OR 635
Discrete System Simulation
Fall 2017

Class time: Monday 7:20pm-10:00pm
Room: Planet 126
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Office Hours: Tuesday 2-3pm, Wednesday 2-3pm, or by appointment

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.

Students are expected to check BlackBoard regularly to read course announcements.

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, November 14. Make-up exam can only be granted if you must be absent because of medical conditions (documentation from doctors required) or other circumstances that you have no control over. Please notify the instructor at least 5 days before the exam. The only exception is medical emergencies that you cannot know beforehand. Make-up will be at the same level of difficulty as the regular exam.

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 2-3 members will work on the term project. Students are encouraged to do a simulation project in one of the following application contexts but can also choose a topic in other areas:
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 and a final project report. Teams will also present the proposal and final report in class. In addition, teams will take turns to present the progress of their projects and have interactive discussions with the instructor and students in class. More details about term project will be given during the semester.

Lecture Materials and Textbooks
Lecture slides:
Powerpoint lecture slides for a topic will be posted online before the lecture(s) on this topic. Slides are not self-contained and only provide a guideline and summary of important background information and results.

Required text:
M. Law, "Simulation Modeling & Analysis," 5th ed. 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," 6th ed. 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.

Other useful books on simulation that may be of interest:

C. H. Chen and L. H. Lee, "Stochastic Simulation Optimization: An Optimal Computing Budget Allocation," 2010.
B. L. Nelson, "Foundations and Methods of Stochastic Simulation", Springer, 2013.

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 (https://www.arenasimulation.com/academic/students). The student version of Arena is essentially the same as professional version except the limit on the size of model you can run.

If you have a Windows-based computer with an Ethernet port, you can also obtain Arena professional license on your own PC for your term project. There is a limit on the total number of licenses available and each team is thus subject to a cap (depending on how many teams we will have) on the number of licenses that can be checked out.

To obtain the professional license, you must download and install the FactoryTalk Activation Manager from Rockwell Automation (https://activate.rockwellautomation.com/). You can then bring your laptop to the instructor's office to borrow a professional license. You should be ready to leave your laptop with the instructor for about 10 minutes. Arena professional version is also 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. Y**ou must only use the professional license 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:
Below is our tentative course schedule, which is subject to change as we progress. Reading materials cover more than what will be discussed in classroom.

Topics	Reading Materials	Optional reading
Introduction to discrete-event systems and simulation	Law 1.1-1.4.5 (except 1.4.4), 1.7, 1.8	For those interested in C implementation of the simulation model, Law 1.4.4
Review of basic probability theory and statistics	Law 4.1-4.7	
Input modeling	Kelton 4.6, Law 6.1-6.6, 6.8, 6.10-6.13	
Generating random numbers from uniform distributions and	Law 7.1-7.2	Law 7.3, 7.4
Generating random variates from general distributions	Law 8.1-8.6	
Term Project Proposal Presentation (09/26)		
Simulation output analysis	Law 9.1-9.5.2	Law 9.5.3-9.6
Comparing alternative system configurations	Law 10.1-10.3, Kelton 6.3-6.4	
Building simulation model	Law 3.1-3.3, Kelton Chapters 3	Law 3.4-3.7
More Arena model building	Kelton 4.1-4.5, 5	
Midterm (tentatively scheduled on 11/14)		
More Arena model building	Kelton 4.1-4.5, 5	
Ranking & Selection	Law 10.4, Kelton 6.5	
Experimental design and optimization via simulation	Law 12.1-12.5, Kelton 6.6	
Term project presentation (12/05)		

Academic Integrity

GMU is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in

this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

Disabilities Statement

If you have a documented learning disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with Office of Disability Services (SUB I, Rm. 4205; 993-2474;http://ods.gmu.edu) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Mason Diversity Statement

George Mason University promotes a living and learning environment for outstanding growth and productivity among its students, faculty and staff. Through its curriculum, programs, policies, procedures, services and resources, Mason strives to maintain a quality environment for work, study and personal growth.

An emphasis upon diversity and inclusion throughout the campus community is essential to achieve these goals. Diversity is broadly defined to include such characteristics as, but not limited to, race, ethnicity, gender, religion, age, disability, and sexual orientation. Diversity also entails different viewpoints, philosophies, and perspectives. Attention to these aspects of diversity will help promote a culture of inclusion and belonging, and an environment where diverse opinions, backgrounds and practices have the opportunity to be voiced, heard and respected.

The reflection of Mason's commitment to diversity and inclusion goes beyond policies and procedures to focus on behavior at the individual, group and organizational level. The implementation of this commitment to diversity and inclusion is found in all settings, including individual work units and groups, student organizations and groups, and classroom settings; it is also found with the delivery of services and activities, including, but not limited to, curriculum, teaching, events, advising, research, service, and community outreach.

Acknowledging that the attainment of diversity and inclusion are dynamic and continuous processes, and that the larger societal setting has an evolving socio-cultural understanding of diversity and inclusion, Mason seeks to continuously improve its environment. To this end, the University promotes continuous monitoring and self-assessment regarding diversity. The aim is to incorporate diversity and inclusion within the philosophies and actions of the individual, group and organization, and to make improvements as needed.

Student Support Resources on Campus

Resources that you may find helpful may be found at:

http://ctfe.gmu.edu/teaching/student-support-resources-on-campus/