American University of Beirut
Maroun Semaan Faculty of Engineering and Architecture
Department of Industrial Engineering and Management

INDE 504 Discreet Event Simulation

Fall 2017, CRN 12271, MW 9:30 AM - 10:45 AM, IOEC 224C
Lab sessions MW 11:00 AM - 12:00 PM, SRB Lab 6[1]

Instructor

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Course Description and Objectives

Simulation is concerned with developing computer models that mimic the behavior of real systems. This is done through the generation of "random variates" that replicate the statistical properties of a system. Simulation falls under the umbrella of Operations Research. The objective of simulation (like other OR models) is to gain insight into the real system with the ultimate goal of enhancing performance. Simulation is generally used when analytical methods are not effective (i.e., the model cannot be developed with closed-form mathematical expressions). It is also used for validating analytical models. As such, simulation is one of the most popular decision making tools used by analysts in OR and related disciplines. The objective of this course is to introduce the student to the main ingredients of a successful simulation study. Students will learn how to (i) process input data for a simulation model; (ii) develop a simulation model on a computer; and (iii) analyze the output of the simulation. Simulation models will be developed using the simulation software Arena and @Risk (Excel add-in). Financial, logistic, manufacturing, and service applications will be emphasized.

Textbooks

1. Banks, J., J. S. Carson, B. L. Nelson, and D. M. Nicol. *Discrete-Event System Simulation*, 5th Edition. Prentice-Hall, 2009. (BCNN)

2. Kelton, W. David, Randall P. Sadowski and Nancy Zupick. *Simulation with Arena*. 6th Edition. McGraw Hill, 2014. (KSZ)

Additional References

1. Law, Averill M. *Simulation Modeling and Analysis*. 5th Edition. McGraw Hill, 2015.

2. Hillier, F. S. and G. J. Lieberman. *Introduction to Operations Research*, 8th Edition. McGraw-Hill, 2004.

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[1]Lab 6 has a capacity of 20 seats only. Since there is only one of me, I have to divide the class between Monday and Wednesday labs. Check the course website to see whether you should attend the lab on Monday or Wednesday.

3. Ross, S. M. *Introduction to Probability Models*, 8th Edition. Academic Press, 2002.

4. Ross, S. M. *Simulation*, 3rd Edition. Academic Press, 2001.

5. Taha, H. A. *Operations Research: An Introduction.* 8th Edition. Prentice Hall, 2007.

Tentative Schedule
Topics will be covered according to the following schedule.

1. Course introduction, OR modeling approach, simulation overview. Review of Probability Theory and Random Variables. A primer on queueing theory. Introduction to Arena. (Chs. 1-6 BCNN; Ch 3 KSZ)

2. Introduction to discrete event, Monte Carlo, and process oriented simulation. Hand simulation of a queueing and an inventory system. Introduction to Monte Carlo simulation in @Risk. (Chs. 1-6 BCNN)

3. Input Analysis. Collecting input probability distributions, estimation of parameters, MLE estimators goodness of fit tests, Chi-Square, Kolmogorov-Smirnov. Input Analysis in Arena and ExpertFit. (Ch 9, BCNN; Ch 4 KSZ)

4. Random number generators. Linear congruential generators (mixed and multiplicative), more general combined generators, tests for random numbers. Modeling basic systems with Arena. (Ch 7 BCNN; Ch 4 KSZ)

5. **Midterm exam** (Friday October 27 at 5:30 PM).

6. Generating random variates. Methods, inverse transform, convolution, composition methods, acceptance-rejection. Application to well-known distributions and processes, generating from Normal, Gamma and arrival processes. Modeling detailed operations with Arena. (Ch 8 BCNN; Ch 5 KSZ)

7. Output analysis. Statistical estimation, confidence intervals, termination rules, variance reduction technique, comparing multiple system designs. Output analysis in Arena. (Chs. 11-12 BCNN, Ch 6 KSZ)

8. **Class presentation of student projects.** (Friday December 8 at 5:30 PM).

9. **Final exam** (scheduled by the registrar's office).

Grading

Midterm Exam	25%
Final Exam	25%
Project	25%
Homework and Lab	25%

Homework
Homework will be assigned frequently. It will involve conceptual problems from BCNN book and Arena applications from KSZ book. All students are encouraged to solve the homework problems, and to discuss them with each others and the instructor. However, every student must write and submit the homework assignment individually. Homework problems should not be typed unless they are the output of Arena or Excel spreadsheets.

Make sure you staple the homework. Certain assignments require emailing Arena files. Doing the homework is the best way to excel in this course.

Project

The project involves simulating a real system with complete input analysis, model development in Arena and output analysis with suggestions for improvement. Possible ideas nclude simulating traffic, parking systems, port and airport operations, computer and communications networks, call centres, bank operations, supermarket check-out lines, hospitals, diseases spread, emergency rooms, emergency response, construction operations, manufacturing systems, games, or any *interesting* system you find. You should work in groups of three. **A one-page proposal for the project is due on Wednesday September 27, 2017.** In this proposal, you briefly describe the system you want to simulate and the objective of the simulation study. Upon reading your proposals, I will either accept your proposal or ask you to look for another idea. In the last week of classes, you are required to do a 15-minute presentation of your project. You must also submit a written report not exceeding 15 pages, double-spaced, font 12, ample margins, and containing an abstract, an introduction and a conclusion section.

Attendance Policy and Class Management

Attendance will be noted utilizing random sampling.[2] A student is allowed **two** unexcused absences at most. Each additional unexcused absence will lead to losing five points from the final grade. No student will be admitted to class after 15 minutes from the beginning of the lecture. Cell phones, laptops and other gadgets are not allowed in class.

Examination Policy

A student is not allowed to miss an exam except for a valid medical excuse. However, no make-up exam will be given for the midterm exam. Instead, for students who miss the midterm exam, with a valid excuse, the weight of the final exam will be changed to 50%. Students who miss the final exam will be given an incomplete grade and will have to take a make-up exam at the beginning of the following semester. **The make-up exam is expected to be more challenging than the regular final exam**.

Course Website

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www.aub.edu.lb/∼bm05/INDE504/

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Look for assignments and slides presented in class there.

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[2]I'll call on one quarter of the students at random in every session. There is a 25% chance that your name is called in a given session. With approximately 28 sessions in the semester, there is a 98.3% chance that your name will be called more than two times in the whole semester. So, the probability of missing all sessions and not getting penalized is 1.7%.