

ECE 673: Simulation and Evaluation of Computer Systems and Networks

Fall 2013

The course divides into two parts. One deals with analytical methods and the the other with simulation.

It is important that you have a good grasp of the basics of probability theory. I will assume that students taking this course have taken ECE 603 or its equivalent elsewhere.

The anticipated coverage (subject always to adjustment) is as follows:

Analytical Methods

- Elements of probability: Review.
- Conditional probability and some of its uses. Prior and posterior distributions. The idea of maximum likelihood.
- Operational laws; Little's law.
- Mean Value Analysis and Schweitzer's Approximation.
 - *Application: Central Server Model*
- Markov chains; Chapman-Kolmogorov equations.
- M/M/1 queue: Analytical solution; use of transforms.
- M/D/1/K queue: Numerical solution.
 - *Application: Buffer sizing in networks.*
- Product-form queueing networks.
- Buzen's algorithm for closed networks.
 - *Application: Finding bottlenecks in networks.*
- Basic Markov decision theory.
 - *Application: Energy harvesting sensor network control.*

Simulation Techniques

- How to write a simulation.
- Random number generation.
 - Uniform random numbers.
 - Non-uniform distributions.
 - Testing the quality of generators.
- Statistical evaluation of data.
 - Mean and variance.
 - Confidence intervals.
- Goodness of fit techniques
 - χ^2 test.
 - KS test.
- Acceleration techniques (as time permits).
 - Antithetic variables.
 - Control variates.
 - Stratified sampling.

– Importance sampling

You should have some prior knowledge of probability theory. ECE 314 or ECE 603 would be an excellent source for probability; however, most other probability courses should also provide enough background. You should know how to program in some high-level language.

Grading:

Test 1.....	25
Test 2.....	25
Final examination.....	40
Homework.....	10

Textbook:

- S.M. Ross, *Simulation* (4th Edition), Academic Press, 2006. Available online through the library website.
- L. Kleinrock, *Queueing Systems, Vol. 1*, Wiley, 1975. On reserve in the library.

ECE 673: Topics and Reading List

1. *Prior and Posterior Distributions*: This is an elementary outcome of Bayes's Law. See Section 8.9 of DeGroot, *Optimal Statistical Decisions* (on reserve in the library).
2. *Markov Chain Basics*: Read Chapter 2 of Kleinrock.
3. *M/M/1 Queues*: Sections 3.1 and 3.2 of Kleinrock.
4. *Open Queueing Networks*: Section 4.8 of Kleinrock.
5. *Buzen's Algorithm*: Read J.P. Buzen, "Computational Algorithms for Closed Queueing Networks," *Communications of the ACM*, Vol. 16, No. 9, September 1973. CACM is accessible through the UMass library website.
6. *Transforms*: Appendix I and II.4 of Kleinrock.
7. *M/M/m Queues*: Section 3.5 of Kleinrock.
8. *Finite Waiting Room*: Section 3.6 of Kleinrock.
9. *Method of Stages*: Sections 4.2 and 4.3 of Kleinrock.
10. *Little's Law*: Section 2.1 of Kleinrock.
11. *M/G/1 Queue*: Sections 5.1 to 5.10 of Kleinrock.
12. *Operational Methods*: See P.J. Denning and J.P. Buzen, "The Operational Analysis of Queueing Network Models," *ACM Computing Surveys*, Vol. 10, No. 3, September 1978. This is accessible through the library website. Alternatively, from the umass.edu domain, go to www.acm.org/dl which will take you to the ACM Digital Library.
13. *Mean Value Analysis*: There are several good tutorial introductions to MVA available online. For example, see www.cs.ucr.edu/~maart/204/MVA.pdf.
14. *Random Variable Generation*: See Ross, *Simulation*, Chapters 4 and 5. This book should be electronically accessible via the library website.
15. *Writing Simulations*: See Ross, Chapter 6.
16. *Processing Simulation Data*: See Ross, Chapters 7 and 9.
17. *Variance Reduction Techniques*: Selected topics from Ross, Chapter 8.