final Comments

This simulation problem is, by design, open-ended and not all details have been specified. While you will be expected to do some data collection, you will not have all the information you need, and some assumptions and approximations will have to be made. Part of your task is to identify and document what assumptions you are making, and have reasonable justifications for the choices you made. Time constraints and missing important information are the reality in most real world studies. Do the best you can, but be sure you are conscious of the limitations and assumptions you make in completing this study.

References

1.   Henclewood, D., W. Suh, R.M. Fujimoto, M. Hunter, and M. Rodgers, *A Case for Real-Time Calibration of Data-Driven Microscopic Traffic Simulation Tools*, in *Winter Simulation Conference*. 2012.