Stochastic Performance Modeling and Scheduling in Computer Systems

Spring 2023

Instructor:	Ben Berg	**Time:**	Tuesday, Thursday 3:30 - 4:45
Email:	ben@cs.unc.edu	**Room:**	FB 009

Course Page: https://bsb20.github.io/teaching/790_s23

Office Hours: TBD or By Appointment in FB 336

Description This course will be an introduction to the tools of performance modeling, guided by a significant systems research project. Students are invited to work on problems related to their preexisting research. The class will consist of lectures on how to apply the tools of performance modeling to real-world systems research problems. Classes will also be devoted to discussions of results and challenges regarding each student's ongoing research project. We will discuss how these problems can be addressed via quantitative modeling. The goal of the course is to focus on applications of core results from performance modeling rather than focusing on the theoretical foundations of these results. Nonetheless, students should be familiar with applied probability and statistics at the level of STOR 435/535.

Student Learning Outcomes: The goals of this class are to:

1. Develop an understanding of the basic operational laws and core results from queueing theory

2. Complete a significant research project which analyzes a quantitative, stochastic model approach of a real-world computer system

3. Gain experience describing quantitative approaches to a systems audience, and describing systems work to a theory audience. Bridging this gap is a key skill in working at the intersection of theory and systems.

Main References: The main text for the course is *Performance Modeling and Design of Computer Systems* (Harchol-Balter, Cambridge University Press). It is available for free online through the UNC Library.

Target Audience: This class is intended for graduate students with an interest in a quantitative approach to building and optimizing computer systems. This might be a student with a strong theory background who is interested in how theoretical ideas can be deployed in modern computer systems. This might also be a systems student who wants to learn about a more formal approach to optimizing system performance. Students should have familiarity with applied probability at an undergraduate level, but a deeper background in stochastic processes is not required.

Prerequisites: STOR 435/535 or equivalent. Familiarity with the material in Chapter 3 of the course text book.

Lecture	Date	DoW	Topic	Work Due
1	1/10	T	Chpt 1 + 2: Motivating Examples on Queueing Theory.	
2	1/12	Th	Chpt 6: Operational Laws (Little's Law)	Project Ideas Summary
3	1/17	T	Project Brainstorming	
4	1/19	Th	Chpt 7: Modification Analysis	
5	1/24	T	Simulations, Poisson Processes, and PASTA	
6	1/26	Th	Event-driven Simulation	
7	1/31	T	Variability and queueing	
	2/2	Th	NO CLASS	
8	2/7	T	Heavy-tailed Workloads	
9	2/9	Th	Project Proposals	Written Project Proposal
	2/14	T	Well-being Day: NO CLASS	
10	2/16	Th	Project Proposals	
11	2/21	T	Queueing Networks	
12	2/23	Th	Load Balancing	
13	2/28	T	Scheduling I	
14	3/2	Th	Scheduling II	
15	3/7	T	Setup Times: auto-scaling and power management	
16	3/9	Th	Optimizing Tails: concentration bounds, RobinHood caching	
	3/14	T	Spring Break: NO CLASS	
	3/16	Th	Spring Break: NO CLASS	
17	3/21	T	Minimums and maximums of Independent Random Variables	
18	3/23	Th	Project Milestones	Written Milestone Report
19	3/28	T	Project Milestones	
20	3/30	Th	Project Milestones	
21	4/4	T	Topics TBD (based on student projects)	
22	4/6	Th	-	
23	4/11	T	-	
24	4/13	Th	-	
25	4/18	T	-	
26	4/20	Th	Final Presentation	
27	4/25	T	Final Presentation	
28	4/27	Th	Final Presentation	Written Final Paper

Important Dates:

- Project Ideas Summary - 1/12

- Written Project Proposal - 2/9

- Proposal Presentation - 2/9 + 2/10

- Written Milestone Report - 3/23

- Milestone Presentation - 2/32 + 3/28 + 3/30

- Final Presentation - 4/20 + 4/25 + 4/27

- Written Final Report - See final exam schedule

Course Requirements: This course will consist of lectures, a project proposal, project presentations, and a written project paper that summarizes the work you did this semester.

Lectures will consist of core topics in the first half of the class. Lectures in the second half of the class will be tailored to research topics as much as possible.

Project work will be evaluated via a project proposal, weekly "lightning talks", a milestone presentation midway through the class, and a final presentation. Additionally, you will submit a final paper on your project on or before the day of the our final exam slot. There will be no final exam.

Throughout the course, but particularly during the project discussions, participation is critical and therefore will count for 5% of your course grade.

Grading: To Recap:

- Lightning talks: 10%

- Project proposal: 10%

- Milestone report: 25%

- Final presentation: 25%

- Final written report: 25%

- Participation: 5%

Collaboration Policy and Other Rules: Collaboration on homework with current classmates is allowed. This includes any discussion that occurs in office hours. However, everyone must turn in their own version of each assignment. Please document your collaborators at the top of each assignment.

In addition to all UNC policies (below), everyone must adhere to the reasonable person principle.

Please note if any written work was performed by or with the aid of generative AI (lol).

University of North Carolina at Chapel Hill
Information for Undergraduate Classes
Summer & Fall 2022

Syllabus Changes

The professor reserves the right to make changes to the syllabus including project due dates and test dates. These changes will be announced as early as possible.

Attendance Policy

University Policy: As stated in the University's Class Attendance Policy, no right or privilege exists that permits a student to be absent from any class meetings, except for these University Approved Absences:

1. Authorized University activities

2. Disability/religious observance/pregnancy, as required by law and approved by Accessibility Resources and Service and/or the Equal Opportunity and Compliance Office (EOC)

3. Significant health condition and/or personal/family emergency as approved by the Office of the Dean of Students, Gender Violence Service Coordinators, and/or the Equal Opportunity and Compliance Office (EOC).

Class Policy: Instructors may work with students to meet attendance needs that do not fall within University approved absences. For situations when an absence is not University approved (e.g., a job interview or club activity), instructors determine their own approach to missed classes and make-up assessment and assignments.

University Approved Absence Office (UAAO): The UAAO website provides information and FAQs for students and faculty related to University Approved Absences.

Note: Instructors have the authority to make academic adjustments without official notice from the UAAO. In other words, it is not required for instructors to receive a University Approved Absence notification in order to work with a student. In fact, instructors are encouraged to work directly with students when possible.

Honor Code

All students are expected to follow the guidelines of the UNC Honor Code. In particular, students are expected to refrain from "lying, cheating, or stealing" in the academic context. If you are unsure about which actions violate the Honor Code, please see me or consult studentconduct.unc.edu.

Optional Mask Use Statement

UNC-Chapel Hill is committed to the well-being of our community – not just physically, but emotionally. The indoor mask requirement was lifted for most of campus on March 7, 2022. If you feel more comfortable wearing a mask, you are free to do so. There are many reasons why a person may decide to continue to wear a mask, and we respect that choice.

Acceptable Use Policy

By attending the University of North Carolina at Chapel Hill, you agree to abide by the University of North Carolina at Chapel Hill policies related to the acceptable use of IT systems and services. The Acceptable Use Policy (AUP) sets the expectation that you will use the University's technology resources responsibly, consistent with the University's mission. In the context of a class, it's quite likely you will participate in online activities that could include personal information about you or your peers, and the AUP addresses your obligations to protect the privacy of class participants. In addition, the AUP addresses matters of others' intellectual property, including copyright. These are only a couple of typical examples, so you should consult the full Information Technology Acceptable Use Policy, which covers topics related to using digital resources, such as privacy, confidentiality, and intellectual property.

Additionally, consult the University website "Safe Computing at UNC" for information about the data security policies, updates, and tips on keeping your identity, information, and devices safe.

Accessibility Resources and Service

The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, including mental health disorders, chronic medical conditions, a temporary disability or pregnancy complications resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the ARS Website for contact information: https://ars.unc.edu or email ars@unc.edu.

Counseling and Psychological Services

UNC-Chapel Hill is strongly committed to addressing the mental health needs of a diverse student body. The Heels Care Network website is a place to access the many mental resources at Carolina. CAPS is the primary mental health provider for students, offering timely access to consultation and connection to clinically appropriate services. Go to their website https://caps.unc.edu/ or visit their facilities on the third floor of the Campus Health building for an initial evaluation to learn more. Students can also call CAPS 24/7 at 919-966-3658 for immediate assistance.

Title IX Resources

Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at https://eoc.unc.edu/report-an-incident/. Please contact the University's Title IX Coordinator (Elizabeth Hall, titleixcoordinator@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Policy on Non-Discrimination

The University is committed to providing an inclusive and welcoming environment for all members of our community and to ensuring that educational and employment decisions are based on individuals' abilities and qualifications. Consistent with this principle and applicable laws, the University's Policy

[Statement on Non-Discrimination](#) offers access to its educational programs and activities as well as employment terms and conditions without respect to race, color, gender, national origin, age, religion, genetic information, disability, veteran's status, sexual orientation, gender identity or gender expression. Such a policy ensures that only relevant factors are considered and that equitable and consistent standards of conduct and performance are applied.

If you are experiencing harassment or discrimination, you can seek assistance and file a report through the Report and Response Coordinators (see contact info at safe.unc.edu) or the [Equal Opportunity and Compliance Office](#), or online to the EOC at https://eoc.unc.edu/report-an-incident/.

Diversity Statement

I value the perspectives of individuals from all backgrounds reflecting the diversity of our students. I broadly define diversity to include race, gender identity, national origin, ethnicity, religion, social class, age, sexual orientation, political background, and physical and learning ability. I strive to make this classroom an inclusive space for all students. Please let me know if there is anything I can do to improve. I appreciate suggestions.

Undergraduate Testing Center

The College of Arts and Sciences provides a secure, proctored environment in which exams can be taken. The center works with instructors to proctor exams for their undergraduate students who are not registered with ARS and who do not need testing accommodations as provided by ARS. In other words, the Center provides a proctored testing environment for students who are unable to take an exam at the normally scheduled time (with pre-arrangement by your instructor). For more information, visit http://testingcenter.web.unc.edu/.

Learning Center

Want to get the most out of this course or others this semester? Visit UNC's Learning Center at http://learningcenter.unc.edu to make an appointment or register for an event. Their free, popular programs will help you optimize your academic performance. Try academic coaching, peer tutoring, STEM support, ADHD/LD services, workshops and study camps, or review tips and tools available on the website.

Writing Center

For free feedback on any course writing projects, check out UNC's Writing Center. Writing Center coaches can assist with any writing project, including multimedia projects and application essays, at any stage of the writing process. You don't even need a draft to come visit. To schedule a 45-minute appointment, review quick tips, or request written feedback online, visit http://writingcenter.unc.edu.

Grade Appeal Process

If you feel you have been awarded an incorrect grade, please discuss with me. If we cannot resolve the issue, you may talk to our departmental director of undergraduate studies or appeal the grade through a formal university process based on arithmetic/clerical error, arbitrariness, discrimination, harassment, or personal malice. To learn more, go to the [Academic Advising Program](#) website.