OR 635
Discrete System Simulation
Fall 2013

Class time: 7:20pm-10:00pm, Monday, August 26, 2013 – December 2, 2013
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Course Description:
Many complex engineering, operations, and business systems can be modeled as discrete-event systems, including call centers, production systems, supply chain, hospital emergency rooms, airport terminals, and air traffic management systems. The complexity of these systems and the uncertain nature of the environment often make simulation the only feasible analytic tool to model and study the design and operations of these systems. This course studies the important topics in discrete-event simulation theory and practice. Topics will include stochastic modeling of discrete-event systems, input modeling, random number generation, statistical analysis of simulation output, and techniques to improve the efficiency and accuracy of simulation results. A very important part of this course is for the students to learn to actually use simulation to model and analyze a discrete-event system. Simulation packages such as Arena will thus be extensively used through the course. Students will also have opportunities to develop simulation models using a general programming language (Java, C++, etc.). Other types of simulations (Monte Carlo, Agent-Based) will also be briefly introduced.

Prerequisites:
Students should be familiar with basic probability and statistics at the level of OR 542, or STAT 544, or STAT 346, or STAT 354, or equivalent. Students should also be familiar with one scientific programming language such as C++, Java, Matlab, R, SAS.

Grading:
Homework 20%; Midterm 35%; Term Project 45%

In class midterm is tentatively scheduled on Monday, October 7. Make up exam is for certified medical reason only.

Late homework and term project submissions are allowed. However, the penalty for late homework and term project is 30% for the first day and then 5% per day. **No exemption.** Homework problems should be worked out independently but discussions are allowed. Teams with 3-4 members will work on the term project.

Students are encouraged to do a simulation project in one of the following application contexts:

1. Production system and supply chain. Examples include semiconductor manufacturing, inventory system, order-pick warehouse, military logistics, non-profit logistics, etc.
2. Service systems. Examples include hospital operations (such as emergency room, operations room), call center, retail store, etc.
3. Transportation systems. Examples include air transportation, intermodal facilities, etc.
4. Homeland security. Examples include disaster mitigation planning, emergency management and disaster response, crowd evacuation, facility patrol, etc.
5. Communications, computer networks, and Internet. Examples include cloud computing/data centers, wireless sensor networks, etc.
6. Financial systems. Examples include option and future pricing, risk management, portfolio optimization, etc.
7. Other emerging frontiers such as social media, social network, biological systems, and "big-data" related topics.

Students can also choose to work on a project focusing on a simulation methodology topic:

1. Simulation input modeling
2. Stochastic simulation output analysis
3. Simulation-based optimization
4. Simulation model validation and calibration

Winter simulation conference (www.wintersim.org) is a good source of references for simulation application and research. Students are encouraged to come up with their own topics and develop their own models. With instructor permission, it is also ok to replicate a simulation study reported in a research article.

Please be careful to define the scope of the problem to ensure the project can be completed at the end of the semester. Every team needs to submit a written project proposal, a mid-term progress report, and a final project report. Teams will also present the proposal, mid-term progress and final report in class.

More details about term project will be given during the semester.

Textbooks

Required text:

M. Law, "Simulation Modeling & Analysis," 4th Ed. (You may use the 3rd Ed., but be aware of the changes). This book provides a comprehensive coverage of the fundamentals in simulation modeling & analysis. It is also a valuable reference book for successful simulation applications. It is independent of any specific simulation software package.

W. D. Kelton, R. P. Sadowski, and D. T. Sturrock, "Simulation With Arena," 5th Edition, 2010. ARENA is a popular simulation software package. Since ARENA is powerful in its modeling capability and provides many useful features in simulation model building and results analysis, many earlier students used it for their term projects. There will also be homework assignments from this book. You may also use the 2nd, 3rd, or 4th edition (NO 1st edition!) of this book but be aware that they were written for earlier versions of Arena.

Other useful books on simulation that may be of interest

S. Asmussen, P.W. Glynn, "Stochastic Simulation: Algorithms and Analysis". This book provides in-depth coverage of many advanced topics in stochastic simulation
C. H. Chen and L. H. Lee, "Stochastic Simulation Optimization: An Optimal Computing Budget Allocation," 2010. This book gives an introduction to simulation and focuses on the use of simulation optimization, i.e., optimizing system design using a simulation model.

Simulation software

Arena:

ARENA is a very popular simulation software package and will be used in this class. The student version of Arena is free of charge (http://www.arenasimulation.com/Arena_Home.aspx). The student version of Arena is essentially the same as professional version except the limit on the size of model you can run.

Please read the instructions in the appendix of the book carefully before installation. If you have a Windows-based computer, you can install Arena on your own PC. In addition, Arena professional version 14.0 is available at the IT&E PC Lab on the first floor of the engineering building. The professional version allows you to run much bigger models. However, **you must only use it for educational purpose**!

Excel add-in software packages for simulation:

@Risk and Crystal Ball are two popular Excel add-in Monte Carlo (note that they are not developed for discrete-event simulation) simulation software packages. We will not use them in this class. But keep in mind that in practice, many simulation studies are done on a spreadsheet using software tools like them. Some useful reference books for these tools are: (1) Crystal Ball: "Introduction to Simulation and Risk Analysis" by J. R. Evans & D. L. Olson, Prentice Hall. (2) @RISK: "Simulation Modeling using @RISK", by W. L. Winston, Duxbury.

High-level programming languages:

In principle, all simulation models can be built using a high-level programming language like C++ or Java as long as there is a good random number generator. It gives you the most control and flexibility to build the simulation model but requires much more time and expertise than readily available simulation software packages.

Agent-based simulation software:

We will not study agent-based models in this course. General programming languages can handle agent-based models easily and generally outperform a "canned" simulation software package. AnyLogic is a commercial software package that supports agent-based modeling and simulation. NetLogo is a free and popular software for agent-based modeling and simulation. Mason has its own agent modeling and simulation library in Java (http://cs.gmu.edu/~eclab/projects/mason/).

Tentative Course Schedule & Reading Assignment:

Topics	Lectures	Reading Materials	Optional reading
Introduction to discrete-event systems and simulation	0.5	Law 1.1-1.4.5 (except 1.4.4), 1.7, 1.9	For those interested in C implementation of the simulation model, Law 1.4.4
Review of basic	0.5	Law 4.1-4.2, 4.4	Law 4.3, 4.5, 4.6

probability theory and statistics			
Building simulation model	1	Law 3.1-3.3, Kelton Chapters 3	Law 3.4-3.7
Input modeling	1	Kelton 4.6, Law 6.4	The rest of Law Chapter 6
Generating random numbers from uniform distributions	0.5	Law 7.1-7.2	Law 7.4
Generating random numbers from non-uniform distributions	1	Law 8.1-8.5	Law 8.6
Simulation output analysis	1.5	Law 9.1-9.5.2	Law 9.5.3-9.6
Midterm	1		
More Arena model building	2	Kelton 4.1-4.5	Kelton 5
Term project mid-term Progress report	0.5		
Comparing alternative system configurations & optimization via simulation	2	Law 10.1-10.4	
Variance reduction techniques	0.5	Law 11.1-11.2.2, 11.3	11.2.3-11.2.4
Monte Carlo Simulation	1	Law 1.8.3	
Term project presentation	1		